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Epistemic Causality and Hard Uncertainty:
A Keynesian Approach

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Abstract - The interplay of epistemic and empiric conditions of human behaviour plays a crucial role in economic causality but it is not satisfactorily analysed by the existing approaches to economic causality, including the most influential of them: Granger causality. In order to find a more satisfactory approach to economic causality, this paper draws inspiration from the contributions of Keynes. In particular it is argued that the systematic use of probabilistic causality in the *General Theory* is deeply rooted into the theory of probabilistic causality outlined in the *Treatise on Probability* which is based on the crucial distinction between epistemic and empiric causality. In this view, since epistemic causality is conceived as probabilistic, also empiric causality has to be conceived as probabilistic in economics since in this case, differently than in natural sciences, the observed events are mediated in a crucial way by epistemic links, such as beliefs and expectations. In particular, the awareness of the relevant ignorance, represented by what is called by Keynes the 'weight of argument', affects in a crucial way the behaviour of economic agents. The Keynesian approach is extended by observing that a change in the weight of causal arguments represents a sort of 'second-order epistemic causality' that may become a possible independent source of empiric causality.

Keywords: probabilistic causality, economic causality, weight of argument, Keynesian economics.

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1. Introduction

The approach to causality that has prevailed in economics in the last two decades is based on a peculiar definition of probabilistic causality suggested by Granger (1969) who elaborated on a previous hint by Wiener (1958). The basic idea is very simple: a stochastic variable x_t causes in the Granger sense the stochastic variable y_t whenever the knowledge of the past and present values of x_t helps forecasting the future values of y_t as it reduces the variance of the prediction errors (in some well-specified sense). Though the technical details of the definition and of its implementation through econometric tests are quite sophisticated, the underlying conceptual framework is very simple, if not simplistic, as it is nothing but a particularly naive version of Humean causality: the stochastic variable x_t 'causes' (in the Granger sense) the stochastic variable y_t whenever we may detect in their co-movements a significant correlation and a prevailing time lag between their 'realisations' that specifies the direction of the causal arrow.

This new concept of causality has not been immediately successful because most economists were at the time suspicious with any concept of asymmetric causality apparently inconsistent with the general interdependence of economic variables as represented in general equilibrium theory, while the few economists dealing with asymmetric causality were utilising concepts of deterministic causality,[1] and were not prepared to recognise an epistemological legitimacy to any concept of probabilistic causality. However since the late 1970s the Granger concept of causality began to spread and to be routinely applied in economic analysis ousting almost completely the other concepts of causality and obtaining a success that no concept of causality had obtained before in economics. Among the main reasons of the unprecedented success of Granger causality the following reasons may be briefly recalled:

- The strong affinity with the new emergent stream of economic analysis based upon the assumption of rational expectations, both in the modelling techniques utilised (rooted in the theory of stochastic processes) and in the underlying vision of the real world conceived as closed and stationary.[2]

[1] The concept of causality suggested by Simon (1952), the most popular within economics until the late 1970s, was based on the order of computation of the endogenous variables implicit in the structure of coefficients which characterises a system of equations.

[2] We define the world as *closed* whenever the decision maker knows all the possible states, all the possible acts and the probability of occurrence of all the possible consequences of these acts in any possible states. We define the world as *stationary* whenever it is assumed that the set of possible states, acts and consequences do not change through time, and the same act leads to the same consequence conditional to the same state with the same probability. Though these two properties

- The wealth of apparently simple econometric tests to corroborate or falsify causal assertions based upon the Granger concept so that the new kind of economic analysis could distinguish a priori between endogenous and exogenous variables, a necessary requisite for its correct implementation.
- The philosophical legitimacy of the Granger concept of probabilistic causality based on its formal analogy with philosophical concepts such as that of Suppes (1970) which in the meantime had acquired prominence in the philosophical debate.

Notwithstanding its extraordinary success, the approach of Granger causality continued to raise many sharp criticism (for a critical survey see, e.g., Vercelli, 1989, 1991, and 1992). We just recall here two of them which are particularly relevant for this paper:

- Granger causality is correctly defined as relative to a set of background information; however it is claimed by its practitioners that such a set only includes the past and present values of the relevant stochastic variables while, differently from the other causal concepts, it does not need to include any kind of a priori theoretical knowledge. Therefore it is claimed that the causal assertions grounded on the results of Granger causality tests are unconditional to a priori theoretical assumptions and that this makes this approach superior to the competing alternative causal approaches. Unfortunately it is possible to demonstrate that this claim is false (see Vercelli, ibidem) and that this undermines any general claim of superiority for the Granger approach vis-à-vis alternative approaches.
- The Granger concept of probabilistic causality implies by definition the existence of some sort of relevant uncertainty in the economic system; however both the conceptual underpinnings of this approach (in particular the crucial link with prediction rather than with explanation) and the assumptions of the tests (that in particular have to rely on the stationarity of the relevant stochastic processes) imply that it can be applied only to situations characterised by a very weak kind of uncertainty which we are going to call 'soft' uncertainty.[3]

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attributed to the real world are very demanding they are explicitly assumed in the received decision theory either objectivist (Morgenstern-von Neumann, 1944) or subjectivist (Savage, 1956), which underlies both orthodox economic theory and Granger causality.

[3] In this paper we will distinguish between *soft* uncertainty, whenever the beliefs of the decision-makers may be represented through a unique, fully reliable, additive probability distribution and *hard* uncertainty whenever the beliefs of the decision-makers may be represented only through a non-additive probability distribution or through a plurality of probability distributions that may be additive but none of which is considered as fully reliable (on this distinction and its implication for decision theory see Vercelli, 1999).

These two shortcomings are strictly linked as they are both a symptom of a narrow and simplistic way of conceiving the relationship between the epistemic and empiric conditions of causality. The assumption of rational expectations which characterises the style of economic analysis within which Granger causality has become so popular is an extreme, though ubiquitous, example of this attitude: the crucial assumption that characterises the 'rational expectations hypothesis', i.e. that the subjective probability distribution coincides with the objective probability distribution, by definition eliminates any tension, indeed operational distinction, between epistemic and empiric conditions of causality and decision.

In order to work out a more satisfactory notion of probabilistic causality based on a more sophisticated analysis of the complex relationship between epistemic and empiric conditions of causality we may still find useful inspiration in the contributions by Keynes. Though the passages explicitly dedicated to causality by Keynes in both the *Treatise on Probability* (1921, from now on *TP*) and its economic works are sparse and scanty, still they are inserted in a very rich conceptual framework which makes them a pregnant source of inspiration. The *TP* hints at a notion of probabilistic causality which, at first sight, may be considered as an early forerunner of the Granger notion (Vercelli, 1989). However, though the formal language utilised by Keynes is obsolete and much less sophisticated than that of Granger, on the contrary its philosophical underpinnings are much sounder from the epistemological point of view. In particular Keynes emphasises that 'since our knowledge is partial, in the use of the term *cause* there is always an explicit or implicit reference to a limited corpus of knowledge' (*TP*, p.306) This conceptual framework has to be made explicit ex ante as clearly as possible in order to clarify the meaning and scope of any causal assertion. In particular, in the absence of such a conceptual framework, we could not distinguish between a spurious and a genuine cause (see Vercelli, 1989). The claim of superiority of Granger causality based on its alleged unconditionality to a priori theoretical assumptions must therefore be rejected, if not reversed. The same opinion may be found already in the *TP*: 'The opposite view, which the unreliability of some statisticians has brought into existence,--that it is a positive advantage to approach statistical evidence *without* preconceptions based on general grounds, because the temptation to 'cook' the evidence will prove otherwise to be irresistible,--has no logical basis and need only be considered when the impartiality of an investigation is in doubt' (*TP*, p.338). This point is a fundamental assumption which underlies the following analysis. In addition Keynes has a very sophisticated understanding of the nature and implications of uncertainty for the 'moral sciences' (i.e. human and social sciences) such as economics, as well as of the complex interaction between epistemic and empiric conditions in decision making and causality (Keynes, 1939, and CW XIV and XXIX). In particular he emphasises the need of distinguishing different modalities of

uncertainty which have different implications for rational decision making; one important implication underlined by Keynes is the fact that probabilistic arguments may have a different 'weight' that is liable to affect the rational behaviour of decision makers.

This paper intends to clarify the nexus between epistemic and empiric conditions of probabilistic causality within a Keynesian conceptual framework applied to the economic empirical field. In the second section the contributions by Keynes to probabilistic causality are briefly summarised and discussed by explicitly connecting the contributions put forward in the *TP* with those contained in his economic works (with special reference to the *General Theory*, 1936, from now on *GT*). In the third section the relationship between the weight of argument and probabilistic causality is discussed; this suggests the introduction of a new concept here christened as 'second-order epistemic causality'. In the 4th section an example drawn from the *GT* illustrates the pragmatic relevance not only of the Keynesian concepts of epistemic causality and weight of argument but also of the concept here introduced of 'second-order epistemic causality'. A few concluding remarks follow.

2. Epistemic causes and economic causes in Keynes

In the TP there is an unsolved tension between '*causa cognoscendi*', which may be translated as 'epistemic cause', and '*causa essendi*' which could be translated as 'ontological[4] cause' according to the philosophical tradition to which the latin words alluded to, but that we prefer to translate as 'empiric cause' in order to avoid in this paper philosophical problems which are not central for the argument. In particular, the empiric cause is seen as deterministic, i.e. its occurrence is seen basically as a necessary and\or sufficient condition ceteris paribus for the occurrence of the effect, while the epistemic cause is seen as probabilistic since we are led, according to Keynes, to use the term 'cause' in a broader sense than that of 'sufficient cause' or 'necessary cause', because being rarely evident the necessary and\or sufficient causal link of particular events with particular events, the strict sense of the word is almost useless (*TP*, 306-7), particularly in moral sciences (Keynes, 1939). The ontological determinism of the empiric cause is for Keynes just the 'received view' on the natural world apparently confirmed by the amazing empirical success of Newtonian physics but he is fully aware that the limits of the human mind coupled with the complexity of the real world

[4] Of course also the epistemic conditions have their 'being' which is not necessarily altogether different from that of natural phenomena, unless an extreme dualism such as that of Descartes is assumed. In our dichotomy 'empiric' stands for 'directly observable' while the epistemic states are not directly observable.

allow in most cases only a knowledge of probabilistic relations, as Laplace had clarified already long ago. This point of view leads Keynes to conceive of the epistemic cause as probabilistic even when the underlying ontological cause is assumed to be deterministic. This is true also for the physical world with limited and partial exceptions in the fields, such as celestial mechanics, where the phenomena to be forecasted are particularly simple (as a solar or lunar eclipse) and the relevant knowledge that may be acquired is almost complete for the purpose, so that a deterministic version of epistemic causality may be applied. However the predominance of the probabilistic version of epistemic causality is much more evident in the 'moral sciences' where the phenomena are particularly complex and crucially depend on the subjectivity of decision makers. This point which is just hinted at in the *TP* is developed on many occasions in his economic works. However the only definition given by Keynes of the probabilistic version of epistemic causality may be found in the *TP*. Translating his definition in the modern language suggested by Suppes (1970) we may reformulate Keynes's definition in the following way:

A_t is an epistemic cause of B_t relative to Z_t iff:

(i) $P(A_t \cap Z_t) > 0$

(ii) $P(B_{t'} \mid A_t \cap Z_t) \neq P(B_{t'} \mid$

(iii) $Z_t)$, $t' \geq t$,

where A_t and $B_{t'}$ are events occurring respectively at time t and t', Z_t is the background information (including the relevant theoretical assumptions) and P the probability of occurrence of the events under the specified conditions.

This definition is substantially equivalent to the definition of 'potential prima facie' cause in Suppes (1970) apart from two minor differences:

- A temporal lag between the occurrence of the cause and the effect is not required, and thus the possibility of contemporaneous causation is explicitly admitted;
- The occurrence of the cause may reduce the probability of occurrence of the effect; in other words the possibility of an inhibitory cause is explicitly admitted.

In the *GT* Keynes clarifies that probabilistic *epistemic* causes may play the role of *empiric* causes in economics (as well as in other human and social fields). A change in the quality and quantity of the relevant knowledge on the part of the decision maker is likely to modify, even significantly and abruptly, the expectations over the variables which affect decisions. Therefore, generally

speaking, in the economic field, as well in the other human and social fields, even the empiric causes may be, and typically are, probabilistic. We have a chain of causes which goes from the new evidence available to the change of expectations (epistemic cause) that determine a change in decisions which produces a change in the observable behaviour which affects the available evidence so closing the feedback between cognitive conditions and empiric conditions; even if we consider the nexus between a change in expectations and a change in behaviour as deterministic, in the way economic theory routinely does, the empiric cause which connects a new observable event with an ensuing change in behaviour has to be conceived in principle as probabilistic since it is mediated in a crucial way by a probabilistic epistemic cause.

3. Weight of argument and second-order epistemic cause

As we have seen, the use of probabilistic causality in the *GT* is deeply rooted in the theory of probabilistic causality outlined in the *TP*, while its epistemological implications for an empirical field such as economics are clarified. Probabilistic causality is not at all the only specific link between *TP* and *TG*. A further crucial link is provided by another innovative concept introduced by Keynes in the *TP*: the *weight of argument*. Its emergence in the *TP* is determined by the inner conceptual logic of his approach while its pragmatic relevance remains in doubt;[5] in the *GT* Keynes provides important examples of its crucial relevance for an empirical field such as economics. This link has been already explored in the literature (see, e.g., Carabelli, 1988, O'Donnel, 1989, and Runde, 1990), while no one –to the best of my knowledge- has explored and discussed the link between the weight of argument and probabilistic causality neither in the *TP* nor in the *TG*. We intend to show that this link, only implicit in the Keynesian works, deserves to be made explicit and discussed. In order to do so we have to introduce briefly the very controversial concept of weight of argument. In the *TP* we may find at least three (apparently) different definitions of weight of argument. We argued elsewhere (Vercelli, 1998) that the most satisfactory and comprehensive definition is the following:

[5] In the *TP* Keynes explicitly confesses his doubts to the reader in a few passages, including the following: 'I do not feel sure that the theory of 'evidential weight' has much practical significance' (*TP*, p.83).

Given the argument $Q = (x \mid y)$, where x is a proposition (or set of propositions) that is true with a certain probability given the hypotheses and the background knowledge, i.e. the set of propositions y, the weight V of the argument Q is defined:

$$V(Q) = K /(K+ I)$$

where K designates the relevant knowledge and I designates the relevant ignorance.

In intuitive terms the weight of argument measures the degree of completeness of the relevant knowledge of the epistemic subject. The range of values that the weight of an argument may assume goes from zero, when the epistemic subject believes to be in a state of complete ignorance in respect to the argument, to one when the epistemic subject believes to have a complete knowledge in respect to the argument. However, Keynes also clarifies that for an argument to be meaningful the relevant knowledge cannot be inferior to a certain minimum value ε (*TP*, p.78 ; see fig.1).

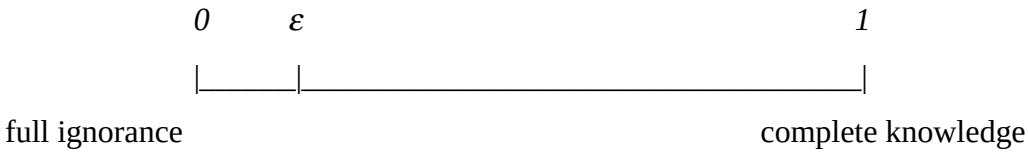

Fig. 1

Now, we want to emphasise that also the causal arguments have a weight which expresses the reliability attributed to them by the epistemic subject. This is not made explicit in the *TP* by Keynes himself but descends from his conceptual framework since in his view all causal assertions in the epistemic sense are arguments connecting with some degree of probability a few propositions asserting the occurrence of one or more events, given a certain corpus of background knowledge,

with the occurrence of one or more events which describe the effects. We may guess that Keynes did not make explicit this implication of his conceptual framework because having admitted his own doubts about the pragmatic relevance of the new concept of 'weight of argument', he did not perceive the potential relevance of its application to epistemic causality. However in the *GT* he is pushed by the inner logic of his economic analysis to attribute a crucial role to the weight of argument within a framework of probabilistic causal relationships between the relevant variables. A deep understanding of these passages of Keynes requires the introduction of a 'new' concept, new in the sense that it is only implicit in Keynes and never developed in the literature (to the best of my knowledge). I suggest to call it 'second-order cause' as it refers to a second-order measure of uncertainty, i.e. the weight of argument, the change of which may play a causal role, not only epistemic but also empiric. We may say in general that a change in the weight of a causal argument may change the decision strategy of a decision maker who is led by it to adopt a different decision criterion. When the weight of argument is low it is rational to adopt a very prudential decision criterion such as the maxi-min criterion which is the most popular criterion adopted in case of full ignorance; when the weight of argument is high, i.e. the knowledge is almost complete, it is rational to exploit fully the available knowledge through a criterion such as that of the maximisation of expected utility (see Vercelli, 1999). Of course the change in the decision criterion induced by a change in the weight of argument induces ceteris paribus a change in the behaviour of the decision maker. Therefore also in this case an epistemic cause in principle may play the role of an empiric cause.

A proper use of second-order causality for epistemological and empirical analysis requires a rigorous definition. As a preliminary step in this direction, the following basic definition may be suggested:

> C_t is a *pure* second-order epistemic cause of $B_{t'}$, in reference to the causal argument $Q = (B_{t'} \mid Z_t \cap A_t)$, iff:
>
> (i) $P(A_t \cap Z_t) > 0;\ P(C_t \cap Z_t) > 0,$
>
> (ii) $V(Q) > \varepsilon,\ \ V(Q \mid C_t) > \varepsilon,$
>
> (iii) $P(B_{t'} \mid A_t \cap Z_t) = P(B_{t'} \mid A_t \cap Z_t \cap C_t),$
>
> (iv) $V(Q \mid C_t) \neq V(Q),$

where the (i) and (ii) are conditions of meaningfulness. This definition characterises the event C_t a 'pure' second-order cause since its occurrence does not affect the first-order causal

argument, as specified by the condition (iii) but only its weight, as specified by the condition (iv). In the real world the same event often, though not always, plays at the same time the role of first-order cause and of second-order cause but these two channels of transmission of a causal impulse must be kept separate because their effect may be quite different, even opposite (see the next section).

4. An economic example

We intend to clarify the concepts and the assertions introduced so far through a very simple economic example based on the theory of investment contained in the *GT* (see, e.g., Chick, 1983). In order to determine the equilibrium quantity of investment of entrepreneurs in plants and machinery we have to equate demand and supply of investment. Under the usual assumptions which define a short-period equilibrium, the supply of new real capital S_k is given so that the variations of investment crucially depend on the variations of the demand D_k which is given by the sum of profits E_t expected from the new capital discounted at the rate of interest r:

$$(1) \qquad D_k = \sum E_t / (1+ r)^t, \qquad 1 \leq t \leq i.$$

The rate of interest that equates demand and supply of new real capital identifies the marginal efficiency of capital e_t.

We may define the locus of possible equilibria through a curve which equates the market rate of interest r_t with the marginal efficiency of capital e_t. This curve is negatively sloped[6] and may be shifted by a change in the expectations (see fig 2).

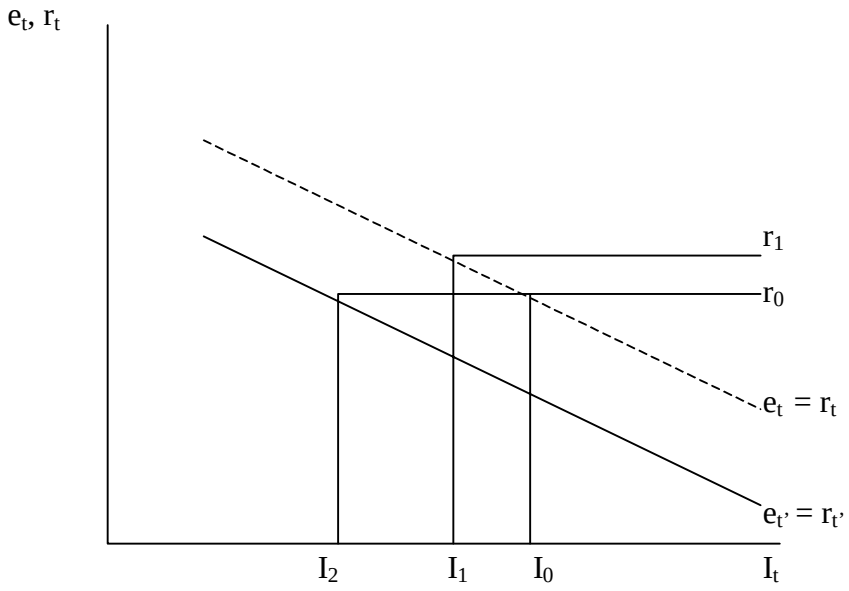

Fig. 2

Therefore, since in the short term the supply curve of new real capital may be considered as constant, a change in investment may be caused only from the demand side, either by a change in the market rate of interest (empiric causality) or by a change in the expectations (first-order epistemic causality), or by a change in the weight of the arguments underlying the expectations and their change (second-order epistemic causality).

In the case of a change only in the observed market rate of interest (in fig.2, e.g., from r_0 to r_1), the curve of marginal efficiency of capital is not affected by this event so that the new value of the equilibrium investment is determined by the shift of the point where the exogenous rate of interest crosses the marginal efficiency of capital curve which determines an increase of the investment from the original level I_0 to the new level I_1. This empiric causal relationship may be conceived as deterministic under the assumption, routinely adopted by economics, that the agent is rational in the sense that the option chosen maximises the expected returns. Let's assume, e.g., that

[6] This is explained by neoclassical Keynesians as a consequence of the falling marginal productivity of capital, and by Keynes himself in terms of a limited stock of opportunities of investment ordered in terms of falling expected returns (see, e.g., Chick, 1983; Vercelli, 1991).

ceteris paribus the market rate of interest diminishes. According to the relation (1) (represented in fig.2 by the downward-sloping curve of marginal efficiency of capital) we may say that

$$Q_0 = P\,[(\Delta I_t < 0) \mid Z_t \cap (\Delta r_t > 0)] = 1.$$

On the contrary, a change in the epistemic state of the decision maker produces a shift in the marginal efficiency of capital curve which cannot be considered as deterministic. These shifts are based upon the probabilistic argument that connects the knowledge available to the decision maker with the expected profits. In the most general perspective the basic argument may be expressed in the following way:

$$Q_1 = \phi\,(E_t \mid Z_t),$$

where $\phi\,(E_t \mid Z_t)$ represents the probability distribution of the expected profits conditional to the background information available to the decision maker.

In our example a certain event is a first-order epistemic cause of the expected profits E_t whenever it modifies their probability distribution:

$$\phi\,(E_t \mid Z_t) \neq \phi\,(E_t \mid Z_t \cap C_t).$$

Let's assume that a central banker (say Greenspan) announces that he is not going to increase the rate of interest but warns the markets that the Stock Exchange is characterised by a speculative bubble which may burst at any time. This new piece of information is likely to depress the expectations of the investors shifting downwards the marginal efficiency of capital curve from $e_t = r_t$ to $e_{t'} = r_{t'}$. Let's assume that C_t represents the new event (say the message of Greenspan), we have the following epistemic causal argument:

$$Q_2 = P\,[(\Delta E_t < 0) \mid Z_t \cap C_t] > P\,[(\Delta E_t < 0) \mid Z_t].$$

This *epistemic* causal argument easily translates into an *empiric* causal argument:

$$Q_3 = P\,[(\Delta I_t < 0) \mid Z_t \cap C_t] > P\,[(\Delta I_t < 0) \mid Z_t].$$

In principle, this empiric cause is independent of the empiric cause represented by the argument Q_0 and is probabilistic. This instantiates and confirms that also empirical causes are in principle probabilistic in the social field as soon as we consider the role played by the epistemic conditions in the causal chain. The two empiric causes represented by the argument Q_3, mediated by epistemic conditions, and the argument Q_0 , independent of subjective epistemic conditions, do not exclude each other. As an example take the announcement by Greenspan of an increase in the rate of interest accompanied by a warning that the bubble of the stock exchange is likely to burst soon. In this case the two effects go in the same direction. However it is not necessarily so. Take the case of an announcement by Greenspan that he is going to reduce the rate of interest in order to react to a high degree of financial fragility. In this case the same announcement has two opposite effects: the reduction of the rate of interest should ceteris paribus increase the investment but its motivations (the fear of a generalised financial crisis) are likely to depress the expectations of the economic agents and to shift downwards the marginal efficiency of capital curve.

The analysis of the main causal determinants of investment would be gravely incomplete in the absence of a third causal factor of the utmost importance. The event C_t may reduce the weight of the epistemic argument underlying the epistemic causes involved in the process analysed either directly or indirectly. A warning by Greenspan that the expansion is about to end, whether or not accompanied by a change in the rate of interest or by other measures of policy, is likely to reduce the confidence of the agents over the future which may well be represented as a fall in the weight of the epistemic argument Q_1 underlying the existing expectations:

$$Q_4 = V(Q_1 \setminus C_t) < V(Q_1)$$

This affects also the causal arguments Q_2 and Q_3 sharply increasing ceteris paribus the probability of a reduction in the investment. Therefore this second-order epistemic cause becomes an important independent empiric cause or an independent channel of transmission of a causal impulse. This example shows that the interplay of epistemic and empiric conditions in economics makes economic causality probabilistic, at least in principle, while the epistemic causes often play an indirect role of empiric causes. In addition we have seen that what we have called second-order

epistemic cause may play a crucial role as empiric cause which confirms its operational role as well as that of the Keynesian concept of 'weight of argument'.

5. Concluding remarks

The interplay of epistemic and empiric conditions of human behaviour is very complex and plays a crucial role in economic causality. We should therefore be suspicious of approaches, such as that of Granger causality, which oversimplify the issue. This approach is well rooted in, and fully consistent with, the prevailing approach of orthodox economics that assumes rational expectations; however the confusion between epistemic and empiric conditions of economic behaviour is typical of all this huge and influential literature, as is clearly revealed by the assumed identification of the subjective (or epistemic) probability distribution of the endogenous variables entertained by the economic agents with their 'objective' or empiric probability distribution.

In order to find a more satisfactory account of the interplay between epistemic and empiric conditions of the behaviour of economic agents we found useful to draw inspiration from the contributions of Keynes by linking together the *TP* with his successive economic contributions as developed in particular in the *GT*. As we have argued, the use of probabilistic causality in the *GT* is deeply rooted in the theory of probabilistic causality outlined in the *TP*, while its epistemological implications for economics are clarified in the *GT*. In particular, the awareness of the decision maker of her relevant ignorance, represented –and to some extent measured-- by the weight of argument, plays the crucial role of ultimate stimulus of structural learning aiming to eliminate systematic mistakes, and determines the choice of the decision criterion on the part of a rational agent. This affects in a crucial way the economic behaviour of rational agents and so also the causal structure of economic events. Starting from these premises Keynes reaches a few important and innovative conclusions:

- Epistemic causality is in principle probabilistic in any field of science, since our knowledge is limited and is unable to detect deterministic links between events or variables even when we believe that such deterministic links exist in the real world. This is true not only of social sciences but also of natural sciences where Keynes accepts the then prevailing conviction in the deterministic nature of empiric causality.
- Since epistemic causality is probabilistic, also empiric causality is in general probabilistic in 'moral sciences' because in this case, differently than in natural sciences, the observed

events are mediated in a crucial way by epistemic links, such as beliefs and expectations, which must be described in terms of probabilistic causality. This acquisition was extremely bald and innovative in the 1920s and 1930s when it was expressed by Keynes in his economic works.

- We have to distinguish different degrees of uncertainty which are expressed, and somehow measured, by the 'weight of argument'.
- Also the causal arguments have a weight. A change in this weight originated from the occurrence of an unexpected event represents what we have called here 'second-order epistemic causality' which often translates in an independent source of empiric causality which may be very important in practice, as illustrated in reference to Keynes's investment theory which has been briefly recalled and analysed here.

Though these important conceptual innovations play a crucial role in Keynes's economic works they have not been made clearly explicit by Keynes himself probably because he was mainly concerned with their practical implications. In any case they have been ignored in the subsequent literature, including most Keynesian economists, probably because, until very recently, it has been widely believed that there were not viable alternatives, at least of comparable rigour and analytical power, to the received decision theories which assume soft uncertainty and apply to a closed and stationary world. However in the last decade new decision theories have been worked out applicable to an open and evolutionary world characterised by hard uncertainty (important examples are Gilboa, 1987, and Gilboa-Schmeidler, 1989; an introductory survey may be found in Kelsey-Quiggin, 1992, or Vercelli 1998). They are not less rigorous than the received theories and have been successfully applied to economic problems, including those studied by Keynes briefly and partially recalled here (see, e.g., Simonsen-Werlang, 1991; Dow-Werlang, 1992a and b). A new continent has been opened where the ideas of Keynes on probabilistic causality, which were much ahead of his time, may be fully developed.

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