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THE ROLE OF FUNDAMENTAL UNCERTAINTY IN ECONOMICS AND DECISION-MAKING

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ABSTRACT
The subject of this paper is the direct influence of uncertainty on economic decisions. The first part is a historical overview of the use of probability as a decision-making tool. The second part explores points of connection between Keynesian economics and uncertainty. After the discussion of epistemological and ontological uncertainty, the substance of fundamental uncertainty is elaborated. A separate section is dedicated to the role of 'animal spirits', conventions and 'black swan' phenomena. The closing section focusses on atomic and organic interrelationships in the economic material, the relation between complexity and uncertainty, and with the triangle probability-uncertainty-econometrics.
The aim of the paper is to substantiate that uncertainty – whether it is termed 'fundamental', 'radical', 'irreducible' or else – is unavoidably and inevitably part of economic reasoning and decision-making.

*JEL codes:*B26, D81, E12, G00, G11

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Motto:

'One needs to exit doubt in order to produce science – but few people heed the importance of not exiting from it prematurely. […] It is a fact that one usually exits doubt without realizing it. […] We are dogma-prone from our mother's wombs.'

17th century philosopher *Simon Foucher* cited in *Taleb* (2007:153)

'In economics, it appears we exited doubts too often without realizing neither the doubt nor the fact that we were prematurely exiting it.'

Mennella, 2005/2006:69

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1 INTRODUCTION

The subject of this study is the direct influence of uncertainty on economic decisions. Uncertainty has acquired different names in economic discourse, such as 'fundamental', 'radical', 'deep', 'true' or 'irreducible'. (In our discussion, these adjectives will be used synonymously, without any difference in meaning.) As uncertainty is central to *Keynes*'s theory in his foundational economic works (*A Treatise on Probability* – TP and *The General Theory* – GT), we will draw heavily on his ideas.

Just like in Keynes's time, the world of today is permeated by non-measurable uncertainty instead of quantifiable stochastic risk. Fundamental uncertainty may be even more acute now than any time in the last few decades as we have entered an era in which politics once more tries to take control over economics in shaping market outcomes, without political variables being involved in prognosis.

In his book, *King* (2016) describes radical uncertainty as 'uncertainty so profound that it is impossible to represent the future in terms of a knowable and exhaustive list of outcomes to which we can attach possibilities.' It is pointed out that the concept of radical uncertainty is especially useful in describing the challenges of a world of polarisation, populism and politics.

As King (2016) also notes, it is not a new concept. Economist usually refer to it as 'Knightian uncertainty', a term introduced in Knight (1921), where he made a distinction between uncertainty and risk. The latter is quantifiable by attaching probabilities based on experience or statistical analysis, while uncertainty – which is essentially unmeasurable – may be represented as an unknowable unknown.

Knight (1921:223) called statistical probabilities that are not *a priori* or empirical 'true uncertainty', or referred to them as an 'estimate' or an 'intuitive judgment' in other instances. As he puts it, business decisions concerning production and the market, for instance,

> '*deal with situations which are far too unique, generally speaking, for any sort of statistical tabulation to have any value for guidance. The conception of an objectively measurable probability or chance is simply inapplicable*' (Knight, 1921:231)-

Feduzi–Runde–Zappia (2014) note that while Keynes (1921) did not explicitly make a distinction between risk and uncertainty, he addressed situations in which numerically definite probabilities can be determined (analogous with Knight's definition of risk) and situations in which only non-numerical representations are available (analogous with Knight's definition of uncertainty).

Just like Knight, Keynes argues that numerical probabilities are restricted to chance-based set-ups, where determination is based on equal probabilities as in

fair games of chance, or where statistical frequencies can be determined with more or less homogeneous trials. Apart from these examples, probability does not exist or cannot be determined numerically.

While mainstream neoclassical economics endorses Knightian risk measured by probabilities, it is proposed that

> '*for a "rational" man – all uncertainties can be reduced to risks [as] the feeling has persisted that [...] people tend to behave "as though" they assigned numerical probabilities [...] to [all possible] events*' (*Ellsberg*, 1961:645).

The aim of this paper is to substantiate that uncertainty – whether it is termed 'fundamental', 'radical', 'irreducible' or else – is unavoidably and inevitably part of economic reasoning and decision-making. In his major article, Mirowski's (1989) point of departure is that determinist models of neoclassical economics in the last third of the 19th century were based on analogies borrowed from physics[2]. But the very beginning of the 20th century ushered in a paradigm shift in physics. It culminated in the origination of quantum mechanics in the 1920s, prompting a move towards stochastic principles.

Neoclassical economics was faced with an important choice at the turn of the century:to stick with the determinism of physics, or to abandon it for the methodology of probability-based stochastic formalisation. *On the example of uncertainty, this paper offers – in addition to a textual analysis of primary sources – a historical reconstruction within a comprehensive contextual framework.*

To provide a plausible argument for the inevitability of uncertainty in decision-making, not only the primary forms of uncertainty and responses to them must be elucidated, but also its deeper theoretical roots. The underlying hypothesis of this paper is that uncertainty can be explained by the organic (as opposed to the atomic) nature of the economic system, the laws of complexity of the system and by interdependencies between economic agents.

The argumentation also seeks to show that to date, neither economics nor decision theory have provided any comprehensively reassuring answer to managing uncertainty. The discussion will reveal how Keynes's economic principles, based entirely on the assumption of uncertainty, come in conflict with the paradigm of econometrics. That conflict is undoubtedly connected to the problematic interpretation of the scientific status of economics. Keynes advocated that economics was 'moral science', separating it from the natural sciences.

2 Authors of the Marginalist Revolution of the 1870s mainly relied on knowledge from engineering, directly appropriating the formalisms of 19th century energy physics. Marginalists rephrased the physics of energy into the social mechanics of utility, embracing the determinist doctrine. As a result, classical determinism was set on a scientific footing (Mirowski, 1989:218).

2 A HISTORICAL OVERVIEW OF THE USE OF PROBABILITY AS A DECISION-MAKING TOOL

Marginalists (*Jevons*, *Walras*, *Edgeworth*) subscribed to determinism, conflating the notion of classical determinism with scientific explanation. Mirowski (1989) highlights that this also meant adherence to a static theory inasmuch the adoption of the metaphor of utility – as potential energy – was intertwined with the classical deterministic posture which equated scientific causal explanation with mechanical prediction. The neoclassical economists mentioned above adopted metaphors from physics for 'scientific legitimation', however, their deterministic conception had lost its appeal by the turn of the 19th to the 20th century[3].

Moore's (1903) relevant criticism is as follows:

> *'In the closing quarter of the last century great hopes were entertained by economists with regard to the capacity of economics to be made an "exact science". According to the view of the foremost theorists, the development of the doctrine of utility and value had laid the foundation of scientific economics in exact concepts, and it would soon be possible to erect upon the new foundation a firm structure of interrelated parts which, in definiteness and cogency, would be suggestive of the severe beauty of the mathematico-physical sciences. But this expectation has not been realized. […] The explanation is found in the prejudiced point of view from which economists regarded the possibilities of the science […]'* (Moore, 1914:84–85).

At the same time, Moore (1914) was sceptical about the mathematical foundation of economics, which is illustrated well by the passage below:

> *'It was assumed gratuitously that economics was to be modeled on the simpler mathematical, physical sciences, and this assumption created a prejudice at the outset both in selecting the data to be investigated and in conceiving the types of laws that were to be the object of research. Economics was to be a "calculus of pleasure and pain," […] a "social mechanics," a "physique sociale." The biased point of view implied in these descriptions led to an undue stressing of those aspects of science which seemed to bear out the pretentious metaphors. One would naturally suppose from this manner of conceiving the science that the economic theorists would at once have entered upon their task with the methods that had proved themselves useful in the physical sciences. […] They seemed to identify the method of the physical sciences with experimentation, and since, as*

3 Mirowski (1989: 222) calls it a curious aspect that Marginalists in the last thirty years of the 19th century (Jevons, Edgeworth, Bowley), and also Keynes from the beginning of the 20th were instrumental in the development of probability theory and statistics.

> *they held, scientific experimentation is impossible in social life, a special method had to be devised. This invention was a disguised form of the classical caeteris paribus, the method of the static state'* (Moore, 1914:85-86).

The distinctive features of individuals, such as 'motive' and 'intention' may disrupt the correspondence between economics and physics. Keynes also suggested that it is due to these attributes that economics is a moral and not a natural science (Keynes, 1973:CW XIV). His hypothesis was that economics deals with introspection, on the basis of motives, expectations and psychological uncertainties.

The passage below, cited again from Moore (1929:29), reinforces that the framework of classical economics was challenged by the new criteria of scientific inquiry, as a large number of empirical observations had substantial statistical demands, impinging on traditional 'ceteris paribus' conditions and static state theorems.

> *'Foremost among the causes of the sense of unreality are these:the method of proceeding by successive approximations in the approach to a theory of general equilibrium, which gives a feeling of an indefinitely postponed real solution; the use of the hypothesis of perfect competition with a meaning which does not accord with reality; the limitation of all conclusions to a static state, when, as a matter of fact, all economic phenomena are in a perpetual flux; the assumption of an immediate adjustment of changes, when in reality there are always lags and leads; the complexity of the functions that must be derived from reality and the absence of any known method of making the derivation […]'*

It must have been obvious to neoclassical economic theorists that *the laws of physics are changing*, that classical determinism had become untenable and also that the future of physics lay in statistical concepts (*Brush*, 1983:102). According to Mirowski (1989:220) neoclassical economics was supposed to *admit indeterminism* so that it could resonate with the evolution of physics, but without giving up its commitment to deterministic explanation and utility.

At the end of the 19th to the beginning of the 20th century, neoclassical theory was clearly motivated by the problems of determinism vs indeterminism, statics vs dynamics, and subjectivity vs objectivity, all bound up together as problems created by the original physics metaphor (Mirowski, 1989:228).

As *Baccini* (2016) marks, in contemporary economics, uncertainty is considered a part of decision theory, but that was not so evident at the turn of the 19th to the 20th century. In the reconstruction of the history of economic thought, *the leading role was not played by utility, but by probability.*

Cournot (1843) represents the classical approach to probability. He viewed mathematical probability as traditionally associated with games of chance and defined it as the ratio of favourable outcomes to the total outcomes. That leads gradually

to a strictly subjective interpretation of probability, depending on the status of individuals' imperfect knowledge (Cournot, 1843:438).

Cournot rejected the idea of expected utility, regarding it as 'arbitrary' and 'without real applications'. He was the first to point out that the main problem was not probability but expected utility.

De Morgan's (1838) conception of probability was also very different from that promoted by classical theory:

> *'Probability is a feeling of the mind, not the inherent property of a set of circumstances'* (De Morgan, 1838:7).

Probability in this sense differs from individual to individual, depending on the status of their knowledge and impressions.

Baccini (2016), relying on De Morgan, proposes that this enlargement of the notion of probability paved the way to its application to all 'questions involving loss and gain' (De Morgan 1838:103) and principally to problems regarding insurance offices, i.e. probability is not limited only to gambling but is applicable also to matters of 'commercial speculation' (De Morgan 1847:404). 'Moral expectation' derived from mathematical expectation also concerns 'the temperament of the individual'. As De Morgan writes

> *'[...] different persons will look forward in the same circumstances with different degrees of hope. One man will consider himself better off than before when he has bartered one pound certain for an even chance of two; a second will contemplate loss more strongly than gain, and will consider himself damnified by the exchange'* (De Morgan 1847:409).

At the same time, as De Morgan sees it, the main problem in practical applications arise not from the side of utility, but in connection with probability:when the probability of an outcome is very small, and benefits depend upon this vanishing probability *'the mathematical expectation is not a sufficient approximation to the actual phenomenon of the mind, even when the fortune of the player forms no part of the consideration'* (De Morgan 1847:409).

As the passages above illustrate, Cournot and De Morgan laid the basis for the theory of choice under uncertainty. *Schlee* (1992) showed that during the Marginalist revolution, expected utility was used to analyse a variety of decisions made under uncertainty, on the basis of the notion of marginal (decreasing) utility. But in light of the foregoing, this explanation is only partial. Some scholars in the last thirty years of the 19th century considered that probability did not belong exclusively to economics, and explored it in the context of ethics, psychology and philosophy (Jevons, 1874; Edgeworth, 1888).

Baccini (2016:5) revealed that behind all this, there was not only a new idea of utility, but also a logical theory of probability, first developed by Jevons (1874:200) who wrote that probability was the 'noblest creation of the intellect' as it

> *'deals with quantity of knowledge, an expression of which a precise explanation and measure can presently be given. An event is only probable when our knowledge of it is diluted with ignorance, and exact calculation is needed to discriminate how much we do and do not know'* (Jevons, 1874:199).

Unlike De Morgan, Jevons' idea that probability 'belongs wholly to the mind' (ibid., 198) does not mean that it is personalistic. On the contrary, it is the basis of 'rational expectation', obtained 'by measuring the comparative amounts of knowledge and ignorance' (ibid., 200).

An examination of the ideas of *Venn* (1888) and Edgeworth (1884) allows for a reconstruction of the history of the application of probability theory to decision theory (under uncertainty). The two theorists made a fundamental contribution to the development of the frequentist version of the theory of probability. It can be shown that while their positions are 'expressed with a somewhat opposite emphasis' (Venn, 1888:119), their theoretical stance is substantially the same.

According to Baccini (2001:767), Venn and Edgeworth both conceived of procedures of choice that are exercised essentially around individual cases. Therefore, their concept of probability obviously cannot be used as a decision-making instrument. On the other hand, it cannot be logically denied that a decision can be made on the basis of the expected utility under conditions that make it possible to apply probability coherently. But in fact, such ideal conditions are unrealistic, and therefore the field of application as well as the relevance of probability for choices under uncertainty is fairly limited.

If probability is defined as relative frequency, it may be considered (moderately) objective, as a property of things – however, in a peculiar way, as *it is a property of the series, and not of the individual events making up that series.* When choices as represented as being tied to single events – be they repeatable or not – probability can be of no help in the choice of actions.

In the second half of the 19th century, theorists of probability discussed the relationship between belief and credibility in detail. In *Bain*'s (1859) lesson, belief is defined as a mental state, associated with and characterised by a disposition to act. Along the same lines, Venn writes the following on belief:

> *'Whatever opinion then may be held about the essential nature of belief, it will probably be admitted that a readiness to act upon the proposition believed is an inseparable accompaniment of that state of mind. There can be no alteration in our belief […] without a possible alteration in our conduct, nor anything*

> *in our conduct which is not connected with something in our belief'* (Venn, 1888:143–144).

According to Bain (1859), belief is *preparedness to act*, and as such, a necessary condition for human action. To apply probability to decision theory, the relations between belief and probability must be defined properly. Following different strategies of reasoning, Venn and Edgeworth both arrived at the conclusion that probability is not a direct measurement of belief, i.e. it does not necessarily give rise to belief, and, as a consequence, it is not useful for the theory of human choice (Baccini, 2001; 2007).

According to Edgeworth's (1922) hypothesis, the measure of probability – derived from experience of relative frequencies – corresponds to the measure of credibility. That hypothesis actually upholds that the mathematical theory of probability deals with phenomena that are utilised for measuring credibility. However, probability is nothing more than the relative frequency of these phenomena. The result is that we simultaneously have a close passage between the phenomena (or better, the series), the statements of probability and the calculus, and the epistemic interpretation of the probabilities.

For *Bentham* (1789), probability calculation will always result in a unique precise, sharp and exact value. For him, the calculation of an outcome will also have a unique value. In this regard, Keynes states the following:

> *'But at any given time facts and expectations were assumed to be given in a definite and calculable form; and risks, of which, tho admitted, not much notice was taken, were supposed to be capable of an exact actuarial computation. The calculus of probability, tho mention of it was kept in the background, was supposed to be capable of reducing uncertainty to the same calculable status as that of certainty itself; just as in the Benthamite calculus of pains and pleasures or of advantage and disadvantage, by which the Benthamite philosophy assumed men to be influenced in their general ethical behavior'* (Keynes, 1937:213).

Keynes explicitly rejected Bentham's exact approach to probability. His rejection was based on the realisation that *only an inexact approach to probability would fit in with the knowledge available to decision makers in the social and behavioural sciences, economics, finance, business and law, as well as practical everyday decision-making.* This is especially the case with the decision to invest in long lived, durable, fixed capital goods or projects. All these clearly show a wide gap between the views of Keynes and Bentham.

Boole (1854) marks a different approach in proposing that many practical problems decision-makers have to deal with are incomplete and indefinite. He was the first to provide a clear distinction between indefinite (uncertainty) and definite (risk) probabilities. The possible causes of incompleteness and indefiniteness are

imperfect information, incomplete data and partial or complete lack of knowledge of the relevant factors. According to Boole, it is only in the standard mathematical theory of probability – which is based on statistics – that individuals can make a choice between the available options in possession of all the relevant data.

Carabelli (2017:33) points out with reference to Keynes ideas that the calculus of probability and mathematical Benthamite calculus are only applicable in restricted cases. Keynes is opposed to Moore's theoretical acceptance of the Benthamite consequentialist calculus, even though Moore rejected it in practice as it is impossible to calculate all the future consequences of an action. Keynes (1936) has expressed the strongest views on the subject in the GT:

> *'We are merely reminding ourselves that human decisions affecting the future, whether personal or political or economic, cannot depend on strict mathematical expectation, since the basis for making such calculations does not exist; and that it is our innate urge to activity which makes the wheels go round, our rational selves choosing between the alternatives as best we are able, calculating where we can, but often falling back for our motive on whim or sentiment or chance'* (Keynes, 1936:162).

As is clear from the above, by the turn of the 19th to the 20th century two roads have been delineated: the first one *shut out uncertainty* and expected utility from the professional toolbox of economists, limiting the use of probability to the narrow problems of gambling and insurance. The second road was concerned with *the application of probability*, including the *frequentist dead end* discussed earlier in detail.

These were the theoretical antecedents to the formulation of Keynes' probability theory (1921), by which he laid the groundwork for his economic theory. Keynes paid attention to shifts in science at the beginning of the 20th century disposing with mechanistic principles and determinism[4]. His apparatus of thought lay within the domain of reasons, grounds, evidence and arguments.

Keynes as a thinker essentially had a *critical orientation*. By the turn of the century, it was generally accepted among economists that utility is difficult to measure, and therefore, any interpersonal comparison of it is impossible. The theory of cardinal utility was hard to grasp, and accordingly, it was reluctantly accepted in economics which dealt mainly with ordinal utilities. In his foundational work on probability, Keynes (1921) attacked frequency theories of probability for their use utilitarian and cardinal (or statistical) notions (*Bateman*, 1991:55). Keynes

4 Keynes wrote his *Principles on Probability* in 1907, which is regarded as the precursor of his *Treatise on Probability*, finalised in 1909. His foundational work on probability (TP) was finally published in 1921.

was convinced that *probability was not an outcome of statistical frequencies, but a logical and rational-objective relation, which marks a significant departure from the relative frequency theories of probability.* Keynes' stance on probability was heavily influenced by contemporary philosopher Moore (1903), who was an opponent of utilitarianism. Keynes observed that Moore's conclusions rested on a frequentist theory of probability, in which probabilities are based on a sufficient number of repeated, uniform (class) observations (*Richard von Mises*, 1939). In frequentism, specific 'case' probabilities do not belong in an established 'class' of events and are unknowable *ex ante*. Drawing on Moore, Keynes recognised that the uncertainties of case-type actions can be avoided by following an institutionalised class-frequency of human actions.

3 THE BASIS OF KEYNESIAN ECONOMIC THEORY AND UNCERTAINTY

Businesses' need for external finance compels savers and company decision-makers to negotiate. Agents are compelled to acknowledge that ignorance and conjecture enter decisions, and that the value of existing capital assets is dependent on the market's view of their returns in the long term. The uncertainty permeating Keynesian economics issues from unsureness about the validity of the mode of argumentation that enters in the decision process. According to *Minsky* (1996), action involves a suspension of disbelief by both sides in the negotiations, and economic success fosters such a suspension.

In decision-making under uncertainty – in line with Keynes's (1936) emphasis – the elements determining long-term expectations often change; therefore, what happens in the economy at any time will be contaminated by market conditions that reflect actions determined by mental models that differ from the model that now guides expectation formation and therefore actions (Minsky, 1996:360).

Decisions to undertake and finance investments are important elements of Keynesian economics. In a basic version, an investment decision is viewed as an incentive for both the realisation and the distribution of aggregate income, with distribution viewed as being determined by the structure of demands and not by production function characteristics.

As to conditions influencing investment decisions, Keynes (1936:61) proposes that' *[…] there is the instability due to the characteristic of human nature that a large proportion of our positive activities depend on spontaneous optimism rather than on a mathematical expectation'.*

Keynes (1936) was a proponent of state intervention into fiscal policy and into the banking system through monetary policy etc., in order to sustain a stable level

of aggregate demand. He concluded that economies operate soundly if they are functionally in a state of equilibrium, i.e. if the level of aggregate demand and supply are equal. That state occurs when the savings of society equal planned investments at the level of the economy.

Lipsey (1992:289) points out that there is no reason why the amount individuals wish to save should be equal to the amount that firms wish to invest. That may be the reason why Keynes considered state intervention into aggregate demand and supply important for a stable economy. The rationale for intervention is that aggregate demand is influenced by a host of public and private economic decisions. As private decisions cannot be influenced, it is public and institutional decisions that should be fined-tuned with the instruments of monetary and fiscal policy (*Blinder*, 2008).

Skidelsky (2011) highlights that Keynes' picture of the economy differs from the classical as well as from the neoclassical view with respect to the *volatility of investment* and the rate of interest as an equilibrating mechanism. Instability of investment – according to Keynes – is due to the inescapable uncertainty about the future. Keynes equally clearly identifies probabilistic knowledge of the future as the key 'tacit assumption' behind the classical theory of the self-regulating market. Keynes (1937:219) regards investment as a completely unsuitable tool for the methods of classical economic theory, because *uncertainty dominates the investment process*.

King (2016) says – in agreement with Keynes – that economic decisions are made under conditions of 'radical uncertainty' – excluding the possibility of quantifying the future by attaching probabilities – and there is no such thing as optimising behaviour. The essence of the conventional Keynesian view is that in the face of permanent problems of equilibrium, a policy stimulating demand should be followed (King, 2016).

The generations of economists that followed after Keynes were more interested in formalising their discipline and constructed formally precise models of the economy based on the idea that probabilities can be attached to future events and outcomes based on observations from the past[5].

Often, real world economies are anything but stable or stationary. Economic and market forecasts are most often based on statistical models; however, it should not be forgotten – but is often ignored – that they rest on the assumption of 'structural

5 As an unfavourable outcome, the global financial crisis of 2008 led critics of mainstream economics to rediscover the idea that many future events are simply impossible to conceive of today and to capture in economic models.

stability'. But from time to time, substantial structural breaks do happen (*Fels*, 2016).

Patinkin (1976) finds it important to note that the central message of the theory outlined in the GT by Keynes (1936) and its analytical novelty is that changes in output act as an equilibrating force to bring aggregate demand and supply – or, equivalently, planned investment and saving – into equality at a level that need not be one of full employment (Patinkin, 1976:Chapters 8–9).

While Keynes establishes that in this regard, the economic system is not self-adjusting (1936:267), he writes the following on the equilibrating mechanism:

> *'The novelty in my treatment of saving and investment consists, not in my maintaining their necessary aggregate equality, but in the proposition that it is, not the rate of interest, but the level of incomes which (in conjunction with certain other factors) ensures this equality'* (Keynes, 1937:211).

Shackle's (1961:228) comment on Keynes (1937) article is included below to illustrate his stance on the notion of uncertainty in Keynesian economic theory:

> *'No reader of Keynes's article "The General Theory of Employment" [...] will be in doubt that Keynes looking back saw as the main theme of his book the commanding importance of uncertainty and of the conventions by which the insoluble problems it poses, and the nonsense it makes of pure "rational calculation," can be shelved in order to make life possible at all.'*

Keynes's well-known statement on uncertainty – which characterises the functioning of the economy so well – is as follows:

> *'[...] there is no scientific basis on which to form any calculable probability whatever'* (1937:214).

It is interesting that the word 'uncertainty' appears only in two instances in Keynes's (1921) foundational work on probability. The same is true to the GT, his foundational work of economics, in which he does not define the meaning of uncertainty. In the note below, which is the closest to a definition, he writes the following:

> *'It would be foolish, in forming our expectations, to attach great weight to matters which are very uncertain. It is reasonable, therefore, to be guided to a considerable degree by the facts about which we feel somewhat confident, even though they may be less decisively relevant to the issue than other facts about which our knowledge is vague and scanty. For this reason the facts of the existing situation enter, in a sense disproportionately, into the formation of our long-term expectations; our usual practice being to take the existing situation and to project it into the future, modified only to the extent that we have more or less definite reasons for expecting a change'* (Keynes, 1936:148).

In his foundational work on probability, Keynes (1921) aimed to revive the epistemological approach to probability to arrive at an interpretation which is *different from either chance or frequency*. Keynes (1921:4) conceives of probability as the degree of *power of the logical relationship* between two propositions, more precisely, the closeness of the conclusion to the evidence.

> *'The terms certain and probable describe the various degrees of rational belief about a proposition which different amounts of knowledge authorise us to entertain. [...] Between two sets of propositions, therefore, 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, 1921:3, 6–7).

It is in Keynes's work on probability (1921:103) that he fully distances himself from *the applicability of the classical and the frequentist notions of probability to economic decisions:*

> *'[...] the identification of probability with statistical frequency is a very grave departure from the established use of words; for it clearly excludes a great number of judgments which are generally believed to deal with probability.'*

The new logical theory of probability developed in (1921) is concerned with 'degrees of belief', which – *unlike* De Morgan's concept – is rational as it relies on given conditions of knowledge, and not merely with the actual beliefs of particular individuals, 'which may or may not be rational' (Keynes, 1921:4).

Keynes posits a direct relationship between probability, rational belief and action, in which having a belief signifies a readiness for action on the basis of that belief:

> *'[...] the probable is the hypothesis on which it is rational for us to act'* (Keynes, 1921:307).

As already outlined, *at the turn of the 19th to the 20th century, it was widely recognised that mathematical expectation and expected utility maximisation were not the right tools to solve problems of deciding between different alternatives.* Keynes had three serious objections against the theory of mathematical expectation, all three concerning probability. According to the *first*, probability is not fully measurable. The *second* is that mathematical expectation does not take into account the 'weights' of the arguments, i.e. the amount of evidence upon which probability is based. *Thirdly*, the element of 'risk' is fully ignored. The reason for this is that in respect of the expected value of a mathematical expectation

> *'an even chance of heaven or hell is precisely as much to be desired as the certain attainment of a state of mediocrity'* (Keynes, 1921:312).

Keynes adopts a rational–positivist approach in his theory of uncertainty, in which the world is innately probablistic (albeit not often in a strictly measurable

sense). According to Keynes, all behaviour rests on the – imperfect – basis of probability, and as such, rational behaviour is subject to the decision-maker's accumulated knowledge and ability to reason about probabilities. For Keynes, all propositions are probablistic and should be so treated. Given that, the matter of uncertainty is whether or not the decision-maker knows and rationally employs those the probabilities. Uncertainty, in Keynes's conception, is the absence of sufficient evidence to predictively determine outcome probabilities *a priori*, which has often been labelled 'ambiguity'(Ellsberg, 1961; *Dequech*, 2000).

In line with the above, *Packard* et al. (2021) establish that the Keynesian notion of uncertainty if entirely epistemic, i.e. all uncertainty is derived from limitations of knowledge or a lack of sufficient evidence. Accordingly, all outcomes are probablistic, and probabilities are embedded in the logical relationship between cause and effect. Consequently, uncertainty arises out of procedural ignorance (lack of knowledge) of these knowable (but often non-numeric) probabilities (*Dosi* and *Egidi*, 1991). In this respect, Keynes writes the following:

> *'To say, then, that a probability is unknown ought to mean that it is unknown to us through our lack of skill in arguing from given evidence. The evidence justifies a certain degree of knowledge, but the weakness of our reasoning power prevents our knowing what this degree is'* (Keynes, 1921:34).

In both the TP (1921) and the GT (1936), Keynes states that *exact, precise numerical probabilities are rarely accessible in the world of economic and financial decision-making* because of the paucity and flimsiness of relevant evidence available. Instead, 'non-numerical' probabilities must be used which incorporate what Keynes termed major 'weight of the evidence' deficiencies in *data, information, knowledge or evidence.*

Therefore, Keynes posits that expectations must be based on confidence or on the weight assigned to different events and alternatives. For Keynes, expectation is a matter of weighting the 'degree of belief' in a probability, which is very distant from stochastic probability distributions.

While individuals have to act now, the effects of their choices will only be known in the future, but all economic acts – at any given time – have intertemporal consequences. Economic operators must have a basis for their decisions, which may either be the recent past or the actions of others, but such frame of reference for choices is 'based on so flimsy a foundation [that] it is subject to sudden and violent changes (Keynes, 1937:214).

Keynes argues for the importance of uncertainty in decisions as follows:

> *'The theory can be summed up by saying that, given the psychology of the public, the level of output and employment as a whole depends on the amount of investment. [...] [Although these are not the only factors on which aggregate output*

> *may depend] it is those which determine the rate of investment which are most unreliable, since it is they which are influenced by our views of the future about which we know so little'* (Keynes, 1937:221).

Although Keynes did not define uncertainty in the TP (1921), *the category of uncertainty provides the theoretical and methodological foundation of Keynesian economics.* In light of that, it is just to say that *Lawson*'s (1985) interpretation of Keynes has enhanced our knowledge of the role of uncertainty. Lawson (1985:913) starts from the observation that Keynes departed from the frequency theory of probability and introduced in its stead *an indicator of the strength of the argument*, i.e. a probability relation between the evidence and the conclusion derived therefrom. Of the relation constructed by Keynes, Lawson (1985:914) writes the following:

> *'When knowledge is absent, propositions are cast into uncertainty in a situation characterised by lack of certainty'* (Lawson, 1985:914).

Uncertainty arises when probability relations are numerically indeterminate and non-comparable.

According to Lawson, uncertainty corresponds to a situation in which direct knowledge of the secondary proposition is absent. On this basis, uncertainty may arise in two ways:The first is when the relevant probability relation is unknown due to individuals' inability to argue from given evidence to the degree of rational belief it justifies in a proposition. The second is when there is no method for determining a numerical measure of the probability relation, namely when probabilities are numerically immeasurable and indeterminate (Lawson, 1985:913). While Lawson's emphasis on the two ways uncertainty may arise in is justified, we must also recognise Keynes's claim for information:

> *'[...] the degree of completeness of the information upon which a probability is based does seem to be relevant [...] in making practical decisions'* (Keynes, 1921:345).

Keynes's (1921) foundational work on probability leaves no doubt about *his aspiration to depart from the assumption of classical and neoclassical economics that decision-makers are perfectly informed and possess complete knowledge of the circumstances.* He believed that decision-makers have probablistic knowledge instead of absolute certainty. In his probability theory, he conceived of probability in the broadest sense possible, which holds even in light of the criticism – he himself made – of the applicability of his probability relation in practical decision-making. In this respect, Keynes writes the following:

> *'We must bear in mind that our theory must apply to all probabilities and not to a limited class only, and that, as we do not adopt a definition of probability which presupposes its numerical mensurability, we cannot directly argue from*

> *differences in degree to a numerical measurement of these differences'* (Keynes, 1921:36–37.)

For completeness, another statement of Keynes should be added:

> *'Many probabilities, which are incapable of numerical measurement, can be placed nevertheless between numerical limits. And by taking particular non-numerical probabilities as standards a great number of comparisons or approximate measurements become possible'* (Keynes, 1921:176).

Based on the above, Keynes clearly indicates that inexact numerical comparisons are better than simply establishing the impossibility of attaching cardinal numbers and deriving probability comparisons (*Brady*, 1993).

Keynes's (1921) approach to probability – even though it is based on rational-objective relations – reinforces that probability is closely connected to the realm of uncertainty. Probabilities are tied up with the unpredictability of unforeseeable events. This approach is reflected in the reappearance of uncertainty in Keynes's (1936) foundational work of economics and in treatises on 'fundamental uncertainty'.

As mentioned earlier, at the turn of the 19th to the 20th century doubts arose as to the applicability of mathematical expectation and expected utility maximisation in the moral sciences. *Keynes's rejection of expected utility was a symptom of the general scepticism towards the usefulness of mathematical methods in solving economic problems.* Keynes's contribution to the theory of probability is more plausible if it is regarded as an escape from both utilitarianism and the frequency approach.

We should also mention Edgeworth's review of one of the guiding principles of Keynes's (1921) foundational work on probability in which he recognises the relevance of individual cases:

> *'[...] mathematical expectation [...] is seen to be no longer a safe guide in the case of transactions which cannot be regarded as forming part of a "series" in Dr. Venn's sense'* (Edgeworth, 1922:277).

Clearly, Keynes – firmly footed in reality – was devising an epistemological method in which the information linked to individual cases – as the basis of personal choices – has much greater relevance than the statistical data available for the choice. In this regard, Keynes writes the following:

> *'The statistical result is so attractive in its definiteness that it leads us to forget the more vague though more important considerations which may be, in a given particular case, within our knowledge'* (Keynes, 1921:322).

The notion of logical probability that unfolds from Keynes's contributions on probability, however, does not resolve the fundamental problem of measurability,

which is also corroborated by his statement that *'probabilities do not all belong to a single set of magnitudes measurable in terms of a common unit'* (Keynes, 1921:85).

Keynes believed that *lack of known reasons (ignorance) and uncertainty are the two most difficult issues in economics.* Both are related to limited human knowledge. In her profound reflections, Carabelli (2017) points out that Keynes's notion of uncertainty is much more complex than mere ignorance. In her view, uncertainty issues from the intrinsic incommensurability of probabilities, and is related to Keynes's philosophy of measurement. *Intrinsic incommensurability is due not to lack of reasoning power or the practical inability to know or to measure (compare) probabilities, but rather to the nature of Keynesian logical probability itself.* The material of that probability consists of propositions and partial reasons, not empirical events.

According to Carabelli (ibid.), Keynes regards ignorance and uncertainty as the main causes of malfunctions in the market. Ignorance of the future and uncertainty are based on the incommensurability of probability and make it impossible for individuals to form reasonable judgements about the outcomes of their actions, or undermine confidence in individual assessments of immediate consequences. As a result, individuals fall back on average common opinions or take refuge in rules, routines and conventions (conventional expectations). *This is the root cause of the reluctance to invest, the consequent failure of the economy to exploit the full potential of available resources* and the speculative behaviour of those who, having above-average knowledge and skills, are able to exploit these behaviours to their advantage, which may *destabilise* the economy as a whole.

3.1 Epistemological and ontological uncertainty

The reader might have already realised that Keynes's writings on uncertainty are *fragmented*, and succeeding theorists of uncertainty were trying to reconstruct his ideas of uncertainty form these fragments.

As already cited from Packard et al. (2021), Keynes's notion of uncertainty is entirely *epistemic* by nature, and probabilities of this kind may be explored by learning the (probability) relations between causes and effects. Scientific efforts mitigate uncertainty by elucidating these probability relations and by producing exponentially growing evidential weight until all uncertainty is eliminated.

Carabelli (2017) corroborates the epistemological character of Keynes's idea of uncertainty by resolving the century-old *controversy* around the *subjective vs objective* nature of probability as conceived by Keynes. He argues that probability is contingent on the limited knowledge available of the circumstances (known partial reason, grounds or evidence), and varies along with them. The selection

of evidence, the process of abstraction by which the individual extracts reason, grounds and evidence judged relevant based on the total knowledge available to the individual, is *subjective*. But probability, given reasons, grounds and evidence, is *logical and objective*.

In certain situations, it is actually impossible to form reasonable judgements if no information about the thing is available, nor even about the present and the immediate future. According to Carabelli (2017:13), this situation represents a condition of total ignorance, in which there is no known reason, grounds or evidence. There is no probability or, if any probability exists, it is unknown. The situation of total ignorance is complemented by Keynes by another relevant situation:uncertainty, when probability exists but cannot be reduced to calculable risk.

De Finetti's (1938) appreciation of Keynes's scholarly commitment to the epistemic approach to probability was a landmark in probability theory. While differences between the objective perspective implicit in Keynes's logic of probability and de Finetti's subjective interpretation (de Finetti, 1938:63-84) were obvious, de Finetti endorsed it as he saw in it a revival of the epistemic approach to probability, overshadowed by the empiricist perspective of the frequentist interpretation of probability. He praises Keynes's interpretation of probability theory *as a logic of thinking* to determine the degree of uncertainty (of propositions or belief) at a given time when there is not enough information to judge them true or false.

Feduzi et al. (2014) reveal that de Finetti's favourable attitude towards Keynes's ideas is not limited to their connections in probability theory and the epistemic approach. de Finetti endeavours to investigate how probability theory could be transformed into a probability calculus. He concedes to rejecting the postulates that every probability corresponds to a number between 0 and 1, and that two probabilities are always comparable with each other.

It was the followers of Keynes who proved that in addition to epistemological uncertainty, ontological uncertainty also exists. Leading post-Keynesian theorist *Davidson* (2015:21) criticises mainstream neoclassical economics for teaching that '*immutable objective probability distributions govern past as well as future events.*'

Elsewhere, Davidson (2003:234) highlights that Keynes's concept of uncertainty reflects a future that is:

> *' [...] transmutable or creative in the sense that future economic outcomes may be permanently changed [...] by the actions today of individuals, groups and/or governments, often in ways not even perceived by the creators of change.'*

This is analogous to 'uncertain knowledge' in Keynes's interpretation:

> *' [...] I do not mean merely to distinguish what is known for certain from what is only probable. [...] About these matters there is no scientific basis on which to form any calculable probability whatever'* (Keynes, 1937:209-210).

Davidson (2009) and Skidelsky (2011) stress the crucial importance of uncertainty, emphasising that for Keynes, it also implies that *uncertainty cannot be modelled with a probability calculus.*

In *Dunn*'s (2001) view, problems of predicting the future are not due primarily to the cognitive limitations of agents or their lack of capacity to access or manage technology. The real cause is that the future constantly changes, shaped by the actions of agents (Dunn, 2001:578). Accordingly:

> *' [...] the agent does not choose from a given list of possibilities; he actually has to create the list [...]'* (Carvalho, 1988:66–81).

The arguments presented to justify ontological uncertainty – having the same role as fundamental uncertainty – relate to*' [...] unknowability of the future, to creative human agency and to the unique nature of unfolding time'* (Dunn, 2008:96).

In the GT, Keynes (1936) fully endorsed fundamental uncertainty and rejected any attempt at precisely predicting the future. Instead, with the creativity of the acts of investors new realities emerge as potential surprises (*Rosser*, 2001:547).

All things considered, propositions and decisions in models of *epistemic* uncertainty – regardless of the way in which the informed agent attempts to acquire knowledge of the given economic reality – *will certainly be based on incomplete information*. Uncertainty can be reduced by acquiring new knowledge of reality, but the complexity of the system prevents agents from acquiring full knowledge at any time (*Terzi*, 2010).

In models of *ontological* uncertainty, agents know that they are living in a constantly changing environment where the future is not predetermined by the past, and that no apparent regularity can be considered a permanent basis for a statistical anticipation of the future. Economic agents have no other choice but to resort to the past as the only source of knowledge, while being aware that *non-predetermined events and surprises are possible.*

The interrelatedness of epistemic and ontological uncertainty is phrased concisely below:

> *'Lack of determinacy is an ontological property of the universe we are considering. Imprecise knowledge is an epistemic property of the agents in that universe'* (*Brandolini et al.,* 2011:73).

Of the followers of Keynes, Shackle (1949) put forward a theory of decision-making that addresses circumstances of risk and uncertainty. His theory is unique in the sense that it does not assume any maximising behaviour. Shackle hypothesizes that – in situations of risk or uncertainty – every possible outcome of the decision is associated with a degree of potential surprise as to one outcome occurring rather than another. Each 'outcome–potential surprise' pair is ranked by their

power to stimulate thinking (stimulation is directly proportional to the plausibility of the outcome and inversely proportional to the degree of potential surprise). Shackle's theory was intended mainly to cope with *individual choices* that happen only once. Shackle – following Keynes – was clearly also in disagreement with proponents of the importance of frequency probability in decision-making. As proponents of the frequentist approach regard probability as a limiting value of the relative frequency of an outcome in many similar trials, Shackle questioned the applicability of notions of probability in the ordinary sense (e.g. within the framework of expected utility maximisation) to individual *choices*.

Mises, L. (1949) had very similar views about the substance of case-probability, assuming that case-probability and true uncertainty were identical:

> *'We know, with regard to a particular event, some of the factors which determine its outcome; but there are other determining factors about which we know nothing. Case probability has nothing in common with class probability but the incompleteness of our knowledge. In every other regard the two are entirely different'* (Mises, L. 1949:110).

In cases involving a lack of clarity (ambiguity), decision-makers cannot assign definite probabilities to every event as some information, which otherwise could be known, is missing. Ellsberg (1961) realised that the concept of 'ambiguity' is especially useful in referring to knowable but missing information. In his paper contextualising Ellsberg's conception of ambiguity, Zappia (2021) concludes that he considered it a mild form of uncertainty, which, however, does not imply that he had no interest in fundamental uncertainty. According to Zappia, Ellsberg, after re-exploring the relevance of Knightian ideas about uncertainty, went on to realise that his position is in fact closer to that of Keynes (1921) in the TP, and ascribed great importance to fundamental uncertainty in decision-making.

Before putting his probability scheme on the footing of formal logic, Keynes (1921:21) deliberately limited the scope of application of probability theory, and contested the generally accepted view that comparisons between pairs of probability are not only possible but are actually within our power. Keynes was of the opinion that degree of belief is numerically measurable only when the principle of indifference can be applied, and when equal probabilities can be assumed or it is possible to estimate statistical frequencies. Nevertheless, as Keynes notes (1921:29), in the majority of cases

> *' [w]hether or not such a thing is theoretically conceivable, no exercise of the practical judgment is possible, by which a numerical value can actually be given to the probability of every argument.'*

With his logical theory Keynes proved that probabilities – as opposed to what the frequency theory holds – may be derived not only statistically (*a posteriori*) but

also logically (*a priori*). Keynes (1939:561) reasoned that if 'à priori' probabilities are based on measurable phenomena, an important condition of their validity is that

> *'[...] calculating the relative importance of these measurable factors essentially depends on the assumption that [...] they are comprehensive.'*

According to Keynes, such an assumption holds when all economic problems are regarded significant with all their political, social and psychological factors, including the progress of invention and the state of expectation. He posits that logical probabilities are more credible, which, when we know the underlying 'probability-relations', are applicable also to individual events with no precedent. Consequently, a generic institutional rule of behaviour must be assumed relevant and beneficial over time despite the consistently unique circumstances of action (Packard et al., 2021).

The social determination of values plays a role in individual valuation that Keynes suggests is played by the uniformity of the human apparatus. That strategy of course has its own difficulties, as social values are many and compete with each other. Accordingly, they do not easily explain individual values.

By his analysis of the wide-ranging relationships between uncertainty and probability, Keynes had a major contribution to exploring the role of uncertainty in economics. Keynes eventually endorsed part of *Ramsey*'s (1922) criticism, in respect of logical differentiation. Analysing his own logic, he yielded to accept Ramsey's distinction between 'formal logic' and 'human logic' and the inclusion of his (also non-numerical) degrees of probabilities (referred to here as '*a priori* probabilities') in the latter. Keynes allowed for transferring the 'logical character' from the relational aspect of probabilities to a peculiar human one.

There have been other important gradations in Keynes's thought during the 1930s. *He moved away from objective probability relations toward a subjective interpretation of probability, to arrive at an intersubjective approach*, as he held that most individuals are unfit for forming any probability calculus. Keynes's (1936) GT informs the diminished importance attributed to the role of probability in decision-making, and animal spirits, reliance on conventional judgement and psychological considerations gaining ground. These factors are systematically presented in an article written by Keynes (1937) essentially for the interpretation and defence of the GT.

Initially, Keynes (1909) rejected the relevance of frequency probability and mathematical expectation for decision-making. Later, he sought for an effective decision-making tool to deal with situations of uncertainty by laying the foundations of the logical theory of probability. When writing the GT, he realised that analysing human behaviour on a purely logical basis (which he elaborated in the TP and its precursor) is not sufficient for understanding practical decision-making. In the

GT (1936:Chapter 12), Keynes draws on social developments, and the understanding of actual economic experience, building up a logic of conventions that had no trace in the TP. *Gerrard* (2003) is therefore right to state that Keynes did not reject his early thought on probability and uncertainty.

3.2 The substance and occurrences of fundamental uncertainty

In the GT, Keynes (1936) was fully in accord with the notion of fundamental uncertainty which removes any attempt at a precise prediction of the future under non-ergodic conditions. This must be considered jointly with the fact that with the creativity of actions by investors, new realities come up as potential surprises (Rosser, 2001:547).

Investment decisions under fundamental uncertainty are exposed to provisions issued by the prevailing institutions, which include (despite their limited nature) measures ensuring the liberalisation of the market, promoting stock-option strategies as well as the use of risk-management solutions by investors.

Keynesian fundamental or 'true' uncertainty is different from risk, although they are often conflated in mainstream neoclassical economic theory which posits that economic processes are governed by a stochastic process with a known and stable distribution, which is independent of individuals' actions, so risk can be reduced by aggregations of homogeneous agents (*Dymski*, 1993). By contrast, Keynesian uncertainty must be distinguished from any other probabilistic concept, as here, agents' play a role, although people cannot be fully aware of the impact of their actions (Dymski, 1993).

What the literature describes as fundamental uncertainty pertains to ' *[...] unknowability of the future, to creative human agency and to the unique nature of unfolding time*' (Dunn, 2008:96).

Based on the foregoing, *fundamental uncertainty can be defined as the probability of non-predetermined structural changes and states.* The elementary notion of fundamental uncertainty is grounded in social reality characterised as being subject to non-predetermined structural change. In this very elementary form, fundamental uncertainty is due to lack of knowledge resulting from such a characterization of reality. As a first refinement of this elementary notion, social reality is described as inhabited by potentially creative individuals. When this is made explicit, we arrive at the original definition of the notion of fundamental uncertainty provided above (Dequech, 2011).

Non-predetermined structural changes can typically be of a political, social, or cultural nature. They may have a significant impact on preferences, work rela-

tions, the bargaining power of workers and employers, or on government decisions. They also interact with economic innovations.

Non-predetermined changes may occur as the intended or the unintended consequences of people's actions, meaning that surprises may happen. The problem is not simply that there is not enough information to reliably attach probabilities to a given number of events. To an event that seems unimaginable – in the sense explained above – no probability can be attributed.

In general, without denying that decision-makers can still construct subjective probability distributions in situations of fundamental uncertainty, they must acknowledge the unknowability of a list of all possible events and the consequently *limited guidance* these probability distributions can provide (*Crotty*, 1994:113 puts forward similar arguments).

However, in cases of fundamental uncertainty, the notion of state of the world as it is usually constructed constantly assumes *creativity and unpredictable structural changes* caused by people's actions.

According to Fels (2016), King (2016) considers that radical uncertainty is pervasive and the probability models that economists, central banks and investors use are wrong. To cite King (2016):

> *'In a world of radical uncertainty there is no way of identifying the probabilities of future events and no set of equations that describes people's attempt to cope with, rather than optimize against, that uncertainty. […] In the latter world, the economic relationships between money, income, saving and interest rates are unpredictable, although they are the outcome of attempts by rational people to cope with an uncertain world'* (King, 2016:304).

In his memoir, former US Secretary of Defense *Donald Rumsfeld* (2011) writes the following:

> *'[r]eports that say something hasn't happened are always interesting to me because as we know, there are known knowns:there are things we know we know. We also know there are known unknowns:that is to say we know there are some things [we know] we do not know. But there are also unknown unknowns – the ones we don't know we don't know'* (Rumsfeld, 2011:xiv).

Consequently, he defines known unknowns as known *gaps in knowledge* in contrast to unknown unknowns which are gaps that we don't know exist. The basic idea is fairly clear:while there are many features of the world of which individuals do not know, there are probably others (known unknowns) of which they know they don't know anything about, and there are yet again others (unknown unknowns) of which they do not even know that they do not know them.

The crucial difference is not about the current state of knowledge of individuals and their individual gaps of knowledge. What is critically important is whether they take into account factors they do not know about. In the explanation of Feduzi et al. (2021) the difference is that *a known unknown is a gap in knowledge that an individual knows about and is aware of at the relevant time while an unknown unknown is a gap in knowledge that an individual is not aware of at that time, either because they do not know about that gap in knowledge or because, despite knowing of it, they are unaware of it.*

As Keynes's follower, Skidelsky (2011) proposes that the future cannot be predicted because it is 'open', which is in a large part due to its dependence on individual intentions and beliefs, and on the organic nature of human life. Keynes's thoughts on irreducible uncertainty do not reflect ignorance of such relevant probabilities but rather original ontological indeterminacy:some probabilities are not just unknown, but non-existent.

3.3 Animal spirits, conventions and 'black swan' phenomena

Carabelli (2017) notes that in Keynes's (1921) TP, decision-makers' choices were determined by 'caprice', while in the GT (1936) 'animal spirits', whim or chance took over the same role. In Carabelli's view, there is an important difference between the two. As fundamental uncertainty is irreducible and unavoidable, decision-makers must have been making attempts at managing uncertainty.

In his foundational work of economics, Keynes (1936) was quite explicit about his views about the drivers of decisions:

> *'We are merely reminding ourselves that human decisions affecting the future, whether personal or political or economic, cannot depend on strict mathematical expectation, since the basis for making such calculations does not exist; and that it is our innate urge to activity which makes the wheels go round, our rational selves choosing between the alternatives as best we are able, calculating where we can, but often falling back for our motive on whim or sentiment or chance'* (Keynes, 1936:162).

Another, closely related passage on animal spirits should also be cited here:

> *' [...] our decisions to do something positive, the full consequences of which will be drawn out over many days to come, can only be taken as a result of animal spirits – of a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities'* (ibid., 161).

Classical economic theorists overestimated the stability and self-regulating capacity of the market economy even in areas clearly characterised by uncertain

outcomes and where economic processes and decision-making was not guided by deterministic or causal laws. According to *Koppl* (1991:204), Keynes *introduced the term 'animal spirits'* to give emphasis to irreducible uncertainty and volatility of expectations, especially expectations about the expectations of others (mainly indeterminately) – and he did not receive much credit for the idea at the time. Animal spirits seemed a *diabolus ex machina*, an arbitrary element introduced to make the story come out wrong. But for Keynes, animal spirits stood for *a state of mind, an intuition, a belief or an urge.*

As opposed to the subsequent views of *Savage* (1954), Keynes established that subjective probabilities are generally non-numerical and therefore cannot be fitted – unproblematically – into the calculus of expected utility. Keynes (1937) wrote the following in this respect:

> *'About these matters [of uncertainty] there is no scientific basis on which to form any calculable probability whatever. We simply do not know. Nevertheless, the necessity for action and for decision compels us as practical men to do our best to overlook this awkward fact and to behave exactly as we should if we had behind us a good Benthamite calculation of a series of prospective advantages and disadvantages, each multiplied by its appropriate probability, waiting to be summed'* (Keynes, 1937:214).

Early on, Keynes was convinced that a fundamentally different concept of probability is applicable to the social sciences from that used in the natural sciences. He went even further and called for a more challenging concept of uncertainty. He thought that uncertainty was not merely non-numerical and non-comparable, like probability, but a 'savage concept' which encompasses animal spirits or *spontaneous optimism*.

According to *Shiller* (2021), Keynes (1936) conceives of 'animal spirits' or 'spontaneous optimism' as a major driving force in *economic fluctuations*. Creation of the term was partly motivated by the observations of Keynes and his contemporaries of human reactions to *ambiguous* situations where probabilities could not be quantified. According to Shiller (2021), the concept of animal spirits – defined by Keynes in a famous passage from his foundational work of economics (Keynes, 1936) – came to be central to his theory. Keynes explained that people face obstacles in making economic decisions due to the difficulty of predicting very far into the future, or trying to ascertain all the possible long-term implications of any economic decision.

Keynes believed that most uses of the term 'probability' lack an objective basis. As Shiller (2021) writes, on the problem of coping with uncertainty, similar terms were invoked by Keynes (1921) already in the TP, suggesting that something like animal spirits must play a role in decisions:

> *'If, therefore, the question of right action is under all circumstances a determinate problem, it must be in virtue of an intuitive judgment directed to the situation as a whole, and not in virtue of an arithmetical deduction derived from a series of separate judgments direct to the individual alternatives each treated in isolation'* (Keynes 1921:312).

A relevant comment by Knight (1921) reflects a similar viewpoint:

> *'We act upon estimates rather than inferences, upon "judgment" or "intuition," not reasoning for the most part'* (Knight 1921:36).

Keynes (1936) proposes that animal spirits inspire decision-makers to act on intuitive judgments in situations of uncertainty that were complex and ill-defined. Shiller (2021:2) identifies in this context the important role of *popular narratives* composed of individual stories. Shiller (2021:9) acknowledges the criticisms directed at the relevance of animal spirits and narratives on the basis of direction of causality, but such unclarities are present in much of econometrics today.

Conventions are another device of addressing uncertainty in Keynes's (1936) economic theory. In his conception, induction is regarded as a convention, of which he writes the following:

> *' [...] the present is a much more serviceable guide to the future than a candid examination of past experience would show it to have been hitherto'* (Keynes, 1937:214).

As another convention, Keynes stresses the testimony of the crowd:

> *'Knowing that our own individual judgment is worthless, we endeavour to fall back on the judgment of the rest of the [...] majority or the average'* (Keynes, 1937:214).

Along the same lines, Keynes (1936:150) says in the GT about the effect of *public opinion* that we follow the crowd, which itself relies on the opinion of experts, who are themselves trying to guess *'what average opinion expects the average opinion to be.'*

In most cases, having recourse to convention is the best that reasonable people can do in the circumstances. Rosser (2001) posits that there is no specific need for evoking the irrationality postulate to explain conventional behaviour. The assumptions of rational individuals maximise own utility in isolation from fellow individuals, which is always pointless in a world where *unpredictable events stand in our way.* Similarly, uncertainty explains the importance attributed to institutions, which build confidence and stabilise expectations.

Let us repeat that conventions on which investors fall back on when there is too much uncertainty in the market, especially those covering contracts, indicate the disciplining capacity of official institutions, which includes regulation.

> *'Especially in situations of uncertainty, government action may reduce it and thereby increase confidence'* (Rosser, 2001:547).

The opposite is the situation when institutions facilitate speculation in the market and thereby become responsible for the rise of instability.

The 'black swan' phenomenon, elaborated by Taleb (2007), is about the background and consequences of the occurrence of uncertain events. It refers to events characterised by three attributes, described as follows:

> *'First, it is an outlier, as it lies outside the realm of regular expectations, because nothing in the past can convincingly point to its possibility. Second, it carries an extreme impact. Third, in spite of its outlier status, human nature makes us concoct explanations for its occurrence after the fact, making it explainable and predictable'* (Taleb, 2007:xvii-xviii).

At the end of his book, Taleb writes:

> *'Remember that for an event to be a Black Swan, it does not just have to be rare, or just wild; it has to be unexpected, has to lie outside our tunnel of possibilities.'*

According to *Terzi* (2010), Taleb's (2007) description of black swan events as rare, consequential, unforecastable events expresses *how statistical risk differs from intractable uncertainty.*

Despite their similarity, Taleb's and Keynes's views of uncertainty are conflicting with respect to both method and consequences. Taleb considers that epistemic and ontological uncertainty are similarly applicable to black swan events, but his conclusions do not hold under the more extreme assumption of ontological uncertainty. On the other hand, there is a major difference in terms of the consequences of uncertainty. In Taleb's world, the possibility of surprises (identical with black swan events) is typically ignored by most agents. In Keynes's scheme, the possibility of surprises encourages agents to protect themselves from outlooks that may change adversely as compared to what may be envisioned based on past events.

Taleb (2007) asserts that very rare and highly consequential events that cannot be forecast by attaching probabilities to them may happen. Applying his arguments to the randomness of financial crises, he states that the impossibility of statistically forecasting large-impact events with small but incomputable probabilities should be accepted, especially because they are rare and we cannot collect enough data to calculate with such small probabilities. Similarly, a central element in Keynes's theory is the assumption that economic agents know they have to operate in an uncertain environment. Known past observations provide a sample too small to quantify the probability of extremely rare events.

Intractable uncertainty for Taleb means that there are outlier events that have a large impact on processes. As black swan events are incalculable, the best protection against uncertainty is to establish a robust – management, financial and competitive – system that is resilient to such events.

A significant body of knowledge has been accumulated about uncertainty in economics and economic decision theory. It led economists to *question the fundamental principles of classical economic theory assuming determinacy and perfect information, and to attribute greater importance instead to probability.* The logical approach to probability presented by Keynes (1921; 1936) seemed the only methodology that was based on argumentation and qualitative considerations and therefore able to avoid the logical fallacies bound up with frequency probability. The non-comparability of probabilities allowed *economists to get a grip on the world of the uncertain and to seek the root causes of irreducible fundamental uncertainty further.* For that purpose, we should study the atomic and organic dimensions of the material of economics and the role of complexity as a cause of uncertainty as well as Keynes's isolation from mathematical and statistical uncertainty.

3.4 The atomic and organic dimensions of the economic material

Keynes (1921) took a quite unique position on the relation of the different disciplines to uncertainty. In his foundational work on probability, Keynes (1921) pointed to important differences between perspectives on probability and uncertainty in the natural and the moral sciences. In his view, the former was based on the atomic, while the latter on the organic assumption. Keynes (1921:276) described the atomic assumption as follows:

> *'[...] the material universe must consist, if this kind of assumption is warranted, of bodies which we may term [...] legal atoms, such that each of them exercises its own separate, independent, and invariable effect, a change of the total state being compounded of a number of separate changes [...] Each atom can [...] be treated as a separate cause and does not enter into different organic combinations in each of which it is regulated by different laws.'*

Keynes (1924) had a strong opinion about the atomic vs organic controversy:

> *'The atomic hypothesis which had worked so splendidly in physics breaks down in psychics. We are faced at every turn with the problems of organic unity, of discreteness, of discontinuity – the whole is not equal to the sum of the parts, comparison of quantity fails us, small changes produce large effects, the assumptions of a uniform and homogeneous continuum are not satisfied.'* (Keynes, 1924, *'Essay on Edgeworth'*, CW X:262).

If we agree with Keynes that the world of economic or social relations is *organic rather than atomic*, it is obvious that lack of knowledge of the future is not always reducible to a question of mathematical risk. Identification of the future value of an economic variable – with its conditional expectation – is a clear example of 'statistical induction', which can only be applied if the atomic hypothesis is acceptable as a first approximation.

Credit should be given to Lawson (1985:909) for revealing that *Keynes drew a sharp distinction between the natural and the moral sciences, and questioned the applicability of the atomic hypothesis in the latter.*

Lawson's (1985) was one of the most successful attempts at an explanation for the contested application of probability in economics. He takes realism simply to be the view that there is an objective material world which exists independently of, but is knowable by, consciousness. An immediate feature of his realist viewpoint is a distinction drawn between knowledge on the one hand and a mind-independent material reality on the other. It allows the following question to be asked:are probabilities, as understood with economic analyses, a property of this external material reality, or are they only a property of knowledge? Or putting the question differently:are probabilities understood as objects of knowledge, or merely as a form of knowledge?

By atomic probabilities, Keynes had in mind intensive magnitudes capable of analytic measurement that were assumed empirically holding for the objects of natural sciences, such as physics, because the propositions about the occurrence of events were based on the premise of their independence:he referred to the underlying structure of the material universe inquired by the laws of natural sciences.

That – among others – is why Keynes was opposed to one of the basic tenets of classical economic theory:the assumption of the independence of economic variables. He writes the following in this respect:

> *' [...] methods of ' [classical economic theory] expressly assume strict independence between the factors involved and lose all their cogency and authority if this hypothesis is disallowed'* (Keynes, 1936:257).

The assumption of an atomic system Keynes considered *inherent* in the view of Nature cherished by classical Newtonian mechanics was clearly impossible for the organic reality embedding inductive arguments, such as moral scenarios and business decisions (Mennella, 2005/2006).

As Keynes (1921:276–277) put it:

> *' [...] there might well be quite different laws for wholes of different degrees of complexity, and laws of connection between complexes which could not be stated in terms of laws connecting individual parts.'*

Keynes sees this *irreducible* complexity as the reason why natural laws do not fit into the organic universe, which makes prediction impossible and foremost the reduction of the inductive method to mechanics. The social and economic material was naturally reflected in the general logical scheme and organic possibilities in Keynes's (1921) TP: they did not present themselves as either demonstrative or numerically definable propositions and were free of generalisations.

Keynes (1921:277) promoted that if the world we consider the social world is organic rather than atomic then the nature and methods of analysis should change, too. *He recognised that an important corollary of inductions based on the principles of limited independent variety and necessary connection which leads to the ontological position of atomic uniformity was the existence of a strict methodological individualism in the material world.* According to Keynes (1921:278–279), here, a relationship between parts and wholes is clearly defined whereby the individual, *a priori* parts define, but are not defined by, the whole:

> *'Given, on the other hand, a number of legally atomic units and the laws connecting them, it would be possible to deduce their effects pro tanto without an exhaustive knowledge of all the coexisting circumstances.'*

However, under organic conditions, rational inferences are less likely because there may not be a set of immutable premises which can be learned about with experimentation. Experience does not give us a better knowledge of those unique premises because the nature of those premises is not necessarily independent of the acts of knowing them. Or, in Carvalho's (1988) words:

> *' [...] some of the variables that work as premises may be influenced (but not necessarily determined) by the very decision the agent has to make in the present'* (Carvalho, 1988:74).

As Carabelli (2017:46) sees it, the problem of the relationship between parts and wholes, of organic interdependence between parts and ultimately of organic unities, as to probability, goodness, utility and economic magnitudes, cannot be avoided. She also raises the question of whether we risk falling into the fallacy of composition[6]. Logical fallacies lead us 'into error' in economic reasoning (Keynes, 1936:297). The relation between the parts and the whole is in fact to be connected, in addition to complexity and incommensurability, with fallacious probable inferences and causality.

6 Or more precisely, to 'fallacy of independence' or 'false independence' as Keynes (1921:191) also calls it in the TP.

Winslow (1986:421) suggests that after writing the TP, Keynes '*[...] explicitly abandons atomism in favour of organicism as the metaphysical description appropriate in the moral sciences generally and in economics particularly.*'

Nevertheless, it cannot be stated that atoms became insignificant. In Keynes's system, they assume the following role:

> '*[...] each of them exercises its own separate, independent, invariable effects, a change of the total state being compounded of a number of separated changes each of which is solely due to a separate portion of the preceding state*' (Keynes, 1921:277)

In Lawson's (1988:55) interpretation, the social world for Keynes is an organic system in which uncertainty is defined as a local and interactionist phenomenon. Keynes's early thinking informs the atomist and organicist principles jointly, each requiring the other to account for their respective proper applications. Keynes adopted a formation described by interdependence between individuals; something like societal interactionism, that might be captured by principles and laws that could be said to operate solely at the level of the whole. While it is necessary that an organic system display principles or laws operating solely at the level of the whole, their operation is not sufficient to determine the presence of an organic system. Atomistic systems themselves generally display principles or laws operating at the level of the whole which are not only compatible with the atomistic relation of their parts but are indeed instrumental to their functioning.

In his writings, Keynes repeatedly defended the place of economics among the moral sciences, since economic relations between individuals were organic in the same sense as he originally held that the individual mind is an organic unity. The GT does not discuss the atomicist vs organicist problem, but its line of argumentation is consistent with Keynes's earlier thought giving primacy to the organicist approach. *Keynes always considered the recognition and identification of interdependences between economic agents decisive.*

The importance of the atomist vs organicist distinction is that in economics, an organic arrangement assumes interrelationships between economic agents, factors and variables, and that *the thousands or millions of those interrelationships unavoidably increase uncertainty. Due to these diverging and intersecting relations, uncertainty is unexplorable and fundamental uncertainty is irreducible.*

3.5 Complexity and uncertainty

In the foregoing, the application of the atomicist vs organicist distinction to economics has opened up the possibility of exploring the numerous interrelationships between factors, variables and agents. Next, we will *examine the density of*

this mass of relations. In *Hodgson*'s (1997) view, in the context of complexity, two problems may be distinguished:one is due to large amounts of information, which Hodgson calls extensiveness, while the other one refers *'to the density of structural linkages and interactions between the parts of an interdependent system'*.

The latter one is what Hodgson (1997:668–669) calls *intricacy* (complexity).

In the understanding of Dequech (2011), both problems lead to the complexity of the decision-making environment, which may be managed relative to the agents' capabilities. For a limited number of agents, even a problem of a large amount of information without intricate interrelationships may be complicated. This statement is probably in line with the common usage of the term 'complexity.' A good example for that is *Hayek*'s (1989:3-7) statement below:

> *' [...] the social sciences [...] have to deal with structures of essential complexity, i.e., with structures whose characteristic properties can be exhibited only by models made up of relatively large numbers of variables. [...] A theory of essentially complex phenomena must refer to a large number of particular facts'* (Hayek, 1989:6–7).

As Dequech (2006:112–113) phrases it, reality is a complex phenomenon, populated by a limited number of individuals, involving the possibility of non-predetermined structural change and creative individual behaviour. A reality that is subject to non-predetermined structural change may also be complex and people who are creative may also have limited computational abilities. *A source of complexity in the functioning of the economy is the fact that the result of individual decisions is dependent on the decisions of others.* Such interdependence generates uncertainty about the consequence of someone else's actions. This is what happens even when a single logic underlies actions, just like in economics and in economic decision-making where the market logic is emphasised.

Dequech's (1999) paper discusses how the concept of uncertainty accommodate the complexity and mutability of social reality as well as the limits and creative potential of the individuals inhabiting it, and – in some cases – also the role of institutions and the features of the process of technological change.

Decision-makers trying to predict and manage uncertainty are faced with the problem in the epistemology of risk of how to deal with the limitations that characterize our knowledge of the behaviour of unique complex systems. That is why *Hansson* (2011) regards these significant for risk estimation and uncertainty management, e.g. within modern financial systems. These systems contain several *components and factors*, and so many *varying interactions* between them that they are unpredictable in practice. *Hoffmann* (2018) concludes that *deep, irreducible uncertainty emerges from highly organized and dynamic complexity.* For studying

the deeper causes of fundamental uncertainty, complex systems provide a useful example that may be applied to cases in economics.

In his classic and frequently cited article, *Weaver* (1948) distinguishes three significantly different grades of complexity, also requiring different mathematical treatment. He offers a classification with *'organised simplicity'*, a simple variant containing only a few variables (or a small number of relevant factors) *at one end of the spectrum*. *At the other end of the spectrum*, there is *'disorganised complexity'*, involving numerous variables. As is logical, *the third variant is 'organised complexity'*, positioned midway. The importance of this intermediary grade, however, does not depend on the fact that a moderate number of variables is involved, as opposed to multi-variable systems.

The typical feature of problems of organised and dynamic complexity lies in the fact that – in contrast to the disorganized situations which may be untangled with statistical or probablistic methods – they show the essential feature of organisation (Weaver, 1948:539). *Problems of investment, from the financial markets, the general market and sub-markets involving uncertainty in decision-making belong here.*

In problems of organised complexity, numerous factors are involved which are interrelated into an organic whole. Interactions and the *interdependences* resulting therefrom lead to the emergence of features that cannot be traced to the character of the individual parts of the system, and therefore cannot be captured by probability statistics or reduced to a simple formula. *Huberman* and *Hogg* (1986:376) identify the need for *profound logical and qualitative analysis* beyond mathematical analysis or the mathematics of averages and distributions.

Taking system complexity as a basis suggests that the applicability of probability theory does not only depend on the human action vs natural laws (or, phrased positively, human economic action vs inquiry by the natural sciences) dichotomy, but also from the degree of the complexity of the economic (market, sub-market) system where fundamental (deep) uncertainty arises from highly organised and dynamic complexity (Hoffmann, 2018).

Complex problems in biology, medicine, psychology, economics and political science are too complicated to arrive at a correct decision intuitively and to be successfully analysed by techniques used on one or few-variable problems.

The notion of fundamental (deep) uncertainty discussed in that article resembles the case-probability concept of Mises, L. (1949). Nevertheless, it may be established that deep uncertainty is broader in scope, i.e. case-probability is only a subset of fundamental uncertainty that arises from highly organised complexity. Minsky (1996) is right to state that uncertainty (or unsureness) is a deep property of decentralised systems in which *a myriad of independent agents make decisions whose impacts are aggregated into outcomes that emerge over a range of tomor-*

rows. Uncertainty about what the outcomes will be follows from the uncertainty with which agents hold the model that guides their actions.

3.6 Uncertainty, probability, econometrics

The line of neoclassical economics keeping pace with the paradigm shift in physics from the mid-1920s went down on an unknown path of economic inquiry by laying the foundations of econometrics. The new quantum mechanics developed by *Heisenberg*, *Born* and *Jordan* irreversibly changed the ontological position of stochastic concepts in the physical sciences (Mirowski, 1989).

Eddington (1935:77-78) described this new scientific development as follows:

> *'The formulae given in modern textbooks on quantum theory [...] are exclusively concerned with probabilities and averages. [...] But further it is now recognised that the classical laws of mechanics and electromagnetism [...] are simply the limiting form assumed by the formulae of quantum theory when the number of individual quanta or particles concerned is very large. This connection is known as Bohr's Correspondence Principle. The classical laws are not a fresh set of laws, but are a particular adaptation of the quantum laws.'*

New discoveries concerning the laws of quantum mechanics revealed that all deterministic laws were merely limiting cases of a more fundamental stochastic substratum. In this situation, neoclassical economists saw two possible choices. On one side, there were those who thought that the stochastic laws of economics cannot assume the same status as the statistical laws generated by the natural sciences. Theorists on the other side believed that econometrics is the right method of scientific inquiry in economics.

To complete the train of thought of this study, we must examine the second alternative.

Keynes's 1938-39 critical review of Tinbergen's multiple correlation analysis adds to his earlier discussion on atomism vs organicism (Keynes, 1973:CW XIX). His doubts centre upon *Tinbergen*'s (implicit) characterisation of the economic world as finite and atomic. While Keynes (1936) did not touch upon the atomism vs organicism dichotomy in the *General Theory*, the conclusions he formulates against the line of thought represented by Tinbergen are in accord with his relevant statements in the TP (*Davis*, 1989).

Upon reviewing Tinbergen's (1939) book, Keynes (1973) revisited his discussion of the atomist hypothesis in the TP. Here, a central *objection* of Keynes was directed against Tinbergen's assumption that forces operating in the economic world can be presumed *constant, homogeneous and independent*.

> *'There is first of all the central question of methodology, – the logic of applying the method of multiple correlation to unanalysed economic material, which we know to be non-homogeneous through time. If we were dealing with the action of numerically measurable, independent forces, adequately analysed so that we knew we were dealing with independent atomic factors and between them completely comprehensive, acting with fluctuating relative strength on material constant and homogeneous through time, we might be able to use the method of multiple correlation with some confidence for disentangling the laws of their action [...]'* (Keynes, 1973:286 CW XIX).

Keynes (1973:287 CW XIX) asserts that 'we know that every one of these conditions is far from being satisfied by the economic material under investigation' while it may be possible to *'cook a formula to fit moderately well a limited range of past facts', the character of the underlying economic material precludes any reasonable inductive argument about the future on the basis of these past statistics.*

Keynes's arguments explain why the economic material cannot be treated as constant and homogeneous through time, as would be required for the method of multiple correlation, and why it must rely more heavily on introspection and judgments of value for assessments of the strength and significance of these human factors. It is only through these methods that we can begin to explain how economic agents respond to situations in which the normal course of economic affairs is disturbed by the upheaval of war, politics or inventions (Keynes, 1973:309 CW XIX).

Therefore, Keynes states of multiple correlation analysis in his review of Tinbergen's book that

> *' [...] the method is only applicable where the economist is able to provide beforehand a correct and indubitably complete analysis of the significant factors. The method is one neither of discovery nor of criticism. It is a means of giving quantitative precision to what, in qualitative terms, we know already as the result of a complete theoretical analysis [...]'* (ibid., 309).

Economic experience is not sufficiently constant that one might apply the atomist hypothesis of uniformity and independence of economic events as one would in natural science. However, introspection and judgements of value still permit us to explain the *motives, expectations and psychological uncertainties underlying economic objectives that we know already as the result of a complete theoretical analysis.*

Keynes's proposition that economics is a moral science is solid proof that his critique of Tinbergen's ideas only means that the atomist approach is not generally applicable. Recognition of the predominance of the organicist reasoning indicates some refinement of Keynes's thinking (Davis, 1989).

If the methodological approach to probability has to reflect the nature of its own material, the same should be true to the approach to economics. *If the economic material is heterogeneous, organically interdependent, 'shifting' and uncertain', so should be the methodological approach to it.* The logic of probability reflects the nature of the material of probability; similarly, the logic of economics should reflect the nature of the economic material (Carabelli, 2017).

Already in the TP, Keynes's (1921) discussion of the philosophical premises of calculus point to a contrast between 'reasoning' and 'calculation', i.e. *between the principles of reasoning and the rules of calculus*, which remains a constant in his argumentation. In the TP, his critique of the applicability of the method of correlation in statistical inference follows the same approach:

> *'The controversial side of the method of least squares is purely logical; in the later developments there is much elaborate mathematics of whose correctness no one is in doubt. What is important to state with the utmost possible clearness is the precise assumptions on which the mathematics is based; when these assumptions have been set forth, it remains to determine their applicability in particular cases'* (Keynes, 1921:233).

This is an attitude which Keynes adopts in his critiques of the economic method in general and of Tinbergen's method in particular:

> *' [...] the difficult logical problems involved in applying to economic data methods which have been worked out in connection with material of a very different character [...] it leaves unanswered many questions which the economist is bound to ask before he can feel comfortable as to the conditions which the economic material has to satisfy, if the proposed method is to be properly applicable [...]'* (Keynes, CW XIV:306–307).

As mentioned before, Keynes regarded economics as a branch of logic, a way of thinking. Economists have to draw logically correct conclusions, *avoiding logical fallacies in reasoning.* The key point, according to Keynes, is that without this logic, economists may lose themselves in the empirical and mathematical wood. The problem – as Keynes (1936:298) saw it – is the application of mathematical and statistical languages – with their presuppositions of homogeneity, atomism and independence – to the economic material that is essentially 'vague' and 'indeterminate'. As Carabelli (1991:120) writes: *'[this] gives rise to logical fallacies:one of them being the fallacy of "ignoratio elenchi" in the classical economic theory.'*

In the GT, Keynes refers to mathematics as an 'imprecise' tool, meaning that the blind application of mathematics and statistics to economics, with its non-numerical, non-comparative and non-ordinal aspects, necessarily requires logical attention.

The assumption of the organic nature of economic relations, recognition of the uncertainty-inducing effect of complexity and limitations of the application of the methodology of econometrics makes uncertainty an integral part of economics and decision-making.

4 CONCLUSION

From the end of the 19th century, economics gradually shifted away from the classical and early neoclassical paradigms together with the metaphors borrowed from physics. This process was also fuelled by the appearance of probability and uncertainty among the factors considered in economics and decision-making. Quantum mechanics, the new paradigm in physics also found its reflection in economics in emerging econometrics. Keynes's theoretical and methodological standpoint is indicative of the *conflict in theory* arising during the 20th century instead of the development of a concept of uncertainty in an effective role, which culminated in the acceptance of fundamental (or deep, irreducible, true) uncertainty.

Keynes (1937:214) clearly stated that irreducible uncertainty is not attributable to unknown probabilities since they are intrinsically non-calculable in uncertain situations.

Keynes held that probability relations are intrinsically, essentially and qualitatively *incommensurable* or *indeterminate*. Carabelli (2017:6) – corroborating Keynes's argument – writes that 'the impossibility of a numerical measurement, of a quantitative comparison or of ordering of probability is not ascribed to the individual's incapacity, lack of knowledge or skill but to the nature of the material of probability itself'. Already in the first draft of the TP, Keynes (1907:53) writes that this impossibility, in this sense, is 'absolute and inherent in the subject matter', adding that probability is 'essentially' indeterminate, especially in the case of economic decisions, because there is no determinacy in its units of quantity, which belong to 'different kinds' of magnitudes of probability.

Carabelli (2017:7) also highlights that neither in probability nor in economics is comparison as a whole possible between 'complex or manifold' objects/phenomena. These objects/phenomena are characterised by an ensemble of qualitative attributes moving, in a non-proportional way, in different and *opposite directions*, such as time or space. These non-homogeneous complexes are characterised by heterogeneous attributes which not only move in different directions, but eventually belong to different dimensions.

Variation and change in economic variables are *not mechanical* but *qualitative* and *organic*. Time is not homogeneous and there is additional organic unity through

time. That is why the measurement and quantitative comparison of economic magnitudes through time is problematic. As with non-comparable probabilities, direct judgements, caprice or habits play equal roles in the case of incomparable economic quantities. Here, arbitrariness in choice does not imply total indeterminacy (Carabelli, 2017:45).

The conditions establishing equality or inequality between probabilities require that the material of probability should have characteristics of homogeneity. Keynes criteria of atomicity should also be mentioned, i.e. *independence, divisibility, finiteness, symmetry of alternatives and completeness.* Without these criteria being fulfilled, new fallacies would arise. Keynes (1921:33–34) stated that atomism cannot be applied to probability, since the material of probability, in addition to its lack of homogeneity, is not (in general) divisible into parts of similar character (as the degree of probability is not made up of homogeneous material).

Keynes (1921:32) was of the view that probability and its material, in general – except in limited cases – are non-atomic:

> *'A degree of probability is not composed of some homogeneous material, and is not apparently divisible into parts of like character with one another.'*

In line with Keynes, Carabelli (2017:47) asserts that the relation between the parts and the whole is *organic*. This means an internal rather than an external relation. Similar to the material of probability, the economic material is, in general – except for certain limited conditions – characterised by organic interdependence. The economic material is therefore organic (or partly organic) and indivisible.

Keynes may hardly be regarded as an atomist, especially based on his 1913 paper on the structure of the Indian financial system:

> *'I have tried to bring out the fact that the Indian system is an exceedingly coherent one. Every part of the system fits into some other part. It is impossible to say everything at once, and an author must need sacrifice from time to time the complexity and interdependence of fact in the interest of the clearness of his exposition. But the complexity and the coherence of the system require the constant attention of anyone who would criticize the parts. This is not a peculiarity of Indian finance. It is the characteristic of all monetary problems. The difficulty of the subject is due to it.'* (Keynes, 1913, CW I:181–182).

Keynes distanced himself from the paradigm of classical economics specifically because the assumption of 'independence from' implied logical 'irrelevance' (of changes in the value of money, in the level of output, in the level of income). A direct consequence of this irrelevance is the implicit generality of the premises:for all levels or values of the variables. But that would also mean *an implicit assumption of the mathematical theory of probability in economic decision-making, along with the 'atomic hypothesis', with all its quantitative and measurable attributes, i.e.*

numerical measurability, divisibility, time-reversibility, homogeneity, exhaustivity, completeness, permanent forces and primary qualities – all of which are in conflict with fundamental uncertainty.

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