UNIVERSIDAD COMPLUTENSE MADRID

FACULTAD DE CIENCIAS ECONÓMICAS
Y EMPRESARIALES

# MAINSTREAM MACROECONOMICS IN THE LIGHT OF POPPER

Iván H. Ayala
Alfonso Palacio-Vera

**Working Papers / Documentos de Trabajo.** ISSN: 2255-5471
DT CCEE-1404 Octubre 2014
**http://eprints.ucm.es/27128/**

**Aviso para autores y normas de estilo:** http://economicasyempresariales.ucm.es/working-papers-ccee
Esta obra está bajo una licencia de Creative Commons: Reconocimiento - No comercial.

# MAINSTREAM MACROECONOMICS IN THE LIGHT OF POPPER

**Abstract:**
Macroeconomics has been dominated over the last four decades by the Rational Expectations Hypothesis (REH) which implies that economies are inherently stable. REH is a key element of the New Neoclassical Synthesis (NNS) macroeconomic model which has also played a dominant role in theory and policy analysis over the last two decades. We analyse REH in light of Popper´s evolutionary theory of knowledge and learning. We claim that the latter provides macroeconomics with an epistemological and ontological foundation that, unlike REH, takes full account of human fallibility and upon which economists can build a more useful macroeconomic theory.
**Keywords**: knowledge, Learning, Rational expectations, Evolutionary, Popper.

# LA MACROECONMÍA ORTODOXA A LA LUZ DE POPPER

**Resumen:**
La macroeconomía ortodoxa ha estado dominada durante las últimas cuatro décadas por la llamada "hipótesis de expectativas racionales" (HER) que conlle-va el supuesto implícito de que las economías de mercado son inherentemente estables. A su vez, la HER constituye un elemento esencial de la llamada "Nueva Síntesis Neoclásica" en macroeconomía que también ha desempeñado un papel dominante tanto en la teoría macroeconómica como en la política económica durante las últimas dos décadas. En este trabajo analizamos la HER a la luz de la teoría popperiana del conocimiento y el aprendizaje y afirmamos que esta última dota a la teoría macro-económica de unos fundamentos epistemológicos y ontológicos que, a diferencia de la HER, incorporan plenamente el concepto de falibilidad humana y sobre los cuales los economistas pueden construir una teoría macroeconómica más útil.
**Palabras clave:** Conocimiento, aprendizaje, expectativas racionales, evolucionista, Popper.

**Materia:** Metodología de la Economía
**JEL:** A12, B41, B50

**Iván H. Ayala**
Facultad de Ciencias Económicas y Empresariales. Universidad Complutense de Madrid
E-mail: ivanhuascarayala@ucm.es

**Alfonso Palacio-Vera**
Departamento de economía Aplicada III (Política Económica)
Facultad de Ciencias Económicas y Empresariales. Universidad Complutense de Madrid
E-mail: apv@ccee.ucm.es

**Octubre 2014** (fecha de recepción)

Este trabajo ha sido editado por la Biblioteca de la Facultad de CC Económicas y Empresariales de la UCM, de acuerdo con los requisitos de edición que figuran en la Web institucional. Las opiniones expresadas en este documento son de exclusiva responsabilidad de los autores.

## INTRODUCTION

According to Woodford (2009), there has been a considerable convergence of views in macroeconomics over the last two decades. The evidence for such convergence is the observation of a cessation of methodological struggles within macroeconomics. More specifically, he recognizes that a New Synthesis emerged in macroeconomics over the last two decades or so. A key component of the alleged synthesis is the adoption by most macroeconomists of the 'Rational Expectations Hypothesis' (REH) as their natural way of modelling economic agents´ expectations formation. Likewise, Goodfriend and King (1997) argue that a New Synthesis emerged in macroeconomics in the nineties. They denote it as the 'New Neoclassical Synthesis' (NNS) model and note that REH is a key ingredient of it. More recently, Farmer (2013) has recognized that REH is a useful concept which, if applied carefully, can help us understand what went wrong in the recent financial crisis. This stands in stark contrast to those theorists who believe that contemporary macroeconomic and financial theory and, particularly REH, bears some responsibility for the occurrence of the recent financial crisis (Guesnerie, 2013, p. 50). Such critical evaluation of REH adds to criticisms made in the past by distinguished theorists including several Nobel Prize Awards in economics like Arrow (1978), Tobin (1981), Krugman (2009), and Stiglitz (2011). Criticisms focus on the notion that REH begs key epistemological issues such as how market participants acquire the knowledge they need to produce 'rational expectations' (RE). For example, Frydman and Goldberg (2013, p. 130) argue that 'REH has no connection to how even minimally reasonable profit-seeking individuals forecast the future in real world markets'. In a series of recent contributions, Frydman and Goldberg (2007, 2011, 2013) argue that economists´ belief in the efficacy of REH stems from the premise that they have discovered a universally valid way to capture how individuals make decisions. However, this basic presumption

has profound methodological implications. First, human fallibility is restricted to market participants´ inability to fully predict exogenous shocks. Second, models which fully pre-specify how the surrounding environment unfolds over time obliterate economic agents´ creativity. As noted in Phelps (2007, p. xv), it is *contradictory* to adopt the REH premise that whatever change takes place in the future is either known or knowable in the present since ―as Schumpeter argued― change and innovation are key features of capitalist economies. Third, by imposing onto macroeconomic models the restriction that market participants´ expectations coincide on average with the conditional forecast generated by the theorist´ model it turns out that fully specified macroeconomic models discard *by default* the possibility that economic agents´ beliefs *independently* affect outcomes in a way that model builders cannot fully pre-specify. Another way of saying this is that REH implies that, to the extent that economic agents´ beliefs are the product of macroeconomic theory, forecasting strategies are determined *jointly* at the individual and aggregate levels. In the wake of it, some theorists have argued that macroeconomic models that adopt REH lack plausible micro-foundations (Frydman and Goldberg, 2013). Last, but not least, it may be 'rational' not to behave as predicted by REH if market participants do not know the 'true' model, know that nobody knows it, and know that they simply cannot know it. Therefore, the question emerges as to what the appropriate notion of individual rationality is when the core above-mentioned premise underlying contemporary macroeconomics is dropped.

Now, we believe that the contradictions embedded in REH and the NNS model stem mainly from their flawed epistemological and ontological foundations. Therefore, if a substantial reorientation of macroeconomics is to take place in the future, the first task to address is to provide it with solid epistemological and ontological foundations. In view of this, the main claim we want to make is that Popper´s evolutionary theory of

knowledge and learning (PTKL) offers such solid foundations. In particular, and unlike macroeconomic models grounded on REH, PTKL presupposes that the 'true' model of the economy is *unknown* by economic agents and theorists alike and presumes instead that: (i) all knowledge is conjectural, (ii) it adaptation to the surrounding environment is always imperfect, and (iii) market participants´ decisions and actions may bring about irreversible changes in the former which they may not be able to fully anticipate. Further, PTKL implies that the main source of transformation in a complex adaptive system such as a market economy is the interaction between individuals´ conjectures and their subsequent revisions in the face of observed discrepancies between expected and realized outcomes. In short, we will argue below that PTKL provides contemporary macroeconomics with an epistemological and ontological foundation that, unlike REH, takes full account of human fallibility and places the latter at the centre of economic analysis.

The content of this essay is as follows. The following section contains a review of REH. We briefly expound PTKL in section II. We analyse REH in the light of PTKL and identify their differences in section III. In section IV we explore the main elements of a new conceptual framework for macroeconomics based on PTKL. Our focus will be on endogenous change, the ephemeral nature of macroeconomic equilibrium, the partial autonomy of expectations, and the notion of rationality that stems from PTKL. Finally, section V summarizes and concludes.

## I. THE RATIONAL EXPECTATIONS HYPOTHESIS

REH has been the dominant approach to modelling agents´ expectations in macroeconomics over the last four decades or so. REH can be viewed as an attempt to provide macroeconomics with a theory of expectations and beliefs formation that is *a*

*priori* consistent with the optimization hypothesis. We owe its first formulation to Muth (1961) who suggests that expectations should be modelled in a way that allows them to change *endogenously* when the structure of the system changes:

'I should like to suggest that expectations, since they are informed predictions of future events, are essentially the same as the predictions of the relevant economic theory… The hypothesis can be rephrased a little more precisely as follows: that expectations of businesses (or, more generally, the subjective probability distribution of outcomes) tend to be distributed, for the same information set, about the prediction of the theory (or the "objective" probability distributions of outcomes)' (Muth, 1961, p. 316).

Therefore, according to Muth (1961, p. 316), REH implies that economic agents´ subjective expectations are, on average, equal to the true values of the variables. In other words, it is only the *average* of economic agents´ forecasts that will be equal to the mathematical expectation of the variable. As a result of it, the forecast of a *given* individual may not coincide with the latter.[1] Yet, as Knudsen (1993, p. 153) observes, the reintroduction of the REH by Lucas entailed a reinterpretation of it. In particular, REH was now reinterpreted as implying that the expectations of *every* single agent were correct on average. The reason Lucas (2001, p. 13) characterizes REH this way is that, under the core premise that economists know the 'true' model of the economy, he interprets the systematic forecast errors made by those market participants who do not formulate their expectations according to REH as a symptom of irrationality on their

[1] However, Muth (1961, p. 317) notes that, for the purpose of analysis, he focuses on a 'specialized' or restrictive form of REH where it is assumed that: (i) the random disturbances that hit the economy are normally distributed, (ii) certainty equivalence holds for all the variables that are to be forecast, and (iii) the equations of the system are linear.

part.[2] Accordingly, the presence of significant but nevertheless unexploited correlations between market participants´ forecast errors and the information available to them was now interpreted as pointing to unrealized profit opportunities in real-world markets. As Lucas (2001, p. 13) puts it, 'if your theory reveals profit opportunities, you have the wrong theory'. This means that, in addition to the premise that the 'true' model of the economy is known or knowable, REH imposes two further requirements on economic models: 'substantive' rationality by *all* market participants and mutual consistency of market participants´ expectations.[3] For the purpose of this essay, a key issue is that REH is viewed by one of its most qualified proponents as requiring a high degree of stability and regularity over time of the phenomenon under study:

'Evidently, this hypothesis [Muthian rationality] will not be of value in understanding psychotic behaviour. Neither will it be applicable in situations in which we cannot guess which, if any, observable frequencies are relevant: situations which Knight called "uncertainty". It will most likely be useful in situations in which the probabilities of interest concern a fairly well defined *recurrent* event, situations of "risk" in Knight´s terminology… In cases of uncertainty, economic reasoning will be of no value… ' (Lucas, 1977, p. 15, term in brackets and emphasis added).

Thus, REH presumes that phenomena exhibit sufficient stability and regularity over time to allow economic agents to infer their stylized facts and attach probabilities to an exhaustive list of potential outcomes. In this respect, Lucas' position coincides

[2] Frydman and Phelps (2013, p. 6) argue that 'in a leap of faith that transformed macroeconomics and finance for generations, Lucas presumed that the right theory of capitalist economies, which arguably thrive on nonroutine change, is a fully predetermined model that assumes that such change is unimportant'.

[3] Simon (1976, p. 130) identifies human behaviour as being *substantively* rational 'when it is appropriate to the achievement of given goals within the limits imposed by given conditions and constraints'.

with that of Savage (1954), the father of expected utility theory, who defines 'small worlds' as situations of perfect knowledge where all alternatives, their consequences, and their probabilities are known for certain. Examples of 'small worlds' are hazard games such as lotteries and roulette. According to Savage (1954), these are the type of environments in which the application of Bayesian decision theory is legitimate. By contrast, he defines 'large worlds' as those environments where part of the needed information is missing or where the future is 'uncertain' in the sense of Keynes (1920) and Knight (1921). Crucially, Savage (1954, p. 16) insists that applying Bayesian theory to decisions in 'large worlds' does not make sense because there is simply no way to know all the alternatives, their consequences, and their probabilities. The regularity and predictability of economic phenomena that Lucas (1977) presents as the *sine qua non* condition for the presence of (neoclassical) economic reasoning thus implies that the environment is ergodic so that market participants can extrapolate into the future the empirical regularities inferred from the past. As Davidson (1991, p. 132) explains, for the REH to provide a theory of expectations formation, not only must the subjective and objective probability distribution functions coincide at any point in time for all market participant but they must also be derived from ergodic stochastic processes. The latter exhibit the crucial property that 'averages calculated from past observations cannot be persistently different from the time average of future outcomes'.[4] Thus, Lucas (1977) apparently accepts that some economic phenomena are non-ergodic but he suggests that economics should be concerned *only* with ergodic worlds.

[4] Specifically, if the stochastic process is ergodic, then for an infinite realization of it the time statistics will coincide with the space statistics. If the realization of the stochastic process is finite, time and space statistics will coincide except for the presence of random errors albeit they will tend to converge as the number of observations increases. Thus, if the surrounding environment is assumed to be ergodic, then statistics calculated from past time series or cross-sectional data will be reliable estimates of the space statistics that will occur at any future date.

Next, Lucas´ allusion in the quotation above to 'repeated instances of essentially similar events' suggests that, at least initially, he had in mind an inductive theory of knowledge acquisition or learning. However, an inductive learning theory is necessarily grounded on a 'cumulative' theory of knowledge. The latter implies that, as the amount of information collected increases over time, the probability that our hypothesis is true increases and converges asymptotically to unity. Yet, as Boland (2003) argues, both the 'cumulative' theory of knowledge and the inductive theory of learning are incompatible with Popper's philosophy. To be sure, according to Popper all knowledge is conjectural and, hence, no matter how much (finite) favourable empirical evidence we accumulate, the likelihood of a hypothesis being true does not increase. In any case, Lucas (1986) apparently adopted a somewhat different theory of learning later on. Specifically, when seeking to justify the optimization assumption he characterizes the situations on which economic theory focuses as the end-result of an *adaptive* learning process:

'Economics has tended to focus on situations in which the agent can be expected to "know" or to have learned the consequences of different actions so that his observed choices reveal stable features of his underlying preferences… Technically, I think of economics as studying decision rules that are steady states of some *adaptive* process, decision rules that are found to work over a range of situations and hence are no longer revised appreciably as more experience accumulates…' (Lucas, 1986, p. 218, emphasis added).

This quotation reveals some features of Lucas's later methodological approach which are not present in Lucas (1977). First, he seems to adopt a 'cumulative' theory of knowledge as he refers to the accumulation of experience. Second, he suggests that the

decision rules neoclassical economic theory deals with, namely, those decisions rules that stem from the implementation of optimization methods can be interpreted as steady states of an *adaptive* learning process. Although he does not elaborate on it the latter presumably consists of a trial and error-elimination process whereby economic agents make decisions which may then turn out to be right or wrong so that by discarding bad decision rules and retaining the good ones they eventually 'learn'. Such learning process bears some resemblance to PTKL in the sense of apparently being adaptive. However, as we will show below, such resemblance is superficial. Third, Lucas (1977) assumes that the learning process eventually converges to an optimal steady state. Specifically, he observed later on that those forecasting rules that are not based on REH will generate systematic forecast errors thus revealing the existence of *unrealized* profit opportunities, the implicit proposition being that if forecasting rules are based on REH an optimum will be attained and unrealized profit opportunities will not emerge (Lucas, 2001). As we will argue below, this represents an extreme position which requires that, at least, the following conditions are fulfilled: (i) the object of knowledge (i.e., the economy) must exhibit stability overtime, and (ii) the feedback mechanism connecting economic agents´ expectations and realized outcomes must be fast and accurate enough.

Finally, and crucially, Lucas apparently suggests that economic theory should be concerned solely with those decision rules that economic agents have adopted *after* the 'true' model has been found, the implicit assumption being that decisions made *prior* to its discovery do not have any repercussions on the economy, i.e., they do not affect the equilibrium. However, this logically requires either that the 'true' model exists *prior* to any decision made by economic agents or else that their actions simply do not affect the economy. Again, this feature of the 'learning' process alluded to in Lucas (1986) is linked to the ergodicity assumption referred to above in that a pre-existing reality that is

independent of economic agents´ beliefs, decisions, and actions can only be compatible with an ergodic environment.

## II. POPPER'S THEORY OF KNOWLEDGE AND LEARNING

Inductive inference is reasoning from the past observed behaviour of objects to their future behaviour. The 'problem of induction' was originally raised by David Hume (1748) who pondered whether inductive evidence can go beyond the available evidence in order to predict future events. He argued that past evidence can tell us about past experience only. Hume's main argument was that we cannot rationally justify the claim that nature will continue to be uniform merely because it has been in the past, as this is using the sort of reasoning (induction) that is under question, i.e., it would be *circular reasoning*. Hume (*op. cit*.) also noticed that we *tend* to believe that phenomena behave in a regular fashion, i.e., patterns in the behaviour of objects persist into the future.

Next, Popper defines the philosophical 'problem of induction' as the problem of providing a rational justification for the belief that the future will be (largely) like the past (Popper, 1972, p. 2). He identifies two problems in Hume´s criticism of induction: (i) a logical problem (*HL*), and (ii) a psychological problem (*HP*). First, Hume´s *HL* is whether we are justified in reasoning from repeated instances of which we have some experience to other instances of which we have no experience. Hume´s answer to *HL* is negative no matter how many repetitions of the instances there are. Second, Hume´s *HP* is why, notwithstanding it, all reasonable people believe that instances of which they have no experience at all will conform to those of which they have experience. Hume´s answer to *HP* was that 'the psychological mechanism of association forces them to believe, by custom or habit, that what happened in the past will happen in the future' (*op. cit.*, p. 90). According to Popper, this explains why Hume abandoned rationalism

and viewed man as a product of blind habit. By contrast, Popper argues that there is no such thing as induction by repetition either in psychology or science:

'We do not act upon repetition or "habit", but upon the best tested of our theories which… are the ones for which we have good rational reasons; not of course good reasons for believing them to be true, but for believing them to be the best available from the point of view of a search for truth or verisimilitude… The central question for Hume was: do we act according to reason or not? And my answer is: Yes.' (*op. cit*., p. 95)

Popper restates Hume´s problem of induction as follows. First, he denies that a theory can be simply justified by assuming the truth of certain observation statements. Rather, he insists that all theories are hypotheses and, hence, they can be overthrown (*op. cit*., p. 13). Further, he states that paradoxically induction is *inductively invalid*, that is, the claim that induction is a legitimate way to acquire (true) knowledge needs to be supported by a 'higher' principle that has, in its turn, been established inductively. But this strategy ultimately leads us into an *infinite regress* insofar as we will endlessly need to resort to a superior principle that has been discovered through induction. Second, he puts forward the proposition that the claim that an explanatory universal theory is false can be justified by the truth of certain observation statements (*op. cit*., p. 7). As the typical example goes, no matter how many white swans we come across, the finding of just one black swan will lead to the rejection of the universal statement 'all swans are white'. Consequently, he urges scientists to construct *severe* tests that help detect false theories so that, by a method of *elimination*, they may eventually hit upon a true theory

even though we can never establish its truth (*op. cit*., pp. 14-15).[5] Thus, he argues that there is an *asymmetry* between verification and falsification; any conjecture may be true or false but even if it turns out to be true, there is no way we can *ever* prove it (*op. cit*., p. 12). According to Popper, the method of science is 'the method of bold conjectures and ingenious and severe attempts to refute them' (*op. cit*., p. 81). Since all theories involve universal statements, we can only 'learn' by proving that our knowledge is false. Specifically, learning takes place either when we reject one´s prior theory or when we are forced to adjust one´s theory in a way that recognizes that in its prior version it was false (*op. cit*, p. 81). As Boland (2003, p. 242) notes, an implication of Popper´s theory of learning is that the mere accumulation of information does not increase the likelihood of our theories being true because all we can 'learn' from experience is that our theories are false.

Third, Popper argues that theories are genetically incorporated into all our sense organs and this predisposes us to discriminate *a priori* between relevant or absorbable input and input that can be ignored (Popper, 1972, p.72). For instance, sense organs like the eye *only* react to those selected environmental events which they 'expect'. However, according to him, this prior knowledge cannot be the result of observation; it must be the result of adaptation to the surrounding environment by trial and error. He claims that 99 percent of the knowledge of all living organisms is inborn and incorporated into our biochemical constitution (Popper, 1990, p. 46). Further, he argues there is no theory-free language to help us interpret data because primitive theories emerge together with language. Thus, there is no such thing as pure perception since all languages are *theory-impregnated* (Popper, 1972, p. 145). This leads him to reject any epistemology which chooses our 'direct' observations and perceptions as the starting point; the fact that

[5] Popper adopted Tarski´s theory that truth is correspondence with the facts or with reality (Popper, 1972, p. 44).

theories are built into our sense organs thus implies that 'the epistemology of induction breaks down even before taking its first step' (*op. cit*, p. 146).

Finally, Popper´s rejection of Hume´s *inductive* theory of beliefs formation leads him to argue that 'logical' considerations may be transferred to 'psychological' considerations. According to him, not only do we reason rationally and thus contrary to the principle of induction, but *we also behave rationally*. He labels this the 'principle of transference' (*op. cit*, p. 6). By applying this conjecture to human psychology he arrives at the method of *trial and error-elimination* in which the trials correspond to the formation of competing hypotheses whereas the elimination of errors corresponds to the refutation of (false) hypotheses. In other words, he proposes the theory that individuals do not really think in an inductive way but rather form their beliefs by eliminating false hypotheses. The theory of knowledge and learning that emerges is thus *evolutionary*. Such theory also implies that adaptation is always 'imperfect':

'Some of the errors that have entered the inheritable constitution of an organism are eliminated by eliminating their bearer; that is, the individual organism. But some errors escape, and this is one reason why we are all fallible: our adaptation to the environment is never optimal, and it is always imperfect' (Popper, 1990, p. 47).

Further, Popper asserts that *no equilibrium state of adaptation* is reached by the application of the method of trial and error-elimination since (i) no optimal trial solution to any specific problem is likely to be offered, and (ii) the emergence of new structures and instructions involves a continuous *change* in the environmental situation (Popper, 1994, p. 4). Specifically, there is the idea we will discuss below that Popper views the growth of knowledge as bringing in its wake changes in the surrounding environment:

'Our very understanding of the world changes the conditions of the changing world; and so do our wishes, our preferences, our motivations, our hopes, our dreams, our fantasies, our hypotheses, our theories. Even our erroneous theories change the world, although our correct theories may, as a rule, have a more lasting influence. All this amounts to the fact that *determinism is simply mistaken*' (Popper, 1990, p. 17).

In short, Popper makes clear that the past *affects* but does not determine the future, i.e., the future is not pre-determined. Hence, the future is 'objectively open' (*op. cit*., pp. 17-18). As we will argue below, this position is in conflict with REH since the former logically implies there is a pre-existing reality that is independent of economic agents´ decisions and actions.

## III. THE RATIONAL EXPECTATIONS HYPOTHESIS VERSUS POPPER

In this section we examine REH in the light of PTKL. Our purpose is to identify the key differences between them in order to substantiate the claim that PTKL provides more solid epistemological and ontological foundations upon which macroeconomists can build a more useful macro-theory. In particular, we argue below that REH diverges dramatically from PTKL in three key respects: 'learning', the nature of knowledge, and the approach to human behaviour.

### *Is 'learning' possible under REH?*

The main contradiction REH encounters when viewed in light of PTKL is that the former does not allow economic agents to select the 'true' model. To be sure, PTKL implies that we can *never* know whether a given hypothesis is 'true' and, hence, the

assumption that economic agents somehow get to know the 'true' model is fallacious. First, if we follow Popper no matter how many models are tested and subsequently replaced, there is simply no way we can know whether the model we use for predictive purposes is 'true'. By the 'true' model we mean, of course, the model that produces unbiased estimates. This is not only because there is no such thing as an inductive logic but also because, as Popper explains, any model is always an *over-simplification* and, in that sense, false (Popper, 1994, p. 166). Consequently, all we can obtain is a model that produces 'better' estimates than other models in a *particular* historical and institutional context — and even this may be hard to achieve due to the practical problems posed by the Duhem-Quine thesis — but this does not prove that our model is 'true'. In other words, we can never prove that a model is 'true'. Thus, REH is a misnomer. It is not really a hypothesis; it is an assumption.

Second, let us assume for the sake of convenience that market participants know the 'true' model so that their forecasts are unbiased on average and, hence, they do not make systematic errors, i.e., their errors do fall on a bell-shaped curve around the 'true' value. Now, if all errors are random economic agents will not be able to 'learn' from them in the sense that they will not be able to adapt their knowledge in the aftermath of a change in the surrounding environment that brings about a change in the 'true' model. To be sure, PTKL implies that we 'learn' by eliminating our non-random errors. That is, error-elimination requires that realized outcomes diverge *systematically* from expected ones. Random errors average out to zero in the long run and, hence, they cannot be a basis for 'learning'.[6] Another way of putting this is that if an economic agent makes a random error in a period and makes different ones in subsequent periods in the wake of new shocks, *she will not be able to discern a systematic pattern in error-making* and,

[6] Under REH forecast errors stem only from the occurrence of 'exogenous' random shocks since the model that generates forecasts is assumed to coincide with the 'true' model.

hence, she will be unable to revise her expectations so as to avoid making further errors in the future. Consequently, error-elimination cannot take place if all errors are random. Now, if the environment changes in a way that the 'true' model also changes economic agents will need to learn the new 'true' model. Otherwise, their errors will not remain random. According to PTKL such learning can only be the result of a process of trial and error-elimination. But, as we argued above, if such a process is to come about errors must occur systematically. Yet, the latter are precluded by REH. Therefore, REH lacks a truly learning mechanism grounded on a trial and error-elimination process as posited in PTKL. The only mechanism it can rely on to justify the assumption that economic agents know the 'true' model is a simple extrapolation into the future of data obtained from the past. This explains why Lucas (1977) rightly suggests that REH only applies to situations of 'risk'. Consequently, if REH is to remain internally consistent its advocates need to assume that: (i) market participants do not need to learn the 'true' model, they simply know it, and (ii) the surrounding environment is ergodic so that the 'true' model does not change throughout. In such environment the only possible source of fallibility will be market participants´ inability to *fully* predict future 'exogenous' random shocks.

***Can our knowledge ever be 'optimal'?***

Now, REH implies that market participants´ knowledge is perfectly adapted to the surrounding environment so that, as noted above, the only source of fallibility they are subject to is their inability to fully anticipate all the 'exogenous' random shocks that will hit the economy in the future. By contrast, PTKL implies that the learning process market participants go through *never* results in an optimal adaptation to the surrounding environment (Popper, 1994, p. 4). In particular, Popper emphasizes that the process of adaptation to the latter is often successful and often unsuccessful owing to the fact that

some errors will inevitably *escape* and this possibility is one of the reasons why we are fallible (Popper, 1990, p. 47). Therefore, and due to the less than complete elimination of errors the adaptation of our knowledge is always *imperfect*. It follows that observed states of adaptation of knowledge cannot be the result of convergence to an optimum. Should *all* errors be purged, the process of adaptation to the surrounding environment would be perfect. At that stage, our knowledge would be fallible *only* to the extent that changes in the surrounding environment cannot be fully anticipated. As we noted above, this is the scenario implied by REH. By contrast, PTKL has it that our errors may also be systematic insofar as our conjectures may be false.

***Is the future 'objectively open'?***

Lucas (1977, p. 15) argues that Muthian rationality 'will most likely be useful in situations in which the probabilities of interest concern a well defined *recurrent* event, situations of 'risk'. The latter correspond to environments in which individuals can infer the empirical regularities observed in the past and extrapolate them into the future. We argued above that the 'learning' process Lucas (1986) has in mind only makes sense in situations where the environment is ergodic. The reason is that, as we explained above, REH is logically inconsistent in a non-ergodic environment due to the absence of a truly learning mechanism. Now, the ergodicity assumption logically implies that the actions undertaken by market participants during the 'learning' process both before and after expectations become 'rational' do not affect the RE equilibrium. But, if so, this will also imply that the latter somehow exists *prior* to the start of the 'learning' process, i.e., it is pre-determined. In short, REH implies a deterministic world in that the future is a mere statistical reflection of the past. But, in that world human action is unduly constrained. Specifically, only actions that bring about *routine* change are allowed. Thus, by stating

that REH only applies to situations of 'risk' (or 'small worlds') Lucas (1977) restricts its validity to a deterministic and, hence, ergodic world. In such a world, there is hardly any room for fallibility. By contrast, Popper posits that the world is not 'deterministic'. He defines the latter as one where there is 'no room for human decision' (Popper, 1990, p. 7). It is only in a non-deterministic and not pre-determined world that macro-theory can fully account for human fallibility.

## IV. A NEW CONCEPTUAL FRAMEWORK FOR MACROECONOMICS

In this section, we will argue that PTKL provides macroeconomic theory with a conceptual framework that can be shared by a wide range of theoretical approaches. Our starting point is the idea that economic agents´ decisions require the previous formation of expectations. Let us think of the relation between expectations and realized outcomes as a *negative* feedback mechanism whereby economic agents systematically revise their expectations in the wake of observed discrepancies between expectations and *ex-post* realizations. In principle, if the object of knowledge about which economic agents form expectations is ergodic and the feedback mechanism is fast and accurate enough then the systematic operation of a trial and error-elimination mechanism should allow their expectations to converge to equilibrium. As we suggested above, this appears to be the scenario contemplated in Lucas (1986).

Now, for the purposes of this essay PTKL envisages an evolutionary process of change driven mainly by the interaction of two different feedback mechanisms. The first one relates economic agents´ expectations and *ex-post* realizations. As explained above, it is a negative feedback that allows economic agents to revise their expectations in the face of perceived discrepancies between the former and the latter. An implication of PTKL is that this feedback mechanism is *imprecise* insofar as some errors will escape

so that, even if the surrounding environment is constant, expectations will not converge to an optimum. The second feedback mechanism stems from the impact upon the object of knowledge (e.g., a market economy) of market participants´ decisions and actions. Popper posited such mechanism in his *Poverty of Historicism* (Popper, 1944, p. 89) and denoted it as the 'Oedipus effect' after Sophocles´ *Oedipus the King* tragedy. The sign of this second feedback mechanism is ambiguous. If it is *negative*, economic agents´ decisions will bring about changes in the surrounding environment that tend to narrow the gap between *ex-ante* expectations and *ex-post* realizations. Thus, if the number of iterations is large enough and the (negative) feedback mechanism driving the revision of expectations is fast and accurate enough, the gap between *ex-ante* expectations and *ex-post* realizations will eventually disappear. This case corresponds to the case known in the economic literature as the case of self-fulfilling prophecies.[7] By contrast, if the sign of the feedback mechanism is *positive* economic agents´ decisions will cause changes in the surrounding environment that *widen* the observed gap between *ex-ante* expectations and *ex-post* realizations. In this second scenario market participants´ expectations will *not* converge to equilibrium.

Now, Soros (2013) denotes this second feedback as the 'principle of reflexivity' and places it together with the 'principle of fallibility' at the centre of a new conceptual framework allegedly aimed at replacing dominant thinking in economics based on REH and the Efficient Market Hypothesis. As Soros (2013) himself admits, his conceptual framework is inspired by Popper´s philosophy and, hence, it exhibits many similarities with the one being proposed here. Yet, a number of differences remain. Specifically, Soros (2013, p. 323) argues that REH represents a *limiting* case within the conceptual

[7] According to Merton (1948, p. 195) a 'self-fulfilling prophecy' is an initially false definition, conception or interpretation of the situation that evokes a new behaviour which makes the originally false definition come true.

framework he proposes. According to him, such case is characterized by the facts that (i) market participants´ revision of expectations can go forever, and (ii) there are no significant changes in the surrounding environment. By contrast, we think that REH is incompatible with PTKL owing to the facts that: (i) all knowledge is conjectural, and (ii) REH lacks a truly learning mechanism that allows market participants to get to know the 'true' model. In the rest of this section we seek to identify the elements of a new conceptual framework for macroeconomics grounded on PTKL.

***Endogenous change***

Let us start by saying that the adoption of REH in macroeconomics *precludes* the exploration of the hypothesis that important malfunctions of market economies are the outcome of *systematic* errors in the formation of economic agents´ expectations. If REH is adopted, phenomena such as financial crisis or aggregate output fluctuations can only be ascribed to the occurrence of 'exogenous' random shocks. Let us dwell on this point. When assuming that economic agents do not make systematic mistakes advocates of REH are also compelled to assume that the economy is hit by 'exogenous' shocks. If expectations are assumed to be 'unbiased' then shocks can only be deemed random and 'exogenous' insofar as economic agents can fully anticipate any troubles lying ahead stemming from endogenous forces and act consequently. Further, REH implies that agents' mistakes always occur *after* the shocks have hit the economy in the sense that they are 'caused' by them. Now, if we put these two elements together we have that REH implies that economic agents *never* make mistakes other than those ones induced by random and 'exogenous' shocks and, consequently, non-random mistakes cannot be a source of instability. For instance, aggregate output fluctuations can only be ascribed to factors 'external' to the economy such as abrupt political changes, 'natural' disasters,

and technological revolutions. In short, REH biases macroeconomic theory by ruling out *by default* the possibility that macroeconomic instability is endogenously generated and, by doing so, it restricts itself to a 'small world' in the sense of Savage (1954).[8]

***Evolutionary approach***

Next, if contemporary macroeconomics is to fully account for human fallibility it needs to adopt an *evolutionary* approach. Several traditions in economic theory have adopted such an approach in the past, some examples being the (Old) Institutionalist School of Veblen and Commons, the Austrian School of Schumpeter, Von Mises, and Hayek and, recently, the Evolutionary School (Nelson and Winter, 2002), Complexity Economics (Arthur, 2013), Imperfect Knowledge Economics (Frydman and Goldberg, 2007), and those Post-Keynesians who advocate Minsky's interpretation of Keynes's *General Theory* (Minsky, 1975). It is beyond the scope of this essay to evaluate whether and to what extent these approaches are fully compatible with PTKL. However, let us note that a common feature of all of them is that change is generated *endogenously* by a negative feedback mechanism connecting observed discrepancies between expected and realized outcomes, elimination of errors, and generation of new (tentative) conjectures.

As noted above, the occurrence of random mistakes in the wake of 'exogenous' random shocks is the only source of fallibility allowed for in macroeconomic models that adopt REH. However, this is a severely restricted notion of fallibility. To be sure, accounting fully for fallibility implies recognition that economic agents´ mistakes may

[8] The dichotomy between exogenous and endogenously-created instability is also captured in De Grauwe (2009) who distinguishes between 'top-down' and 'bottom-up' systems. The former are systems where one or more agents fully understand the system as in the models adopting REH. By contrast, the latter are systems in which no individual understands the whole picture so that rationality consists of a trial-and-error selection process. De Grauwe (2009) recognises that the latter constitutes an example of rational behaviour which may result in a business cycle with a large *endogenous* component. A similar remark is in Arthur (2013, p. 3). However, neither De Grauwe (2009) nor Arthur (2013) mention that the notion of a trial and error-elimination process as the characterization of rationality has its philosophical foundation in PTKL.

be *systematic* owing to the fact that: (i) we can never 'prove' that a given hypothesis is 'true', (ii) learning mechanisms are imperfect, and (iii) the surrounding environment may undergo unpredictable changes. As a result of it, economic agents´ will often face situations of 'uncertainty' in the sense of both Knight (1921) and Keynes (1920) or, equivalently, in so-called 'large worlds' (Savage, 1954). In such scenario, fallibility can be conveniently captured by the operation of the feedback mechanisms described above and, hence, by the adoption of an evolutionary approach.

An example of this approach is the concept of 'Complex Adaptive System' or (CAS) (Holland, 1992). If we think of an economy as a particular type of CAS then its evolution can be viewed as determined by the interaction of *credit assignment* and *rule discovery* procedures. Both procedures constitute complex 'feedback' systems which, on the one hand, reinforce (discourage) the use of rules that have performed well (badly) in the past —'credit assignment procedure'— and, on the other hand, generate new rules by combining the rules that have performed well in the past. The implementation of new rules will be aided by the formulation of 'internal models' that help anticipating the consequences of the adoption of certain rules. Importantly, and regardless of whether anticipations prove to be right or wrong, once they are undertaken they will bring about *irreversible* changes in the surrounding environment thereby forcing CAS to re-evaluate its own 'internal models'. Thus, the process of adaptation is never-ending and cannot be optimal. As noted in Beinhocker (2013), forecasting is extremely difficult in a CAS yet this does not prevent it from generating predictions, the latter being understood as the deductive logical consequences of a theory. An example of this is evolutionary biology. The example of CAS reveals that if macroeconomic theory adopts REH it becomes incompatible with an evolutionary approach. First, as we have argued above REH is not really a hypothesis but an assumption. By way of contrast, in the context of PTKL and,

more generally, of evolutionary epistemology knowledge constitutes the *product* of an evolutionary process whereby false conjectures tend to be eliminated over time. Second, some of the changes that take place in the economy in the wake of decisions and actions adopted by market participants may be 'irreversible' in the sense that once undertaken it will extremely costly to undo them or else that they simply cannot be undone because the surrounding environment may have changed substantially as a result of the decisions made. But, if some changes are 'irreversible' the economy exhibits *path-dependency*. Yet, the latter implies non-ergodicity which, in turn, precludes the REH.

***Expectations and equilibrium***

In the context of the NNS model it is assumed that in the presence of (full) price and wage flexibility a market economy will reach steady-state equilibrium. However, its advocates commonly argue that in the presence of nominal and real rigidities aggregate output may deviate *temporarily* from steady-state equilibrium. In particular, this will be the case if the economy is hit by 'exogenous' shocks. Policy analysis in the NSS model thus consists of determining the optimal values of policy instruments given a fully pre-specified macroeconomic model where market participants are assumed to know the 'true' model of the economy and the stochastic properties of the 'exogenous' shocks. Crucially, the NNS model implies that market participants´ expectations do not play an *autonomous* role in the determination of the values of the variables of the model. This is captured in Frydman and Goldberg (2013, p. 143) when they note that 'REH, by design, imposes exact consistency between the sharp prediction — a single probability distribution of outcomes — implied by an economist´s aggregate model and the probability distribution representing participants´ forecasting strategies'. In order words, market participants´ expectations adapt passively to the predictions that stem from the

model. This device allows macroeconomic theorists to assume the existence of a stable equilibrium where: (i) expectations are fully realized, and (ii) there are no endogenous forces pushing the economy away from it.

By contrast, we have argued above that PTKL implies that market participants´ decisions and actions interact with the surrounding environment by virtue of two interrelated feedback mechanisms. As explained, the interaction of these mechanisms will, by itself, generate endogenous change. Importantly, such interaction will make equilibrium fragile and *short-lived*.[9] This is because as market participants revise their expectations in the aftermath of perceived mistakes in their previous evaluations, the operation of the second feedback mechanism alluded to above may lead to changes in the previous equilibrium by bringing about irreversible changes in the economy. For instance, in the NNS model the (aggregate) demand side of the economy is assumed to adjust smoothly in the long run to the supply-side determined level of economic activity whereas the framework we have posited above implies that the working of the second feedback mechanism may induce changes in the demand side of the economy that may then feed back into the supply side and vice-versa. The picture that emerges is thus one where the demand and supply side of the economy influence each other so that the level of economic activity can be said to be neither supply-side nor demand-side determined. This idea is formalized algebraically in Shaikh (2013) who constructs a system of three differential equations capturing the dynamics of the actual, expected, and fundamental value of an imaginary macroeconomic variable. He goes on to show that a reduced two-

[9] In this respect, Rosenberg (2013) draws a useful distinction between biological and cultural domains. According to him, the difference in the nature of equilibrium in these two domains is only *one of degree*. As he explains, in the biological domain the interaction of different feedback mechanisms produces stable cycles that exhibit a high degree of persistence owing to the fact that the former are 'held in check by environments that change with geological slowness' (2013, p. 435). By contrast, he suggests that the typical environment in cultural domains is subject to very rapid change. In particular, their lifetimes are inversely related to the rate of change of the cultural environment itself. Consequently, equilibria in such domains are short-lived.

dimensional dynamical system capturing the dynamics of the actual and expected values of the variable is stable in the sense that both variables fluctuate around the fundamental value of the variable although, crucially, the latter may drift away. In other words, the system does not possess a fixed point to which the actual, expected, and fundamental value converge but rather constitutes a 'moving centre of gravity'. The main prediction that stems from this model is that the economy exhibits boom-bust cycles of varying amplitude and length.

Next, the possibility that market participants´ decisions affect the surrounding environment implies that expectations play, at least partly, an *autonomous* role in the sense that they do not adapt passively to a pre-determined equilibrium. The recognition of the partial autonomy of expectations takes us right back to the ideas put forward by Keynes in his *General Theory* where he makes clear that:

'The considerations upon which expectations of prospective yields are based are partly existing facts which we can assume to be known more or less for certain, and partly future events which can only be forecasted with more or less confidence... We may sum up the state of psychological expectation which covers the latter as being the *state of long-term expectation*' (Keynes, 1936, pp. 147-148).

Keynes (1936) argues that the 'state of long-term expectations' depends partly on the 'state of confidence' with which we make the most probable forecast we can make. In turn, the former affects both the marginal efficiency of capital and the degree of liquidity preference and, ultimately, it determines the level of economic activity. The partial autonomy of expectations hinders any theorist´s attempt to obtain an overarching account of the economy and, arguably, constitutes a key difference between the natural

and the social sciences. As long argued in Hayek (1943), it is only in the social sciences that our *interpretation* of a situation no matter whether it is right or wrong becomes an integral part of the situation thus affecting subsequent developments. Further, and to the extent that we understand the surrounding world via the 'internal models' we create for that purpose, our understanding of the world will affect our decisions and, in this way, it may affect the world itself. Acceptingly, the partial autonomy of market participants´ expectations with respect to the current structure of the economy poses a formidable methodological challenge to macroeconomists. The challenge is to develop a theoretical framework that takes account of the simultaneous evolution of the economy´s structure and economic agents´ understanding of the latter.

***Rationality***

The notion of rationality embedded in REH is contingent on the premise that the 'true' model of the economy is either known or knowable. This is implicit in Muth´s (1961) description of REH as a purely descriptive thesis and in Lucas´ reinterpretation of REH as an assumption about how every market participant forecasts. As Frydman and Goldberg (2013) note, Lucas took for granted that market participants can construct a fully predetermined model that provides an account of how the economy evolves over time and, consequently, argued that it would be 'irrational' for them to make systematic forecast errors since this would reveal the presence of unexploited profit opportunities (Lucas, 2001, p.13). Thus, even if we disregard the conceptual difficulties that arise if an attempt is made to justify REH as the final result of an *eductive* process the question emerges what the appropriate benchmark for individual rationality is when the 'true' model of the economy is not known.[10] We believe the answer is in PTKL. According to

[10] As Guesnerie (2013, p. 52) points out, the RE equilibrium is a *Nash equilibrium*. Yet, the possibility of attaining an equilibrium through an eductive process — a process that takes place only in people´s minds

it, 'rational' behaviour consists of *making conjectures and the corresponding decisions and, if necessary, revising them in the face of observed discrepancies between expected and realized outcomes*. This notion of rationality does not imply that rational behaviour will be *effective*. Rather, all that is required from market participants is that they revise their decisions as indicated above. In particular, a decision which is correct *a priori* given the information initially available to decision-makers may turn out to be wrong *ex-post* for reasons unrelated to the reasonableness of the decision previously made such as, for instance, the occurrence of unforeseen changes in the surrounding environment.

Now, Popper´s notion of individual rationality (PPR) bears some resemblance to Simon´s (1976) notion of 'bounded' rationality (BR) in that, unlike the accompanying notion of 'substantive' rationality (SR), rational behaviour is not viewed as optimal.[11] Nevertheless, as we show below, it exhibits several differences with it. Table 1 below illustrates the differences and similarities between PPR and the notions of SR and BR coined by Simon (1976, 1979). First, SR presumes that the 'true' model of the economy is known by economic agents whereas BR presumes that the former is not known for practical purposes but could be known provided the costs of searching for information were low enough and the computational difficulties faced by economic agents were not insurmountable. This is apparent, for instance, in Simon (1979, p. 502) who makes clear that BR is 'a residual category — rationality is bounded when it falls short of omniscience'. As he explains, there are three different types of failures of omniscience: (i) failures of knowing all the alternatives, (ii) uncertainty about exogenous events, and (iii) inability (due to computational limitations) to calculate the consequences of every

whereby equilibrium is achieved through *systematic reasoning* of the decision-makers involved — faces insurmountable conceptual difficulties as illustrated in Knudsen (1993).

[11] According to Simon (1979), economic agents´ knowledge is subject to three types of constraints: (i) a limited ability to process, analyse, and store information, (ii) uncertainty, and (iii) the presence of social institutions. His notion of 'bounded' rationality stems from the fact that the existence of these constraints prevents economic agents from 'optimizing'.

choice. Finally, he argues that if the alternatives for choice are not given initially market participants will need to *search* for them and, hence, a theory of BR must incorporate a 'theory of search'. The implicit premise is that if search costs were low enough market participants could know all the alternatives for choice. In other words, Simon apparently assumes there exists an 'inductive logic' so that what prevents market participants from learning the 'true' model of the economy is the presence of relatively high information search costs and computational constraints.[12] In contrast to this, PPR presupposes that the 'true' model of the economy is neither known nor knowable, the main reason being the absence of an 'inductive logic'.

As Lucas (1977, p. 15) explains, 'in cases of [Knightian] uncertainty, economic reasoning will be of no value' which entails that SR and REH only apply to situations of 'risk' or 'small worlds'. By contrast, BR and PPR are applicable both to situations of 'risk' and 'Knightian uncertainty'. In situations of 'risk' BR will essentially consist of using rules (e.g. algorithms) to estimate the statistical probabilities of a list of potential outcomes by extrapolating information obtained from the past. Similarly, in situations of 'risk' PPR will amount to re-estimating periodically the probabilities assigned to a list of potential outcomes in the face of observed discrepancies between estimated probabilities and realized frequencies. However, as Lucas (1977) implies, SR does not apply in situations characterized by 'Knightian uncertainty' due to the impossibility of applying economic theory. By contrast, both BR and PPR do apply in this case thereby leaving some room for 'economic reasoning' even when the surrounding environment is such as to preclude the assignment of numerical probabilities to potential outcomes. There is, by now, a vast literature on rational behaviour under 'Knightian uncertainty'

[12] Or as Boland (2003, p. 40) puts it, Simon (1979) does not really deny Inductivism, only the feasibility of inductive knowledge.

where the former consists of the use of different heuristics (Gigerenzer and Gaissmaier, 2011) and the adoption of habits and social rules (Hodgson, 1997). These approaches to rational behaviour are compatible with PKTL.

<table>
<tr><th>Approaches</th><th>Domain</th><th colspan="2">Dichotomies</th></tr>
<tr><td rowspan="3">Conventional approaches to rationality (The ‘true’ model is either known or knowable)</td><td rowspan="2">‘Substantive’ rationality<br>(It applies only to situations of ‘risk’)</td><td>Rational behaviour</td><td>Optimal (attainable)</td></tr>
<tr><td>Irrational behaviour</td><td>Sub-optimal</td></tr>
<tr><td>‘Bounded’ rationality<br>(It applies both to situations of ‘risk’ & ‘Knightian uncertainty’)</td><td rowspan="2">Rational behaviour</td><td>Optimal (Unattainable)<br>‘Bounded’ rationality presumes that behaviour is sub-optimal</td></tr>
<tr><td>Popper´s approach to rationality (The ‘true’ model is neither known nor knowable)</td><td>It applies both to situations of ‘risk’ & ‘Knightian uncertainty’</td><td>Rational behaviour (Revision of conjectures & expectations)</td><td>No dichotomy between optimality and sub-optimality<br>Human behaviour is rational (‘Principle of transference’)</td></tr>
</table>

**Table 1**: Comparison of Popper´s notion of rationality and alternative notions of rationality in economics

Next, both SR and BR imply an undesirable dichotomy between optimality and sub-optimality. The dichotomy is *explicit* in SR where rational behaviour is associated to optimality whereas irrationality corresponds to sub-optimal behaviour. By contrast, the dichotomy is *implicit* in BR where optimal behaviour is presented as being generally unattainable but potentially attainable under favourable (but unusual) circumstances. In particular, BR implies that results will tend to be sub-optimal owing to the shortcomings of market participants´ cognitive abilities which prevent them from processing, storing, and analysing a large enough quantity of information. Yet, this implies that optimal behaviour constitutes a benchmark against which the actual degree of sub-optimality of

economic agents´ behaviour can be *a priori* determined. By contrast, such dichotomy does not exist in PPR where there is no such thing as an 'optimal' benchmark. Rather, PPR implies that market participants´ choices will never be optimal (except by sheer chance) *even* if their cognitive abilities were unbounded since knowledge — including that about the 'true' model of the economy — is always conjectural and imperfectly adapted to the surrounding environment. In other words, the notion of optimal choice that pervades mainstream macroeconomics makes sense only if the 'true' model of the economy were known either by market participants or the economic theorist. Be that as it may, PTKL implies that market participants´ behaviour will, in normal circumstances, be rational insofar as Popper´s 'principle of transference' (Popper, 1972) entails that individuals form their beliefs by eliminating false theories. To finish off, the notion of 'rationality' that stems from PTKL is compatible and, indeed, inextricably linked to the *fallibility* of knowledge.

## V. SUMMARY AND CONCLUSIONS

Macroeconomic theory has been dominated over the last four decades by REH which implies that economic agents know the 'true' model of the economy so that their expectations are assumed to be unbiased. The impossibility of economic agents making systematic mistakes implies, in turn, that economies are assumed to be inherently stable and that observed volatility is caused solely by 'exogenous' random shocks. REH is a core element of the NNS model which has also played a dominant role in theory and policy over the last two decades or so and which, according to several commentators, bears a great deal of responsibility for the generation of the last financial crisis. We ascribed the difficulties of REH and the NNS model to their flawed epistemological and ontological foundations. Specifically, we argued that the adoption of REH has biased

macroeconomics and, in the process, reduced its practical relevance by restricting it to situations of 'risk' (Knight, 1921) or 'small worlds' (Savage, 1954). In such contexts, the only source of human fallibility is the impossibility of fully anticipating 'exogenous' random shocks. We argued that this is too constraining a conception of human fallibility as it ignores fundamental sources of the latter such as the logical impossibility of knowing the 'true' model of the economy owing to the lack of an 'inductive logic', the imperfect nature of all learning mechanisms, and the possibly changing nature of the environment in which economic agents make economic decisions. We then claimed that PTKL can provide macro-theory with solid epistemological and ontological foundations in the sense of enabling it to take *full* account of human fallibility.

If macroeconomics is to reorient itself to take full account of human fallibility it will need to focus its attention on the changes in the surrounding environment brought about by market participants´ revision of expectations. In particular, we argued that both change and evolution in a market economy can be viewed as generated *endogenously* by the interaction of the following two feedback mechanisms: (i) a negative feedback mechanism whereby market participants revise their previous expectations in the face of observed systematic discrepancies between expected and realized outcomes, and (ii) a feedback mechanism of ambiguous sign whereby market participants´ decisions and actions may alter the surrounding environment. We then argued that the endogeneity of change in market economies generates two predictions: (i) macroeconomic equilibrium is fragile and *short-lived* thereby making it difficult for theorists and policy-makers to exploit it, and (ii) market economies exhibit boom-bust cycles of varying amplitude and duration so that there is *never* a repetition of the same cycle. Finally, we argued that unlike typical notions of individual rationality in economics such as Simon´s notions of

'substantive' and 'bounded' rationality, the notion of individual rationality that stems from PTKL does not generate a *dichotomy* between optimal and sub-optimal behaviour.

Lastly, we noted that some of the concepts we associated to PTKL can be also identified in other approaches in economics which have developed outside mainstream economics which, according to us, suggests that the development of a new conceptual framework for macroeconomics would benefit substantially from a re-examination of these approaches. Notwithstanding it, there are other branches of knowledge economists can also take advantage of and whose conceptual frameworks are fully compatible with PTKL. Some examples of this are: evolutionary psychology, evolutionary biology, and 'complex adaptive systems' theory. Thus, we believe the development of a new macro-theory along PTKL will require that economists adopt a more interdisciplinary and less pretentious approach than has been the case in the recent past. To paraphrase Popper 'the future is objectively open'. Hence, it is in our own hands to change it. Let us hope that economists take up the challenge.

**REFERENCES**

ARROW, K. J. (1978). The Future and the Present in Economic Life. *Economic Inquiry,* 16 (2):157-69.

ARTHUR, W. B. (2013). Complexity economics: a different framework for economic thought. *Institute for New Economic Thinking Research*. Note #033, March.

BEINHOCKER, E. D. (2013). Reflexivity, complexity, and the nature of social science. *Journal of Economic Methodology*, 20 (4), 330-342.

BOLAND, L. A. (2003). *The Foundations of Economic Method: A Popperian Perspective*, 2nd edition. London: Routledge.

DAVIDSON, P. (1991). Is Probability Theory Relevant for Uncertainty? A Post Keynesian Perspective. *Journal of Economic Perspectives*, 5 (1), 129-143.

De GRAUWE, P. (2009). Top-down versus bottom-up macroeconomics. Paper presented at the conference "What is wrong with modern macroeconomics". CESifo, Munich, 6-7 November 2009.

FARMER, R. E. (2013). Animal Spirits, Persistent Unemployment, and the Belief Function. In R. FRYDMAN and E. S. PHELPS (eds.), *Rethinking Expectations: The Way Forward for Macroeconomics*, 251-276, Princeton: Princeton University Pres.

FRYDMAN, R. & GOLDBERG, M. D. (2007). *Imperfect Knowledge Economics.* Princeton: Princeton University Press.

FRYDMAN, R. & GOLDBERG, M. D. (2011). *Beyond Mechanical Markets: Asset Price Swings, Risk, and the Role of the State.* Princeton: Princeton University Press.

FRYDMAN, R. & GOLDBERG, M. D. (2013). The Imperfect Knowledge Imperative in Modern Macroeconomics and Finance Theory. In R. Frydman and E. S. Phelps (eds.), *Rethinking Expectations: The Way Forward for Macroeconomics*, 130-165, Princeton: Princeton University Press.

FRYDMAN & PHELPS (2013). Which way forward for macroeconomics and policy analysis? In R. Frydman and E. S. Phelps (eds.), *Rethinking Expectations: The Way Forward for Macroeconomics, 1-48.* Princeton: Princeton University Press.

GIGERENZER, G. & GAISSMAIER, W. (2011). "Heuristic Decision Making." *Annual Review of Psychology* (62): 451-482.

GOODFRIEND, M. & KING, M. (1997). The New Neoclassical Synthesis and the Role of Monetary Policy. *NBER Macroeconomics Annual*, 231-283.

GUESNERIE, R. (2013). Expectational Coordination Failures and Market Volatility. In R. FRYDMAN and E. S. PHELPS (eds.), *Rethinking Expectations: The Way Forward for Macroeconomics*, 49-67, Princeton: Princeton University Pres.

HAYEK, F. A. ([1937]1948). Economics and Knowledge. *Individualism and economic order*, 33-56, Chicago (IL): University of Chicago Press.

HAYEK, F. A. (1943). The Facts of the Social Sciences. *Ethics*, 54(1), 1-13.

HODGSON, G. M. (1997). The ubiquity of habits and rules. *Cambridge Journal of Economics*, 21 (6), 663-684.

HOLLAND, J. H. (1992). Complex Adaptive Systems. *Daedalus — Journal of the American Academy of Arts and Sciences*, 121 (1), 17-30.

HUME, D. (1748/2006). *An Enquiry Concerning Human Understanding*. Oxford: Clarendon Press; New York: Oxford University Press, 2006

KEYNES, J. M. ([1920]1952). *A Treatise on Probability*. London: Macmillan.

KEYNES, J. M. (1936). *The General Theory of Employment, Interest and Money*. London: Macmillan.

KNIGHT, F. H. (1921). *Risk, Uncertainty, and Profit.* Chicago: The University of Chicago Press.

KNUDSEN, C. (1993). Equilibrium, perfect rationality and the problem of self-reference in economics. In Mäki, U., Gustafsson, B., and Knudsen, C. (eds.), *Rationality, Institutions and Economic Methodology*: 133-70. London: Routledge.

KRUGMAN, P. (2009). How Did Economists Get It So Wrong? New York Times. http://www.nytimes.com/2009/09/06/magazine/06Economic-t.html?pagewanted=alland_r=0 Accessed December 3rd.

LUCAS, R. E. (1977). Understanding Business Cycles. In Carnegie-Rochester Conference Series on Public Policy (ed.), Vol. 5. Stabilization of the Domestic and International Economy: 7-29.

LUCAS, R. E. (1986). Adaptive behaviour and economic theory. In Brunner, K., Meltzer, A.H., R. M. Hogarth and M. W. Reder (eds.), *Rational Choice: The Contrast*

*between Economics and Psychology*. Chicago and London: University of Chicago Press: 217-242.

LUCAS, R. E. (2001). Professional Memoir. Available at: http://home.chicago.edu.

MERTON, R. K. (1948). The self-fulfilling prophecy. *Antioch Review,* 8 (2), 193-210.

MINSKY, H. P. (1975). *John Maynard Keynes*. New York: Columbia University Press.

MUTH, J. F. (1961). Rational Expectations and the Theory of Price Movements. *Econometrica,* 29 (3): 315-335.

NELSON, R. R. & WINTER, S. G. (2002). Evolutionary Theorizing in Economics. *Journal of Economic Perspectives*. 16 (2): 23-46.

PHELPS, E. S. (2007). Foreword. In Frydman, R. and Goldberg, M. D. (eds.), *Imperfect Knowledge Economics,* pp. xiii-xx, Princeton: Princeton University Press.

POPPER, K. R. (1944). The Poverty of Historicism I. *Economica*, 11 (42), 86-103.

POPPER, K. R. (1972). *Objective Knowledge: An Evolutionary Approach*. Oxford: Clarendon Press.

POPPER, K. R. (1990). *A World of Propensities*. Bristol (UK): Thoemmes.

POPPER, K. R. (1994). *The Myth of the Framework: In defence of science and rationality*. London: Routledge.

ROSENBERG, A. (2013). Reflexivity, uncertainty and the unity of science. *Journal of Economic Methodology*, 20 (4), 429-438.

SAVAGE, L. (1954). *The Foundations of Statistics*. New York: Wiley.

SHAIKH, A. (2013). On the role of reflexivity in economic analysis. *Journal of Economic Methodology*, 20 (4), 439-445.

SIMON, H. A. (1976). From Substantive to Procedural Rationality. In Spiro J. Latsis (ed.), *Method and Appraisal in Economics,* 129-148. Cambridge: Cambridge University Press.

SIMON, H.A. (1979). Rational Decision Making in Business Organizations. *American Economic Review*, 69 (4), 493-513.

SOROS, G. (2013). Fallibility, reflexivity, and the human uncertainty principle. *Journal of Economic Methodology*, 20 (4), 309-329.

STIGLITZ, J. E. (2011). Rethinking Macroeconomics: What Failed, and How to Repair it. *Journal of the European Economic Association*. 9 (4): 591-645.

TOBIN, J. (1981). The Monetarist Counterrevolution Today — An Appraisal. *Economic Journal*, 91 (361): 29-42.

WOODFORD, M. (2009). Convergence in Macroeconomics: Elements of the New Synthesis. *American Economic Journal*: Macroeconomics. 1 (1): 267-279.