Prolegomenon

1 Evolutionary economics: a theoretical framework

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1 Introduction

The last two decades have seen an explosion of research in economics inspired by evolutionary thinking. There has been an upsurge in the number of publications addressing evolutionary themes, paralleled by the foundation of new journals and new academic societies devoted to the subject matter. Heterodox contributions in themselves do not yet signal any extraordinary event; in fact, the ongoing challenge of the received view is part and parcel of the theoretical discourse of any 'normal' science. What gives the recent advances in this field – grouped loosely under the heading 'evolutionary economics' – their distinct hallmark are the rapid pace and persistent power of the underlying intellectual dynamic. The 1982 book by Richard Nelson and Sydney Winter on *An Evolutionary Theory of Economic Change* has served as an ice-breaker that arguably gave the early process its critical momentum. In their contributions to this volume, these authors address one of the core issues of evolutionary economics: the change of economic knowledge as it applies to technology and production.

What are the factors that may conceivably account for the present dynamism of evolutionary economics? We get a first hint when we consider that, in their field of study, orthodox economists encounter decreasing marginal returns with respect to new theoretical findings per additional unit of research effort or research time. Linking this with the conjecture that creative minds are attracted by new opportunities for developing their theory enables us to obtain a hypothesis that accounts for the phenomenon that outstanding neoclassical economists are increasingly turning to research areas that can be linked to evolutionary ideas.

Another explanation for this extraordinary dynamism relates to the particular meaning associated with the notion of evolution. In a nutshell, an evolutionary approach addresses foundational issues: it invites not only an exploration of new theoretical vistas but also a rethinking of the paradigmatic-ontological premises on which these are based. Other heterodox approaches differentiate themselves primarily at a less abstract theoretical level. A key aspect of the economic world is usually singled out and used to designate its subject matter. For instance, institutional economics builds its explanations around the notion of institution, and Keynes' legacy provides the hallmark of Keynesian macroeconomics. Evolutionary economics can also be stated in terms of distinct theoretical areas and, in its various theoretical extensions, is linked to specific precursors. In addition, however, the notion of evolution transcends the plane of the theoretical discourse and features criteria that, on the basis of paradigmatic-ontological distinctions, mark the boundaries of the various research areas.

As a consequence, the notional distinction between 'evolutionary' and 'non-evolutionary' runs through the various theoretical approaches and reassembles them with regard to their paradigmatic foundations. Institutional economics, for instance, is divided into an original 'old' branch, in which evolutionary ideas play a paradigmatic role, and a more recent 'new' branch, which lacks a comparable paradigmatic orientation. Analogously, a paradigmatic borderline can be drawn between the hydraulic version of Keynesianism (its neoclassical or 'new' synthesis) and post-Keynesian approaches with notions of radical uncertainty, non-equilibrium, etc. that are linked with evolutionary thinking. In fact, the paradigmatic divide also runs through the field of evolutionary economics itself; some of the theoretical works address evolutionary themes but are still rooted in mechanistic-physicalist thinking. Borderline disputes have emerged about whether the theoretical works of, for example, evolutionary game theory or of equilibrium-based endogenous growth theory satisfy the above-mentioned criteria of the field.

In the following we take the view that evolutionary economics is defined not only by a range of theoretical themes but also by distinct paradigmatic-ontological foundations. This volume brings together contributions by eighteen scholars, each of whom is a pioneer in his field, that address the issue of the nature of the *evolutionary* – as distinct from non-evolutionary – foundations of the science of economics.

2 A posteriori ontology

The view that a valid economic theory requires the explication of its paradigmatic-ontological foundations is not generally accepted. Economists whose allegiance is positivist argue that there is a direct link from empirical observation to theoretical statements and that any reference to foundational statements would blur the objectivity of the process of theory formation, or, at best, would be superfluous. We may concede that this is a reasonable view to start with, and that any alternative contention must furnish plausible arguments against it. Any theory or coherent set of hypotheses (H) represents, in its bare bones, a generalization of a designated range of particular real phenomena (R). The methodological step from the inspection of many individual cases to a general statement in its widest sense represents the process of *induction*. The inductive procedure is employed in the process of both hypothesis generation and hypothesis testing. The inductive inspection of reality thus occurs both before and after the generalization and this yields the schema R-H-R for the entire process of theory formation. A methodological battle has been waged over the issue of whether the primary inferential procedure should be from R to H or from H to R. The *Wiener Kreis* adherents of positivism advocated the inferential procedure R-H, while theoreticians of science led by Karl Popper objected to this inferential route and disapproved of its confirmatory bias. Although this *Methodenstreit* lasted a long time, it should be apparent from the suggested R-H-R schema that verificationism and falsificationism are simply two sides of the same inferential coin. Verification (as a hypothetical claim) is *ex ante* induction, falsification is *ex post* induction. What remains in limbo on this methodological plane, however, is the more basic issue of whether theoretical induction – *ex ante* or *ex post* – meets all the criteria needed to arrive at valid theoretical statements.

The positivist canon presumes that scientists have an innate ability to practise their *métier* in an objective fashion. Scientists are presumably equipped with an inherited set of rules that a priori allows them to arrive at valid scientific statements. Historians of science, however, have provided a substantial body of evidence that demonstrates that the rules scientists employ in their practice change over time and that ontological beliefs and perceptions about which problems are relevant or which methodological standards are acceptable may differ substantially from one 'scientific community' to another. There is no objective a priori base for theory formation. Thomas Kuhn has argued that members of a scientific community are united by a specific '*paradigm*' and in their scientific practice rely on a '*disciplinary matrix*' that provides '*exemplars*' that mark its nature and signal its boundaries. In an analogous vein, Imre Lakatos has argued that scientists always work within a '*scientific research program*' the '*hard core*' of which they defend with an armoury of 'positive heuristics' and 'negative heuristics'. In the positivist agenda the set of rules is constant, and its influence on the inferential procedure can, like a constant in a mathematical equation, be neglected without further consequences. Once we accept the possibility of different rules, we have to explicitly recognize the formative power of a deductive component in the inferential process. The issue subsequently is not whether we accept the notion of a paradigmatic core in the inferential procedure but rather which criteria we can furnish that suggest its validity. What are the procedures that allow us to arrive at a scientifically acceptable paradigmatic core?

There are basically two methodological routes: the a priori and the a posteriori. The former belongs to metaphysics, but, interestingly, scientists also take an a priori posture when it comes to the issue of paradigm or central research questions. In his later writing, Karl Popper explicitly acknowledged the paradigmatic significance of the idea of evolution, but he argued that it was ultimately rooted in metaphysics. Science, by its own codex, cannot, however, rely on an a priori stance; it is bound to take an a posteriori one. Deductive schemes, such as paradigms and research programmes, represent the most abstract views about the status of reality. In philosophical terms, the paradigmatic core comprises a set of *ontological* statements. Given its empirical nature, the paradigmatic core of a scientific theory must be derived with the same methodological rigour as the statements of the theory itself. Hence we suggest applying the standard channel of induction also to the inferential procedure that deals with the paradigmatic-ontological foundation of a theory. This metatheoretical inference can be called *paradigmatic induction*.

Induction builds on many observed or conjectured individual cases. In theory formation the inductive base is associated with a statistical data set of individual observations defined by a particular discipline. In its paradigmatic application the inductive range must encompass all individual cases of all scientific disciplines. Paradigmatic induction does not aim to reach generalization about a (theoretically defined) class of real phenomena. In fact, its focus is 'all' reality – the unity that all existences share: its *ontological* status. As humans we are, of course, not equipped with lenses that would allow us to inspect all statistically significant individual cases; but carrying out this Herculean task is not required to enable us to arrive at reasonable inductive conclusions. Paradigmatic induction essentially means opening up an intellectual discourse between philosophy and science and, within the boundaries of the latter, between the various disciplines. Modern early twentieth-century philosophy under the leadership of Charles Peirce, Alfred North Whitehead and Henri Bergson made a substantial effort to put ontology on a scientific basis. Similarly, scientists of various disciplines have contemplated their own scientific findings and have arrived at conclusions for a reconstructing ontology on a posteriori grounds. In their contributions to this volume Ilya Prigogine and Hermann Haken discuss some of the implications that major advances in modern physics have had on our world-view. Geoffrey Hodgson and Herbert Simon, in their contributions, explore the relationship between economics and biology, and, by so doing, discover their common ontological ground. The following discussion – for which the contributions of this volume have been an indispensable source of inspiration – represents a preliminary attempt to arrive at a set of ontological statements.

3 The legacy of mechanical thinking

In the age of enlightenment Isaac Newton saw the universe as a vast space in which the stars and planets – following eternal laws – moved with clockwork precision. Carolus Linnaeus charted the natural world of minerals, plants, animals and man using a taxonomy that posited all entities in ascending order of casually observed complexity. The scientific advances were paralleled by radical societal changes propelled by political and technological revolutions. The European *ancien régimes*, with their autocratic rule, guild order, regulated earnings and regulated prices, broke down and gave way to freedom of trade and a dynamic market economy. Technical inventions, such as the steam engine and the mechanical loom, paved the way for economic growth and structural change unprecedented in human history.

These societal developments were partly the outcome of the advances in the natural sciences, but they themselves also called for a scientific explanation, leading in the second half of the eighteenth century to the birth of modern economics (then called political economy). From the very beginning, the natural sciences served as a paradigmatic archetype for the young science. The theoretical objectives were, on the one hand, to detect the invisible law (or 'hand') that governed the *coordination* of many individual economic actions, and, on the other hand, to establish the *laws of motion* that determined the long-run pace and distribution of the aggregate resources' magnitudes. Adam Smith's work has generally been associated with the first of these two grand questions, that of David Ricardo and Thomas Robert Malthus, and later Karl Marx, with the second. The classical economists employed a broad scope and they enriched their analyses with many empirical details. In retrospect, their writings appear to us as typically interdisciplinary. This intellectual basis itself suggests that the classicals did not take a narrow mechanistic view or use reductionist modelling. This was particularly apparent in those cases where the factor of economic knowledge played a major role, as in Smith's analysis of the division of labour in the economy and in the firm. But, precisely because their scope was interdisciplinary, they also obtained major inspiration from Newtonian physics.

The birth of what in recent decades has been called 'modern economics' came with *neoclassical economics* in the second half of the nineteenth century. The economists of that period criticized their classical precursors for having worked with aggregate magnitudes and for having assumed an 'objectivity' for the economic process that, in their view, it simply could not have. They challenged the tenet of an objective law that would determine the developmental pace and the distribution between the economic aggregates. They suggested looking at the individuals and reconstructing economics on the basis of a better understanding of human cognition and behaviour. If there was a value theory that could explain market coordination and solve the *Smith problem* – the major, and for a long time the only, research interest of the neoclassicals – then it was a subjective one. It seemed that the focus on the individual would open a new, subjective (subject-related) chapter in economics, but the opposite was the case. The neoclassicals criticized the classical economists not for having used invariant laws as such but only for having looked for them in the wrong places. As for the nature of the laws, the neoclassicals wanted to outdo their precursors by introducing mathematics (basically, Newton's calculus) and called for the utmost formal rigour and precision. Mechanics became, to echo Alfred Marshall's dictum, the Mecca of economics. At that time it was probably not entirely recognized that the method also brought with it an *ontology*. To reduce the subject character of the individual to its mechanical properties was, in any case, bold. Hermann Gossen, Léon Walras, Henry Jevons, Vilfredo Pareto and others frequently used mechanical analogies and metaphors. Hodgson's contribution in this volume discusses the use of mechanical analogies and metaphors in economics from the 1880s to the present day and shows how and why biology, the other potential Mecca of economics, has still largely been ignored. In his contribution Sydney Winter describes the turn from the classical distribution theory to the neoclassical marginalist production function, and the appearance of the mechanistic paradigm in the modern works of linear programming and activity analysis.

A major contribution to the philosophical foundations of the classical paradigm was made by René Descartes. Ilya Prigogine recalls in his contribution the essence and influence of *Cartesian dualism*, stating that 'on one side there was matter, "res extensa", described by deterministic laws, while on the other there was "res cogitans", associated with the human mind. It was accepted that there was *a fundamental distinction* between the physical world and the spiritual – the world of human values.' The corporeal things – all physical and biological phenomena – were visible, definable and measurable in terms of shape, size or motion; they made up the 'hard' side of reality. The incorporeal entities – comprising conscious experience, thinking, ideas, mind, imagination, information, creativity and the soul – were invisible, unextended and incomprehensible and outside the numerical scale of time and space; these made up the 'soft' side of reality. Cartesian dualism, as Prigogine and Ping Chen both point out, went with the important implication that only the 'hard' part of reality was considered to be amenable to scientific inquiry, empirical scrutiny and theory construction. The 'soft' side lacked object character, hence 'objectivity', and consequently fell outside the domain of science; that side contained the stuff from which the *arts* were made. The classical sciences, such as physics, biology and – arguably – economics, were at their very philosophical core designed to be *hard sciences*.

What was the ontological nature of the objects that the hard sciences dealt with? One interpretation of the classical canon that was around the corner would seem to be: matter-energy. However, this interpretation is only half right, and therefore particularly misleading. Descartes had proposed mathematizing science, and, if the job of science was not merely to provide an enumeration of scaled and measured facts, this implied that there was some generality inherent in the objects. Dualism between corporeal and incorporeal things did not preclude some members of the former sharing a common property. This position was also basically that of Aristotle, who proposed that all things had two properties: an essential property and an accidental property. The essential denoted a general property of a thing, the accidental its individual concretization. In this categorization Aristotle left room for Plato's view that the essential had to be associated with some perfect idea, and the individual cases with its imperfect concretizations. Descartes rejected Plato's idealism, and endorsed the modern view that all objects follow a law. This left metaphysics behind, and was a step towards constructing modern science. Nevertheless, its fundamental ontological message was still the same: the property or the behavioural mode of matter-energy – the *essential property* expounded by a *law* – does *not change*.

The statement that an object follows a law involves the assumption that there is some *informant agency* that makes an object behave in a certain way and not in any other way. The term 'informant' here conveys the idea that a 'form' is 'in' an object. At this point this has no causal or information-theoretic significance, but simply means that there is something that occurs in a certain way and not in any other way. If there is only one informant agency for all objects of a kind in all time, we call it a *law*, as understood in the classical sciences. If the informant agency changes over time, we cannot speak accordingly of a law in the classical sense. A statement of difference between informant agencies requires that the nature of the informant agencies compared be specified. We call this specification of an informant agency *idea*. A set of ideas allows us to distinguish between objects on the basis of different informant agencies, or, in classical terms, laws. The classical sciences assume a single universal law, and we do not require the notion of 'idea' to denote a difference between informant agencies. All differences can be stated in terms of their physical actualization of the objects and can be measured exclusively in quantities. It should be noted that here we have a language for talking about change and non-change, but still do not have any causal hint or explanation for these phenomena.

In Newtonian physics the objects are composed of matter with mass that has gravitational force. Every object or body continues in its uniform motion, or its state of rest, unless it is compelled to change that state when forces act upon it. Not only is Newton's gravity law unchanging; the events the law describes also do not change endogenously unless an exogenous force is introduced into the system. The model is *universally deterministic*. Given complete information about the initial and subsidiary conditions, the law allows us to retrodict events precisely on to the past and to predict them to precisely on to the future. The law holds for all bodies, independent of the quantity of their mass, weight or size. For instance, starting from the same height (in a vacuum) a body weighing 1 kilogram will fall with the same speed as one of 10 kilograms. Small bodies can be aggregated into a large body, but aggregation will not change the informant agency of the small bodies.

The power of the Newtonian model is particularly apparent in those cases where it has served as a paradigmatic cornerstone when theoretical discussions were carried into new areas of the discipline. Prigogine and Haken discuss the case of thermodynamics in the mid-nineteenth century, and demonstrate the particular role that the Newtonian model played in its development. Practical work with steam engines and experiments have shown that initial temperature differences between ensembles of particles tend to become zero or to converge over time to a thermodynamic equilibrium. There is a general tendency of a thermodynamic ensemble (in a closed system) for its potential – i.e. its free energy – to tend towards a minimum or maximum entropy respectively. This thermodynamic property can be given an informational twist. The initial relative motions of the particles can be conceived of as a *structure*, and then the informational quality of the dynamics can be interpreted as an irreversible process *from order to chaos* (chaos here denoting simply non-order, without the predictive connotation of the chaos models). A piece of wood that is completely burned up would be an example of entropy conceived of as informational decay.

The concept of 'structure' invites the conjecture that there may be some law that appertains not to its individual particles but to the ensemble *as a whole*. We could assume, for instance, that, under certain thermodynamic conditions, the particles change their behavioural mode spontaneously and lead to a de-structuring of the whole that, in turn, feeds back to the individual particles, causing them to behave in a way that reinforces that structural decay. This is precisely the way Prigogine and Haken have developed their non-classical models of thermodynamics that explain structure and evolutionary change. In the present case the non-classical thermodynamic model would not explain the self-organization of order but rather the self-organization of chaos. There is no such theory available in thermodynamics (in fact, there is none that explains entropy rather than describing it statistically), but the essential point to get across here is that such a *non-classical* view would open up new vistas for a *macroscopic* interpretation of the laws of thermodynamics. In their contributions Prigogine and Haken show how nineteenth-century physics turned to Newtonian physics in trying to explain the behaviour of a thermodynamic ensemble on the basis of a description of the individual trajectories of the particles. The whole of the ensemble could be constructed as an aggregate of individual particles, and from that, in turn, the individual behaviour of the particles could be computed in a disaggregating fashion.

The theoretical statement about the whole in terms of its parts required assigning an invariant informant agency – the classical law – to each of them, thus precluding the introduction of ideas that would have been required for locating the position of the parts within the whole. This approach, pioneered by Ludwig Boltzmann, went a long way; but it had its limitations. Probability distributions and statistical averages, used in classical thermodynamics for computational convenience, could serve the purpose for describing structural decay (entropy), but were bound to fail when it came to a theoretical statement about the *self-organization* of structure and its *evolutionary* dynamics. Non-classical thermodynamics, as pioneered by Prigogine and Haken, shows that, under certain thermodynamic conditions, macroscopic structures – for example, dissipative and synergetic structures – emerge and that the dynamic of an ensemble is characterized by order through fluctuations, phase transitions and cascades of bifurcations, leading to the continuity of evolution. The advances in non-classical thermodynamics indicate that the *Newtonian* model denotes a *special* case rather than a general one. Irreversibility and time asymmetry play an important role, and – as Prigogine says – 'what we need are not approximations to the existing laws of nature, but an extension of these laws to include irreversibility. . . . [L]aws of nature no longer express certitudes, but "possibilities".' To the extent that a paradigm calls for *generality*, Newtonian physics and classical thermodynamics do not provide appropriate guidance for devising an empirically warranted paradigm.