

Book Reviews

Knowledge-Based Economy: Modeled, Measures, Simulated

Loet Leydesdorff

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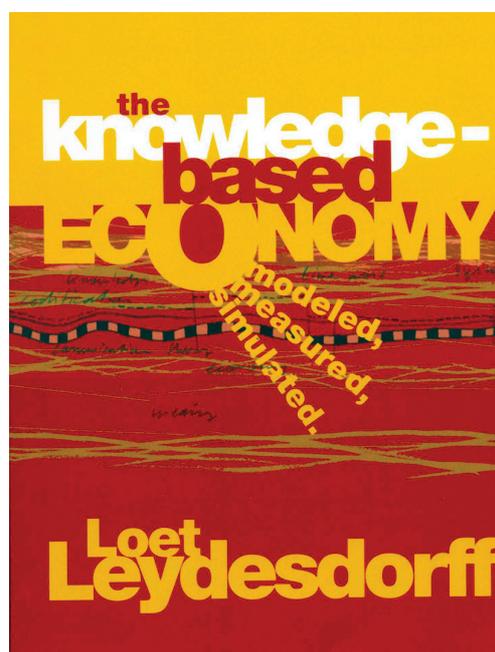
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In his book *The Knowledge-Based Economy*, Loet Leydesdorff analyzes the knowledge-based economy with three goals: to create a model capable of capturing the new dynamic of this economy, which he believes is different from the market-based economy and the political economy, to measure this dynamic, and to simulate it. From the theoretical point of view he focuses on the specification of the system of a knowledge-based economy. The systematic organization of knowledge production and control, which is increasingly “industrialized”, if we can put it like that, provides a third coordination mechanism (third subdynamic) for the social system, making the knowledge base endogenous to the system. He seeks to understand to what extent knowledge-based innovations restructure the social system with a dynamic which is different from the economic rationale or political and management decisions.

From a technical point of view, the author’s focus is the lack of empirical operationalization and methodological rigor in the sociology of Niklas Luhmann and the failure of the theories of social systems to find a solution to fill the gap between the modeling of complex systems in terms of simulation, as has become common in evolutionary economics. He is particularly concerned with the interfaces of the various subsystems which make up the knowledge-based economy. He believes that this perspective for operationalizing the dynamic of the economic system



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has been blocked by the controversy between the neoclassical and evolutionary approaches.

We had the pleasure of meeting the author in 2000 at the Triple Helix III seminar which took place at the Federal University of Rio de Janeiro (UFRJ); both we and he were involved in its organization. The title of the seminar was *The Endless Transition: Relations Between Social, Economic and Scientific Development*. It could be said that this title already anticipated well the author's concerns in preparing the work which we review here.

Leydesdorff is a biochemistry graduate who then undertook postgraduate study in philosophy and sociology. Today he is a Senior Lecturer at the Amsterdam School of Communications Research (ASCoR) at the University of Amsterdam in Holland. In Brazil, he is best known for his publications in the area of science and technology about the Triple Helix of university-industry-government relations. He has also published work in the areas of scientometrics, systems theory, social network analysis and the sociology of innovation. In 2003 he received the Derek de Solla Price Memorial Medal for Scientometrics and Infometrics. In 2005 he was appointed to the Honorary Chair of the City of Lausanne at the University of Lausanne's School of Economics.

The earlier research which supports his current work comes from two branches. The first one was developed in collaboration with Henry Etzkowitz, producing the Triple Helix of university-industry-government relations, which culminated in the development of a model of technological innovation. The different dynamics which may be generated by this model were identified through empirical observation. This book presents an instrument for measuring the Triple Helix dynamic and tests it in the context of a global system (the European Economic Community, see chapter 8) and at national level (the Dutch and German economies, see chapters 9 and 10).

The second branch of research was the development of simulation models for knowledge-based innovations in collaboration with Peter van den Besselaar and Daniel Dubois. Leydesdorff is particularly grateful to Dubois for encouraging him to use the idea of *anticipatory systems* to study knowledge-based systems. In this type of system two discourses are modeled: one historical, following actors along the time axis, and the other analytical – related to the type of scientific discourse which analyzes future events in terms of possible responses. According to the sociologist Antony Giddens, this creates a double hermeneutics. Scientific discourse will allow the discussion of possible futures in the present without being based on the experience of the past, that is, without having actually experienced these historical situations. In other words, unlike biological evolution, cultural evolution restructures the observations of the past and writes the present through the interaction between the anticipatory subdynamics.

This idea that the present is shaped in advance was first expressed by Joseph Shumpeter, in his 1939 book about the business cycle, in which he created the concept of “creative destruction”. It can also be attributed to Edmund Husserl, who introduced the idea of “intersubjectivity” in 1929 as a system different from the notion of “subjectivity”, aspects which are discussed by the author in chapter 11.

The book is divided into eleven chapters and a preface. Chapter 1 and the preface together summarize the main concepts and assumptions of the Triple Helix model which forms the basis of the analytical and theoretical analyses of the knowledge-based economy. This introductory section makes it clear just how challenging the author's proposition is, starting with the definition of the concept of the knowledge-based economy.

Researchers working on this new approach to the economy now have access to a reference which is extremely rich in theoretical and empirical insights. The concept of the knowledge-based economy, presented in the introductory part of the book, is itself radically different from the thinking which has been prevalent up to now. In light of the relevance of the issue, the authors of this review thought it appropriate to provide a brief interpretation of the author's thinking on this question.

The knowledge-based economy does not emerge at the point when digital information and communication technologies begin to spread, even though this process is an inherent part of its dynamic. According to the author, the emergence of this new system took place when institutions were created with the purpose of guaranteeing the systematic organization of knowledge production and control, which he argues took place at the end of the 19th century. He believes that this was responsible for the creation of a third subdynamic, which resulted in the Triple Helix which defines the dynamic of the knowledge-based economy.

The market and the geographical space are the two other subdynamics of the Triple Helix (for the purposes of empirical study, the tangible dimension formed by the university-industry-government trio may be used). The knowledge-based economy should therefore be understood as an analytical reference – a hypothesis – contained in the reflection that each of these subdynamics co-evolve with the others and that these co-evolutions integrate to form a second-order dynamic, defined in relation to the notion of globalization.

The existence of a third subdynamic allows the analytical understanding of a third operator or observer agent, which establishes interconnections with the communication system generated through the co-evolution of the other two subdynamics; however, the information exchanged in these interconnections carries uncertainties, that is, they carry meanings which are still unfamiliar to the processors of the meaning connected within the subdynamics which co-evolve. This

uncertainty generates reflection, which in turn generates incursion, shaping the present in terms of future events which are perceived in the knowledge which is reflected. Discursive knowledge, which defines incursive practice within a co-evolution, upon receiving the element of uncertainty which comes from the third subdynamic, is permanently deconstructed and reconstructed by reflection.

The knowledge-based economy is therefore defined as an economy based on the anticipatory dynamic, that is, on an incursive dynamic in permanent transition. By accelerating the production, the exchange and the processing power of information, the diffusion of digital information and communication technologies has the clear role of deepening this anticipatory dynamic.

Chapter 2 is dedicated to analyzing the dynamic of the knowledge-based economy from a communication theory perspective. The most important thing in this chapter is the theory that perceived events generate information (Shannon-type information), the meaning of which will depend on the specificities and the cognitive capacity of each layer of the system for which these events seem relevant. Before its meaning is processed, all information is an uncertainty. Communication, in turn, is a more restricted concept, since it refers to the exchange of information with a defined meaning (relevant information), thereby forming the links of the communication system. From a dynamic point of view, communication is a process which unfolds along the axis of time, but the reflective and incursive potential of information periodically has an effect on the mechanisms for selecting information and producing meanings, disturbing them. As a result, new meanings and communication channels emerge within the social system. In this sense, the knowledge-based economy can be defined as a system for the exchange of relevant information (meaning) which is in permanent transition and which includes feedback mechanisms which create an ongoing increase in the capacity for reflection and incursion of the operators within the communication system.

In chapters 3 and 4, the author formalizes the concept of the anticipatory system through the simulation models. The central point of these models is the assumption that the layers of the communication system are differentiated in terms of the nature and the structure of the mechanisms for the selection of information and the production of the meaning. These differences create subdynamics with asynchronous temporalities in their feedback operations and orthogonal images of the same object. These differences produce different understandings of the same reality, which introduces the idea of uncertainty into the reflection, from which a second-order dynamic emerges, which materializes in the advance of the operators' capacity to process complexities within the communication system.

Chapter 5 is dedicated to analyses of the conditions which guarantee the emergence and the

operation of the anticipatory system, that is, of the knowledge-based system. According to these analyses, the decisive step for the emergence of this system takes place at the moment when two of its subdynamics stop being recursive – which follows the axis of historical time in its relations with causality (the past determines the present) – transforming itself into incursive subdynamics – which inverts the axis of time (the future determines the present).

In analytical terms, a dynamic evolving in isolation and recursively tends to generate explosive cycles or trajectories. In turn, two dynamics co-evolving recursively tend to generate lock-in (irreversible trajectories). Finally, the incorporation of a third recursive subdynamic on top of two other dynamics which are co-evolving recursively generates bifurcation or chaos. Therefore, an anticipatory system is only conceivable within the assumption that at least two of the subdynamics are co-evolving incursively. By definition, the market is an incursive subdynamic, since the selection process in the present (supply and demand) involves expectations about the future. The same thing happens with the systematic organization of knowledge production and control. In co-evolution, each of these subdynamics makes an incursion on the other, producing hyper-incursion: the operators of the market are interested in the knowledge which can generate profit in the future; the operators of the knowledge are interested in the markets which show the prospect of absorbing the knowledge which is produced.

Hyper-incursion is a necessary condition, but, paradoxically, it creates lock-in tendencies in the absence of a third subdynamic interacting with the others. The role of this third subdynamic is to introduce the limit of uncertainty over the hyper-incursion, which makes it imperative to perfect the capacity of the communication system to process complexities, which defines a knowledge-based system.

Chapters 6 and 7 can be seen as a historical and analytical digression from the emergence of the knowledge-based economy. These chapters focus on the evolution of the communication system, since the Triple Helix dynamic is based on the self-organization of the production and exchange of Shannon-type information (uncertainty) and the selection of this information within each subdynamic.

According to the author, the invention of the printing press and publication on the scale of the Bible (and other books) represented the first milestone on the path towards the emergence of the knowledge-based system, as well as a good example of the self-organization of knowledge production and exchange and its impact on the social system (the arrival of Protestantism and capitalism).

The invention of the printing press was analytically interpreted as a bifurcation (or distortion) of the social system. As was explained above, bifurcation, or chaos, are tendencies which define systems in which the global dynamic (hypercycle) stems from the integration of the

three subdynamics which co-evolve recursively. From a historical point of view, this bifurcation took place at the time when the dynamic of the social system was marked by three fundamental tendencies: the advance of the colonial system, the strengthening of nation-states and the consolidation of scientific thought.

The systematic organization of knowledge production and control represents the bifurcation which definitively consolidated the bases of the knowledge-based system. The roots of this transformation lie in the consolidation of the republican and free market systems.

Chapters 8, 9 and 10 are dedicated to empirical studies measuring the knowledge-based economy, or more precisely, the university-industry-government Triple Helix. Chapter 8 focuses on the global economy and chapters 9 and 10 deal with the Dutch and German economies respectively. The concept of mutual information or transmission is the key idea of these chapters. Every time a piece of information is produced and exchanged within a subdynamic it creates an uncertainty for the operators of the other subdynamics. This results in positive transmission. When the information is produced in co-evolution, it becomes relevant (has meaning) for the operators of the subdynamics which co-evolve, thereby creating a negative transmission. Finally, the information produced and exchanged based on the integration of the three subdynamics creates positive transmission, since a third subdynamic always introduces the limit of uncertainty into the information exchanged between the operators of the subdynamics which co-evolve.

The balance between the total negative transmissions and the total positive transmissions indicates the degree of deepening of the knowledge-based economy. The greater the relative share of negative transmission, the greater this deepening.

It is worth noting that the limit of uncertainty present in the layer of the communication system where the information relevant to the integration of the three

subdynamics is produced and exchanged is a sine qua non condition for the self-organization of the Triple Helix communication system. The presence of this element and the negative balance of transmission are the fundamental characteristics which make the knowledge-based economy a non-chaotic system in permanent transition.

In the final chapter the author presents a summary and conclusions. In this section, he reaffirms his theory that the evolution of the social system is guided by mutual subjective evaluations (intersubjectivity) between the operators of the system, who differ in terms of the mechanisms for selecting information and producing meaning, which leads to the emergence of a generalized and self-organized communication system.

The main contributions of the author can be highlighted as follows. First of all, he provides a radically new modeling and simulation of the system which has the knowledge-based economy at its heart, capturing the existing coordination between structure, communication and hierarchical position in the decision-making process. Secondly, he proposes a rupture, both theoretical and technical, to understand the internal dynamic of the knowledge-based economy, by introducing a third dynamic in the model and proposing the use of simulation models to show the qualitative transition of the economic conditions which are strongly influenced by knowledge. Finally, he makes important contributions to the work of the sociologist Niklas Luhmann, one of the few social scientists capable of explaining a decisive event when it takes place, introducing the phenomenon of anticipation into his theory.

The work reviewed on here may be of interest to all professionals who wish to broaden their knowledge of the knowledge-based economy. We refer not only to theorists of this new kind of economy, but also to the policymakers responsible for the formulation and the implementation of science, technology and health innovation policies.

