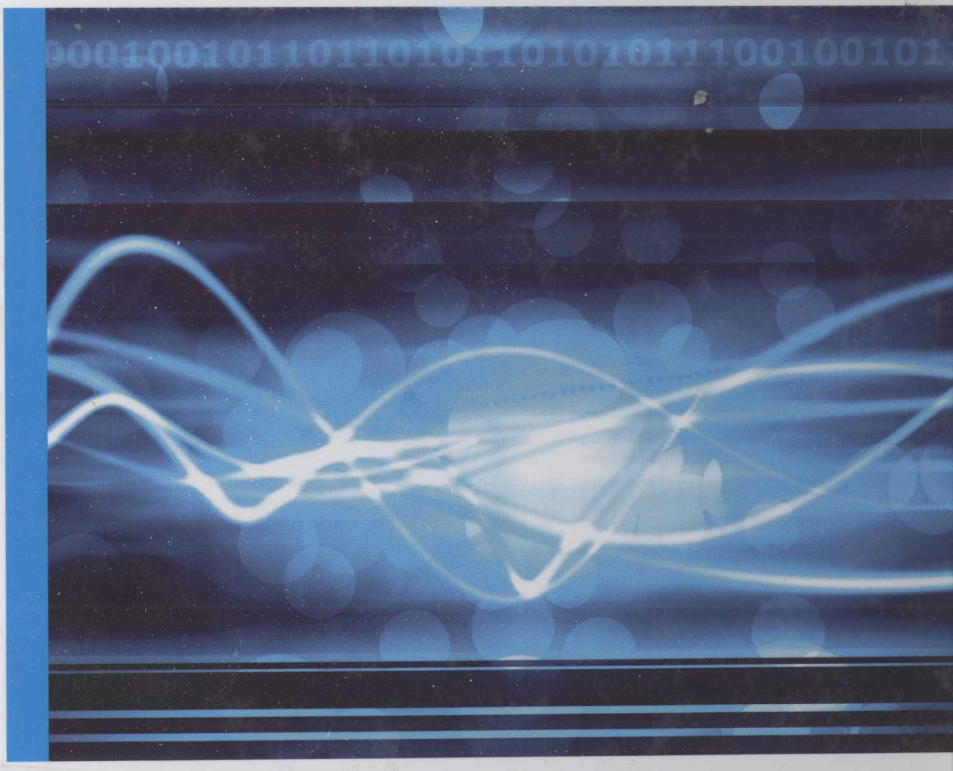
Knowledge Diffusion and Innovation

MODELLING COMPLEX ENTREPRENEURIAL BEHAVIOURS



Piergiuseppe Morone • Richard Taylor

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Piergiuseppe Morone
University of Foggia, Italy

Richard Taylor
Stockholm Environment Institute, Oxford, UK

Edward Elgar
Cheltenham, UK • Northampton, MA, USA

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PART I

Theory

1. Introduction

WHY A BOOK ON KNOWLEDGE DIFFUSION AND INNOVATION?

Economists, scientists, policy-makers and, more and more often, common people refer to modern economies as knowledge-based because of the growing relevance knowledge is acquiring in everyday life. Indeed, institutions, firms and individuals progressively rely on knowledge as a key component for individual and collective growth. This calls for a clear understanding of knowledge and its sharing patterns.

While attempting to define knowledge and investigating the complex process which determines its sharing patterns, we agree with Grant's (1996) concern that these are long-standing questions which have intrigued some of the world's greatest thinkers from Plato to Popper without the emergence of a clear consensus. Hence, in this book the focus of the investigation is restricted to the type of knowledge used by firms in the production process and, more importantly, in innovative activities.

A firm's ability to innovate depends largely upon its ability to capture and nurture human intellectual capital effectively. One important part of this process is research and development (R&D), which represents a fundamental activity for creating new knowledge for production and innovation. However, the simultaneous ongoing processes of knowledge deepening and knowledge widening – which leads to a general expansion of the range of available technologies, as well as to a growing specialization of competencies – calls for new, interactive patterns of learning.

Individual learning activities – as they are conceived in an R&D laboratory – are no longer sufficient to put together all the required knowledge it takes to be competitive. Innovative firms need specialized knowledge, as well as more types of knowledge, which increasingly lie outside the firm itself. However, because of its tacit

component,[1] knowledge, and especially new knowledge, can be difficult to acquire in the market, so firms seek some form of collaboration with other firms and/or institutions that possess the required knowledge and, on a reciprocal basis, are keen on sharing it. Hence, firms act to create links through which to access disparate and specialized resources of knowledge needed to innovate. The emerging configuration and reconfiguration of social networks of all types should then reflect the shifting demand of the knowledge economy.

This ongoing process makes it increasingly relevant to investigate the dynamics through which firms share knowledge, and calls for a thorough understanding of knowledge diffusion patterns. This entails understanding the processes through which external-to-the-firm knowledge is acquired and integrated with internal knowledge, a process which might turn out to be complex and hard to manage.

WHY THIS BOOK ON KNOWLEDGE DIFFUSION AND INNOVATION?

Now that we have explained the need for a book on knowledge diffusion and innovation, we should clarify how this book should serve the purpose of bridging the gaps in the existing understanding of knowledge diffusion and innovation. In the field of knowledge-related studies complexity arises at several levels. First, knowledge should be understood as a complex system which goes well beyond the dichotomous nature of information. Acquiring knowledge, from whatever sources, entails cognition and complex integration processes: as pointed out by Ancori et al. (2000), the economics of knowledge differs from the economics of information in the sense that knowledge is no longer assimilated to the accumulation of information in a stockpile. The distinction between these two concepts has been repeatedly ignored by a certain branch of the economic literature (economics of information), which does not consider the cognitive structure that agents use to elaborate knowledge.

Following this distinction, Ancori et al. developed a theory in which knowledge is acquired 'by a backward process through which the new knowledge is confronted and articulated with previous experience . . . The appropriation of crude knowledge – i.e. its integration in one's cognitive context – is not the result of a transmission, but rather the result of a re-engineering process' (2000, p. 267). Hence

knowledge is a complex phenomenon which requires a complex and costly cognitive process in order to be acquired. However, knowledge diffusion is not the only possible way of sharing competences. For instance firms can pool together their specialized knowledge on specific projects. Such a knowledge integration mechanism does not entail knowledge transfer.

This being said, the main elements of novelty of this study rest precisely on the complex approach undertaken to study the phenomenon under investigation. In this book we provide a definition of knowledge which is grounded in recent studies on complexity theory and, subsequently, use an agent-based social simulation methodology to address the issue of innovation – as we believe that there is great potential in addressing studies on complex social systems employing agent-based simulation models. In areas dominated by complex phenomena (such as modelling social systems) agent-based models represent, in the authors' view, a new and promising tool for scientific computational studies.

THE BOOK STRUCTURE

The book is structured in two parts. In the first part the existing literature on knowledge economics is reviewed and the issues of knowledge complexity, and knowledge and innovation, are introduced. Specifically, we first review the main literature on the knowledge-based economy, focusing on the important link between knowledge and innovation. We focus our attention on various definitions of knowledge (distinguishing between knowledge and information, as well as between tacit and codified knowledge), on the relevance of the geographical dimension for knowledge diffusion, and finally on various patterns of diffusion associated with knowledge flows (distinguishing among various forms of voluntary and involuntary-based knowledge-sharing patterns) (Chapter 2).

Subsequently, we introduce the issue of modelling knowledge and its sharing patterns. We depart from classical studies on social learning, where the patterns of information and knowledge diffusion are explored with respect to innovation adoption dynamics, and proceed to review more recent models where knowledge is considered and modelled as a complex concept (Chapter 3).

This literature review leads us to the core idea of the book, that

knowledge, and the learning processes associated with it, needs to be modelled using complex representations and appropriate tools. Critical factors in formal modelling concern the representation of knowledge (for example whether as a scalar or as a vector), the characteristics of the network structure upon which knowledge interactions (and innovation) take place, and also the temporal aspects of knowledge diffusion – simulations being sensitive to initial conditions and to the application of specific updating mechanisms.

All these factors are explored in Chapter 4 of the book, where we present an original agent-based model of knowledge diffusion, grounded in complex definitions of knowledge and network relations. In addition, the diffusion model is related to innovation processes where innovation stems from the recombination or integration of knowledge by means of a cognitive process which could be conducted either individually or collectively.

The second part of the book is dedicated to applications and empirical studies. This part opens with a chapter (Chapter 5) in which several empirical studies on the measurement of knowledge flows are reviewed. Subsequently, Chapter 6 presents a methodological investigation which first examines two alternative ways of doing research with agent-based modelling. These are theoretical and applied studies, incorporating agent-based models as a means of investigation through simulation. This is followed by a closely related discussion of validation of agent-based models. Here, validation is considered quite broadly, encompassing both inputs and outputs to the modelling as well as all stages of the model building and analysis.

In Chapter 7 an applied version of the knowledge diffusion model developed in Chapter 4 is presented. This is a calibrated model which makes use of data collected from field work conducted in Italy. The aim of this chapter is to test the validity of the model against a real-world case study, providing at the same time an exemplification of how validation of an applied model can be conducted. Chapter 8 concludes the book and presents several ideas for future research.

NOTE

1. Tacit knowledge is a type of knowledge that cannot be codified and, therefore, requires direct experience and personal interactions in order to be communicated. We will return to this concept in Chapter 2.

2. Knowledge economy: old and new issues

Due to the growing competitive pressure coming from emerging economies, modern manufacturing industries in developed countries have progressively shifted their focus from the physical processes of production to the design and marketing phases and, more relevantly, to the innovation of new products and production processes. In fact, in a globalized and competitive environment, the only viable way for firms operating in rich countries to enhance competitiveness is constantly to empower their innovative capabilities.

Innovation, defined as the process by which firms master and put into practice new product designs and manufacturing processes (Nelson and Rosenberg 1993), has to be understood as a process in which 'new knowledge or new combinations of old knowledge are embodied in products and production processes and possibly introduced into the economy' (Oerlemans et al. 1998, p. 4). Hence, innovation crucially involves the use of existing knowledge, as well as the ability to generate and acquire new knowledge (Howells 2002, p. 872). This view, shared by many scholars, supports the idea that firms progressively rely on knowledge as a key input of successful and long-lasting innovating activities (Pinch et al. 2003; Forsman and Solitander 2003). In other words, firms' long-term competitiveness is highly dependent on their ability to innovate and, therefore, on their ability to enhance their knowledge base (Florida 1995; Cooke 2001; Malmberg and Maskell 2002).[1] The knowledge base of a firm could be defined as the collective character of the knowledge which depends both on individual human resources and on the mechanisms of interaction within the organization (Saviotti 1999).

The existing literature has identified at least two broad ways in which firms can enrich their knowledge base: through the use of the internal resources of the firm as well as through the use of resources located externally to the firm. On the one hand, '[l]earning to use

internal resources can be accomplished in several different ways, for example through R&D activities or learning by using or doing' (Oerlemans et al. 1998, pp. 3–4). On the other hand, the external mobilization of resources, which has been labelled 'learning by interacting' (Lundvall 1988, p. 362), involves the use of knowledge and experience of other economic actors (Oerlemans et al. 1998, pp. 3–4). Along these lines, David and Foray (2002) suggest that the 'gear change' in the growing speed and intensity of innovation observed over the recent decades comes about through the intensification of formal R&D activities, that is, working 'offline', isolated and 'sheltered' from the regular production of goods and services, but also, and perhaps more importantly, by learning 'online' where individuals can assess the acquired knowledge and hone their practices for future activities. Thus, understanding the sources of innovation and competitiveness in modern economies calls for a clear understanding of knowledge creation and its sharing patterns (that is, learning activities *latu sensu*).

In this chapter we will try to summarize some of the issues related to the knowledge economy. Specifically, we will focus our attention on various definitions of knowledge (distinguishing between knowledge and information, as well as between tacit and codified knowledge); on the relevance of the geographical dimension for knowledge diffusion (distinguishing between physical and relational proximity); and finally, on various patterns of diffusion associated to knowledge flows (distinguishing among various forms of voluntary- and involuntary-based knowledge-sharing patterns). Finally, we will introduce the issue of modelling knowledge and its sharing patterns. This will serve as an introduction to the analysis developed in Chapter 3.

DEFINING KNOWLEDGE

The growing knowledge flow which characterizes the so-called 'knowledge society' has made organizations increasingly concerned with the problem of selecting and organizing knowledge in a cost-efficient manner. As put by Johnson and Lundvall (1994), firms are becoming 'learning organizations' which define their internal organizational models in order to enhance their learning capabilities. The authors distinguish between different kinds of knowledge which

can be summarized as follows: (1) 'know what'; (2) 'know why'; (3) 'know how'; and (4) 'know who'.

The first type of knowledge refers to knowledge about 'facts' (for example how much does a firm invest in physical capital? how many bones compose the human skeleton? what codebook contains a specific law? and so on); it relates directly to the concept of information. As observed by Lundvall and Foray: 'there are complex areas where experts must hold a great deal of this kind of knowledge in order to fulfil their jobs – practitioners of law and medicine belong to this category' (Lundvall and Foray 1998, p. 116).

The second kind of knowledge refers to 'the scientific knowledge of principles and laws of motion in nature, in the human mind, and in society' (Lundvall and Foray 1998, p. 116). It is extremely relevant to speed up the advances in technology and to reduce frequency of errors in trial-and-error development processes. It serves as a key input for technological progress, and it is typically embedded in a skilled labour force.

The third kind of knowledge refers directly to personal skills and should be explicitly interpreted as the capability of being able to do something. Know-how has been typically associated with the kind of knowledge developed and kept within the firm. However, 'as the complexity of the knowledge base increases, a mix of division of labour and co-operation is also tending to develop in this field' (Lundvall and Foray 1998, p. 116).

The fourth kind of knowledge (know who) is similarly becoming increasingly relevant for firms nowadays. Know who refers directly to the kind of information 'about who knows what and who knows how to do what' (Lundvall and Foray 1998, p. 116). Because specialized knowledge and skills are essential elements for innovation and 'are widely dispersed due to the highly developed division of labour among organizations and experts' (Lundvall and Foray 1998, p. 116) knowledge of whom to contact is particularly valuable in this context.

Behind this classification of various kinds of knowledge there is a general distinction between knowledge and information which it is worth thinking upon. As it clearly emerges, knowledge and information are interlinked concepts; however it would be incorrect to refer to the learning activity (independently of the kind of knowledge we are referring to) simply as the accumulation of information.

Knowledge and Information

As recognized by many scholars, knowledge differs substantially from information (see, among many others, Foray 2004; Steinmueller 2002). However, Ancori et al. observed how the neoclassical approach of economics adopts a vision that 'allows the reduction of knowledge to information, or more precisely allows knowledge to be considered a stock accumulated from interaction with an information flux' (Ancori et al. 2000, p. 259). In a typical neoclassical fashion the universe can be described by a finite set of states to which probabilities can be assigned (Laffont 1989). In this view: '[k]nowledge improves when the probability of a particular state is estimated more accurately' (Foray 2004, p. 4). Hence, knowledge is assimilated to information upon a vector of probability related to a predetermined set of states.

This view has recently come under criticism as it does not allow such important concepts as learning and cognition (Foray 2004). As maintained by several scholars, knowledge and information should be considered as two distinct concepts: the latter taking the form of structured data which can be easily transferred through physical supports, and the former involving cognition (see, for instance, Steinmueller 2002; Forero-Pineda and Salazar 2002; David and Foray 2002).

In Howells's view:

> knowledge can be defined as a dynamic framework or structure from which information can be sorted, processed and understood . . . Knowledge is therefore associated with a process that involves cognitive structures which can assimilate information and put it into a wired context, allowing actions to be undertaken from it. (Howells 2002, p. 872)

Hence, knowledge is generated through a cognitive process within which information is articulated with other information. This process, which we can label 'learning', allows actors to undertake actions which require the use of the acquired knowledge.

The full meaning of this distinction becomes clearer – maintains Foray – when one looks at the differences between the reproduction processes of knowledge and information: while the cost of reproducing information amounts solely to the physical cost of making a copy (for example the cost of a photocopy, the cost of duplicating