Introduction

Ken Green, Marcela Miozzo and Paul Dewick

This collection of essays brings together papers that were presented at the sixth biennial conference of Advances in Social and Economic Aspects of Technology (ASEAT) on 'Knowledge and Economic and Social Change: New Challenges to Innovation Studies' that was held in Manchester between 7 and 9 April 2003. The contributions have a common theme: the role of knowledge and innovation in firm strategy and industrial change. Underlying all the papers is an understanding that firms have distinctive ways of doing things and, moreover, that these ways of doing things have strong elements of continuity. The papers explore the role played by firms in developing, linking and utilizing knowledge produced in many social institutions to advance their organizational and technological capabilities. Understanding how firms advance their capabilities is essential to understanding how the economy operates and changes.

There is a long tradition of research underlining the importance of differences in organizational and technological capabilities of firms and their effect on economic performance. Edith Penrose's writings are the first point of departure to the understanding of how firms grow in the direction of their capabilities and how these capabilities expand and alter. Penrose (1959) saw the growth of a firm as based on the possession and development of unique and idiosyncratic resources. The second point of departure is George Richardson (1972) who presents firms as sets of activities which require knowledge, experience and skill in their performance.

Offering a different perspective to dominant equilibrium models and the competitive forces framework, other scholars have linked this broad capabilities perspective to questions of competition and industrial change. The importance of routines has been emphasized by evolutionary economics. Nelson and Winter (1977) have argued that R&D strategies of firms do not follow maximizing criteria but, instead, follow rules of thumb. They suggest that there are powerful intra-project heuristics when technology is advanced in certain directions, with payoffs from advancing in that same direction. The importance of routines has been further refined by the contributions on strategic management (Teece et al., 1997) that argue that the competitive

advantage of firms is seen as resting on distinctive processes, shaped by the firm's assets and the evolution path it has adopted or inherited. These theories emphasize the significance of knowledge, and place the practices that surround the development and use of knowledge as fundamental elements defining the firm. The competitive advantage of firms is regarded as resting on distinctive high performance routines operating inside the firm, embedded in the firm's processes and conditioned by its history.

These contributions have helped advance a so-called 'dynamic capabilities' framework to examine the sources and methods of competitive advantage of firms operating in Schumpeterian environments of innovation-based competition. The work of business historians such as Chandler (1977) and Lazonick (1991) has added to this framework, contributing to the understanding of the way in which firms' organizational and technological capabilities have changed over the past century and how these changes explain the shifts in international industrial leadership.

Drawing on the above contributions, the chapters of this book take up the challenge of identifying the significance of mechanisms, internal or external to the firm, which can assist the development and use of resources, routines and capabilities through the management of knowledge. These give rise to patterns of technical change and knowledge bases underlying innovative activities, 'technological trajectories' (Dosi, 1988) and 'technological paradigms' (Freeman and Perez, 1988). More generally, they link to Schumpeter's (1934, 1942) work, which suggested that there are 'technological revolutions', which can have pervasive effects throughout the economy, leading not only to the emergence of new products, services, systems and industries but also affecting almost every other branch of the economy. These 'technological revolutions' affect the input cost structure and conditions of production and distribution, and the general 'natural trajectories' (Nelson and Winter, 1982) which, once established, exert a dominant influence on engineers, designers and managers. Schumpeter's long waves or cycles ('gales of creative destruction') can be seen as a succession of 'techno-economic paradigms' (Freeman and Perez, 1988) whose diffusion is accompanied by structural crises, in which social and institutional changes are required to bring about a better 'match' between the new technology and the institutions in the economy.

SYNOPSIS OF THE BOOK

Part One examines the mechanisms internal to the firm which contribute to the development of firm capabilities through the management of knowledge. Mark Dodgson, David Gann and Ammon Salter argue that the

recent application of new electronic technologies in simulation and virtual modelling techniques in design and prototyping activities has resulted in the intensification of the innovation process. The authors ground their analyses on resource-based and behavioural theories of the firm, and strategic management theories on dynamic capabilities and evolutionary economics – all of which emphasize the significance of knowledge, and place the practices that surround the use of knowledge as fundamental elements of firm constructs. Also, they base their discussion on empirical research with engineering firms. They state that analyses in the innovation literature on the potential effect of these technologies have been limited. Technologies associated with design, particularly those built on ICT, have major implications for the cost and speed of the innovation process. Also, higher levels of involvement and integration of users and consumers facilitate industrial specialization and disaggregation. However, after considering the application of a number of ICT tools, they conclude that although ICT is important in its ability to codify some actions and behaviour, providing new mechanisms for the management of knowledge and innovation and development of routines and capabilities, it is the remaining tacit elements that define a firm's competitive advantage.

Cristiano Antonelli argues that the analysis of the role of knowledge in the economics of governance provides a framework that can integrate the research programmes of the economics of transaction costs and of the resource-based theory of the firm and overcome their limitations. He compares and contrasts the two theories and discusses the weaknesses of the approaches. He argues that transaction costs economics pays little attention to organizational knowledge and the competence necessary to coordinate and use the markets respectively and hence little room is left for understanding the process of accumulation of new organizational knowledge and the introduction of organizational innovation. The resource-based theory is unable to appreciate the role of organizational constraints in shaping the rate and direction of the growth of the firm. In the context provided by the economics of governance, he models the interdependence among transaction, coordination and production as a microsystem where localized technological and organizational knowledge plays a central role. The dynamic model presents the firm as a bundle of activities characterized by learning.

Jeremy Howells explores the role of consumption in the firm's innovation process, both in the existing literature and using primary case study material. The author argues that services play a key intermediary and conduit role in the innovation process and the analysis focuses on the role of services in the consumption of new goods by firms. The chapter briefly explores the trend by which firms are offering service products related to the manufactured goods they produce and takes examples from the vehicle

manufacturer, aerospace and healthcare industries. These encapsulation mechanisms suggest a new concept of the relationship between consumption and innovation moving beyond the ideas of outsourcing and vertical integration. The chapter assesses the effect of the encapsulation process on innovation and suggests that firms need a more integrated consumption knowledge framework within which they can harness core capabilities.

Part Two examines the role of innovation and knowledge in the development of distinctive firm capabilities and strategy. Virginia Acha and John Finch draw upon the capabilities approach to examine recent changes in the upstream petroleum industry, in which a subset of operating firms have begun exploration, and, in some cases, production activities offshore in what the industry calls deepwater. Deepwater raises significant technical challenges, but also represents significant opportunities of large hydrocarbon accumulations. Such opportunities are widely believed to have been exhausted in shallow water offshore. The authors examine the tenacity of some large oil companies in maintaining these capabilities, instead of falling back on increasingly routine activities in mature fields, compared with the reluctance of other large firms to commit to deepwater activities. Drawing from case study evidence of three major firms involved in deepwater exploration and production, they identify counter tendencies to those of routinization and modularization. Building on Penrose, they argue that managers within these firms harness resources freed up by routinization and direct these to new non-routine activities.

Staffan Hultén, Anna Nyberg and Lamia Chetioui examine the different transitions from computer and telephone banking to internet banking in two retail banks, Nordbanken in Sweden (partner in the Nordic bank Nordea) and Société Générale in France; both of whom were well known for their successful use of computer banking. Their chapter focuses on the banks' technology choices and management of external resources and also assesses the role of customers and suppliers. The two case studies, informed by a series of interviews with managers in the two banks, identify different strategies in the choice of external partners and adoption rates based on path dependency, which ultimately determined the relative success of the banks' initiatives. The more immediate success of the banks' strategies is gauged by how many Internet banking customers they have managed to attract but the authors also consider the long term effects of the different trajectories Nordea and Société Générale are following.

Robert van den Hoed and Philip Vergragt examine the automotive industry's search for an alternative to the internal combustion engine. Increasingly the fuel cell vehicle (FCV) is seen as the sustainable alternative to the internal combustion engine and during the 1990s automotive programs on FC technology grew spectacularly. However, at present, there is

no dominant design for the FCV, and the industry is split between using hydrogen, methanol or gasoline as the fuel for fuel cell vehicles. Using institutional theory and technology dynamics, the authors examine the environmental, infrastructural and technical consequences that underpin the industry's R&D decisions with regard to fuel preference. The authors draw on both qualitative and quantitative evidence from extensive interviews conducted with senior managers in the major car manufacturers to explore the factors behind the adoption decision. Institutional, strategic and cultural reasons are highlighted as important determinants in the technology choice decision and the authors identify a few opinion leaders who are shaping the decisions of the industry.

Margarida Fontes examines the characteristics of the biotechnology industry, focusing on the network structure of interfirm relationships that acts as coordination device between a variety of actors. While clustering is important for the evolution of this sector, biotechnology also presents some features – namely the international nature of scientific production and markets – that may facilitate firm development outside them. Through in-depth interviews with six new biotechnology firms in Portugal, the author identifies and discusses the main features of an 'out-cluster' strategy. She finds that these firms have been able to devise strategies to overcome some of the relative disadvantages of their location, enabling them to access and integrate nonlocal networks, to draw creatively from a combination of local and distant relationships and to manage this specific form of knowledge acquisition and business development.

Finn Valentin and Lund Jensen examine the distributed forms of innovation induced by biotechnologies in the food processing industry. The authors focus on the role of large firms and outside partners: universities, government research institutes and small specialist firms (Dedicated Biotechnology Firms, DBFs). In contrast to the US model of biotech success where DBFs have played a key role, industry incumbents have introduced virtually all innovations in the field of Lactic Acid Bacteria (LAB). Public research organizations (universities and government research institutes) are shown to contribute significantly to distributed R&D. Using a novel patent data mining tool, the authors build a complete map of contributions and collaborations from and between different institutions to describe the way in which a scientific discontinuity (in this case, biotechnology) shapes the emergence of a distributed organization of innovation and its subsequent evolution. Large incumbents are shown to patent at a level tenfold higher than general food processing firms; universities and, in particular, government research institutes are important collaborators in R&D. The findings of the chapter suggest that the US model of scientist–entrepreneurs–venture capitalists does not thrive in the area of LAB food biotechnology. The authors

attribute this finding to low decomposability of the problem definition, which instead relies on an active role of public science.

In light of the downsizing or closing of research labs in many R&D-intensive firms over recent years, Robert Tijssen examines questions whether corporate research capabilities and activities are being managed increasingly as an economic asset, ruled by market forces. Despite a lack of global comparative measurements of industry's basic research efforts and its effect on research outputs, the author uses a new source of information on corporate research activity: research articles published in international scientific and technical journals. Important changes are identified from a statistical analysis of 290 000 corporate research articles that list author affiliate addresses in the corporate sector and which were published in international journals during the years 1996–2001. Whilst the number of patents and patent citations to research literature has increased significantly, the numbers of corporate research articles have declined steadily. The author undertakes a detailed analysis of trends in the pharmaceuticals sector and semiconductors sector and highlights sector-specific publication trends and patterns related to their innovation processes. Robert Tijssen concludes that the observed declines provide suggestive empirical evidence that corporate research is in a process of structural change where appropriation and commercialisation of research results reduce accidental and voluntary knowledge spillovers from industry into the public domain.

Part Three explores the relation between the internal mechanisms of the firm designed to develop and use knowledge and the long term patterns of technological change. Jonathan Köhler develops a simulation model of long term technical change. He argues that, due to deficiencies in data, the unsuitability of econometrics for modelling beyond the short to medium term as well as the number of socioeconomic variables to be considered, means that there is no generally accepted theory to date on long term technical change for incorporation into a macro-modelling structure. Based on Freeman and Louçã's (2001) descriptive theory, which encompasses the ideas on long waves from Kondratiev and Schumpeter, Kohler argues that socioeconomic activity since the late 1700s can be interpreted by a dynamic macroeconomic model. Learning by doing and falling production costs are combined with an investment bubble and a lagged supply response to generate the boom phase of a Kondratiev wave.

Building on the literature on diffusion of innovation, Masaaki Hirooka examines the period of technology development in firms, which occurs before innovation diffusion takes place (a phase which is more extensively researched than the technology development period). He argues that this period can be characterized by two trajectories: the technology trajectory and the development trajectory. The technology trajectory is composed of a

series of core technologies (encompassing basic research) and the development trajectory is a locus of new products in the course of technology development (encompassing technology transfer from universities to research). Whilst it is well established that the diffusion of innovation has a nonlinear nature, Hirooka shows that the technology and development period can also be characterized by a logistic curve. Thus, the innovation paradigm is composed of three logistic trajectories describing the technology, development and diffusion stages. He offers evidence for all three trajectories and for the structure of the innovation paradigm. Considering the electronics paradigm, he identifies and discusses the key actors involved in the development trajectory: universities, venture businesses and the government.

REFERENCES

- Chandler, A. (1977), *The Visible Hand: The Managerial Revolution in American Business*, Cambridge, MA: Harvard University Press.
- Dosi, G. (1988), 'Sources, procedures, and microeconomic effects of innovation', *Journal of Economic Literature*, **26**, 1120–71.
- Freeman, C. and F. Louçã (2001), *As Time Goes By*, Oxford: Oxford University Press.
- Freeman, C. and C. Perez (1988), 'Structural crises of adjustment, business cycles and investment behaviour', in G. Dosi et al. *Technical Change and Economic Theory*, London: Pinter.
- Lazonick, W. (1991), *Business Organization and the Myth of the Market Economy*, Cambridge: Cambridge University Press.
- Nelson, R. R. and S. G. Winter (1977), 'In search of a useful theory of innovation', *Research Policy*, **6**, 36–76.
- Nelson, R. R. and S. G. Winter (1982), *An Evolutionary Theory of Economic Change*, Cambridge, MA: Harvard University Press.
- Penrose, E. (1959), *The Theory of the Growth of the Firm*, Oxford: Oxford University Press.
- Richardson, G. B. (1972), 'The organization of industry', *Economic Journal*, **82** (327), 883–96.
- Schumpeter, J. A. (1934), *The Theory of Economic Development*, Cambridge, MA: Harvard University Press.
- Schumpeter, J. A. (1942), *Capitalism, Socialism and Democracy*, New York: McGraw-Hill.
- Teece, D. J., G. Pisano and A. Shuen (1997), 'Dynamic capabilities and strategic management', *Strategic Management Journal*, **18** (7), 509–33.