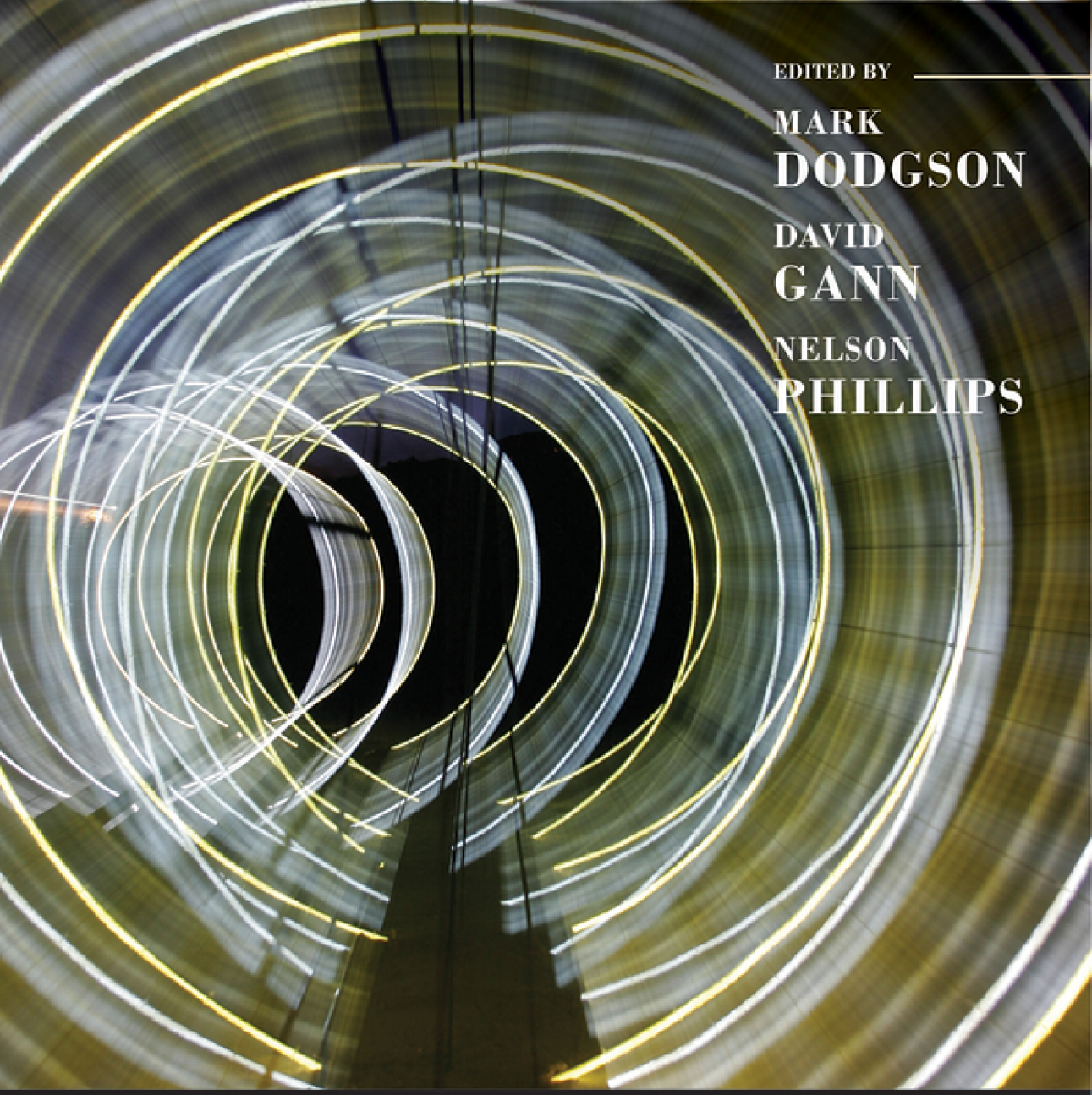

EDITED BY
MARK DODGSON
DAVID GANN
NELSON PHILLIPS

The Oxford Handbook *of* INNOVATION MANAGEMENT

THE OXFORD HANDBOOK OF

INNOVATION MANAGEMENT

THE OXFORD HANDBOOK OF

INNOVATION MANAGEMENT

Edited by

MARK DODGSON,
DAVID M. GANN,
and
NELSON PHILLIPS

OXFORD
UNIVERSITY PRESS

OXFORD
UNIVERSITY PRESS

Great Clarendon Street, Oxford, OX2 6DP,
United Kingdom

Oxford University Press is a department of the University of Oxford.
It furthers the University's objective of excellence in research, scholarship,
and education by publishing worldwide. Oxford is a registered trade mark of
Oxford University Press in the UK and in certain other countries

First Edition published in 2014

Impression: 1

Published in the United States of America by Oxford University Press
198 Madison Avenue, New York, NY 10016, United States of America

British Library Cataloguing in Publication Data
Data available

Library of Congress Control Number: 2013950632

ISBN 978–0–19–969494–5

Printed and bound in Great Britain by
CPI Group (UK) Ltd, Croydon, CR0 4YY

For Sheridan, Anne, and Cristina

Acknowledgements

Our first and greatest thank you should be to the contributors to this Handbook. Writing authoritative chapters that concisely summarize substantial literatures and identify their most important themes is a challenging task, and the authors continually surpassed our high expectations. We are grateful to them all.

We would also like to acknowledge the funds supporting the production of this volume from the University of Queensland Business School, Australian Research Council, and the Innovation Studies Centre at Imperial College, supported by the UK Engineering and Physical Sciences Research Council.

Chapter authors were prevailed upon to review other chapters, for which many thanks are due. We also wish to thank Andreas Eisingerich, Anna Plodowski, and Ileana Stigliani for their comments on individual chapters.

Contents

List of Figures

List of Tables

List of Contributors

Pamela Adams, Professor of International Management, Franklin College, Switzerland.

Gautam Ahuja, Harvey C. Fruehauf Professor of Business Administration, Ross School of Business, University of Michigan.

Oliver Alexy, Professor of Strategic Entrepreneurship, School of Management, Technical University of Munich.

Erkko Autio, Professor of Technology Venturing and Entrepreneurship, Imperial College Business School, Imperial College.

Michelle Barton, Assistant Professor in Organizational Behaviour, School of Management, Boston University.

Frans Berkhout, Professor of Innovation and Sustainability, and Director of the Amsterdam Global Change Institute, the VU University Amsterdam.

Michael A. Cusumano, Sloan Management Review Distinguished Professor of Management, Sloan School of Management, Massachusetts Institute of Technology.

Linus Dahlander, Associate Professor, European School of Management and Technology.

Andrew Davies, Professor in the Management of Projects, Bartlett Faculty of the Built Environment, University College London.

Claudio Dell'Era, Assistant Professor, Department of Management, Economics and Industrial Engineering, Politecnico di Milano.

Mark Dodgson, Professor and Director of the Technology and Innovation Management Centre, University of Queensland Business School.

Graham Dover, Mindset Foundation.

Nicolai J. Foss, Professor, Department of Strategic Management and Globalization, the Copenhagen Business School, and Department of Strategy and Management and Center for Service Innovation, Norwegian School of Economics.

Nik Franke, Professor and Founder, Institute for Entrepreneurship and Innovation, Vienna University of Economics and Business.

Sascha Friesike, Researcher, Alexander von Humboldt Institute for Internet and Society, Humboldt University of Berlin.

Takahiro Fujimoto, Professor, Faculty of Economics, University of Tokyo.

Bryan Gallagher, Researcher, Beedie School of Business, Simon Fraser University.

Alfonso Gambardella, Professor of Corporate Management, Bocconi University.

David M. Gann, Vice-President (Development and Innovation), Imperial College, and Professor, Imperial College Business School.

Oliver Gassmann, Professor and Director, Institute for Technology Management, University of St. Gallen.

Annabelle Gawer, Assistant Professor in Strategy and Innovation, Imperial College Business School.

Paola Giuri, Associate Professor, Department of Management, University of Bologna.

Andrew Hargadon, Charles J. Soderquist Chair in Entrepreneurship, Professor of Technology Management, Graduate School of Management, University of California, Davis.

Lars Håkanson, Professor of International Business, Department of International Economics and Management, Copenhagen Business School.

Alan Hughes, Margaret Thatcher Professor of Enterprise Studies and Director, Centre for Business Research, University of Cambridge and Director, UK Innovation Research Centre.

Tim Kastelle, Senior Lecturer, University of Queensland Business School.

Jerry Kim, Assistant Professor, Columbia Business School.

Keld Laursen, Professor, Department of Organizational Economics and Innovation, Copenhagen Business School and Centre for Service Innovation, Department of Strategy and Management, Norwegian School of Economics.

Thomas B. Lawrence, Weyerhaeuser Professor of Change Management, Faculty of Business Administration, Simon Fraser University.

Aija Leiponen, Associate Professor, Charles H. Dyson School of Applied Economics and Management, Cornell University and Imperial College Business School, Imperial College London.

Dorothy Leonard, William J. Abernathy Professor of Business Administration Emerita, Harvard Business School.

Franco Malerba, Professor of Applied Economics and Director, Centre for Knowledge, Internationalization, and Technology Studies, Bocconi University.

Lorenzo Massa, Researcher, University of Bologna and Vienna University of Economics and Business.

Rita Gunther McGrath, Associate Professor, Columbia Business School.

Maureen McKelvey, Professor, Institute of Innovation and Entrepreneurship, University of Gothenburg.

Elena Novelli, Lecturer in Management, Cass Business School, City University London.

Ritsuko Ozaki, Senior Research Fellow, Imperial College Business School.

Nelson Phillips, Professor of Strategy and Organizational Behaviour, Imperial College Business School.

Jaideep Prabhu, Jawaharlal Nehru Professor of Indian Business and Enterprise and Director of the Centre for India and Global Business at Judge Business School, University of Cambridge.

Ammon Salter, Professor of Technology and Innovation Management, Imperial College Business School.

John Steen, Associate Professor, University of Queensland Business School.

Bruce S. Tether, Professor of Innovation Management and Strategy, Manchester Business School.

Llewellyn D. W. Thomas, Lecturer, Imperial College Business School.

Salvatore Torrisi, Professor of Strategic Management, University of Bologna.

Christopher L. Tucci, Professor of Management of Technology, Ecole Polytechnique Fédérale de Lausanne.

Roberto Verganti, Professor of Management of Innovation, Politecnico di Milano.

Maximilian von Zedtwitz, Professor and Director of Research Centre for Global R&D Management, University of St. Gallen and Tongji University.

Marina Yue Zhang, Associate Professor, School of Economics and Management, Tsinghua University.

PART I

INTRODUCTION

CHAPTER 1

PERSPECTIVES ON INNOVATION MANAGEMENT

MARK DODGSON, DAVID M. GANN, AND NELSON PHILLIPS

Introduction

Innovation is an essential means by which organizations survive and thrive. As a result, innovation must be managed, but before it can be managed it needs to be understood. This Handbook addresses the wide range of management processes and structures supporting innovation. It is concerned with understanding the nature and dynamics of innovation and the contextual influences affecting innovation choices: historical, social, economic, cultural, legal, and technological. These shape the strategies and practices decision-makers use to improve organizational benefits from innovation. It encompasses the choices managers make regarding what innovations to pursue, and how they develop, introduce, and gain value from their endeavours.

Innovation management is an important area of study because the differing abilities of organizations to obtain benefits from innovation depend upon how well it is managed. Innovation contributes centrally to economic performance, corporate competitiveness, environmental sustainability, levels and nature of employment, and, in the final analysis, overall quality of life. There are widespread social and economic benefits from innovation, but the organizational returns from it are skewed towards those better at managing its risks and complexities.

The immense contributions innovation has made to economic welfare and social well-being have depended on innovation managers successfully overcoming its many challenges. The risks, costs, and timescales of innovation often conflict with the financial objectives, operational routines, and managerial incentives found in most organizations. The best returns to innovation may be accrued not by the innovator, but by those that emulate and copy. Innovation disrupts markets, technologies, and workplaces. It requires levels of collaboration across professional and organizational boundaries, and

tolerance of failure, that organizations find difficult to coordinate and sanction. In many instances it involves efforts to manage activities and events that are beyond the control of even their most influential contributors. At the same time, and despite these difficulties, innovation can be the most stimulating and rewarding of all organizational activities.

The study of innovation management builds upon understanding of the sources, nature, and outcomes of innovation and the economic, technological, and social context in which it occurs. There is a long tradition of research in this broader area of innovation studies, ably portrayed in *The Oxford Handbook of Innovation* (Fagerberg et al., 2005), but innovation management is a more specific, recent, and emerging area of study. This Handbook will take careful account of knowledge about innovation in general, but its interests lie particularly with how innovation is managed and the broader contextual factors that influence its management. Its concern lies with innovation within the organization and factors that affect its occurrence: its sources, strategies, and practices. It will also address the dramatic changes that have occurred over recent years in innovation resulting from new strategies and practices in companies, for example around business models, design and innovation ecosystems, and the opportunities provided by new digital technologies. There has been a recent paradigm shift in our understanding of innovation that significantly expands its scope, and this is captured in this Handbook.

This chapter offers a number of perspectives on innovation management as a developing field of study, on explanatory theories, recurrent challenges, and on its application to innovation processes. The chapter briefly introduces the rich contributions, made on a wide range of issues of innovation management, from the leading scholars whose efforts have produced this Handbook.

Before these explorations into innovation management begin, it is useful to summarize some general features of innovation. In the following chapter by Salter and Alexy, contemporary thinking about innovation in general is captured by a number of 'stylized facts', which help establish the basis for the discussions of innovation management in the rest of the book. It shows how innovation creates growth, takes different forms, is pervasive, and is based on relationships and new combinations. It discusses the patterns, speed, geography, and routines underlying innovation. Along with this chapter on perspectives on innovation management, the chapter by Salter and Alexy provides context for what follows in the rest of the Handbook.

Three Challenges in the Study of Innovation Management

1. Defining the Scope of Innovation Management

The term 'innovation' is used widely and promiscuously. As a result there is an unhelpfully extensive range of activities included under the rubric of innovation management.

If innovation management is said to include breakthroughs at the cutting edge of science, or revolutionary new business models, on the one hand, and providing new colour options for products, or forms for reporting, on the other, then its scope is too broad to develop coherent and meaningful analysis.

We are content with the widely accepted definition of innovation as the successful application of new ideas, but believe that for analytical and practical purposes the definition of innovation management has to be more nuanced. Clearly ascertaining the specific aspects, levels, and types of innovation to be managed is crucial for improving understanding.

Innovation is both an outcome and a process, a fact and an act. An innovative outcome involves the successful application of new ideas, which results from organizational processes that combine various resources to that end. Its objectives are to produce positive results for organizations and their employees, customers, clients, and partners—such as growth, profit, sustainability, and job security—with better and cheaper products and services for consumers, and personal satisfaction for its contributors. Achieving these requires a process that creates, delivers, and captures innovative outcomes by combining and coordinating resources—including people and knowledge, finance, technology, physical spaces, and networks—and their capabilities—that is, their bundles of skills.

The innovative outcomes that have received the most attention by management researchers in the past have been in new and improved products, followed by operational processes, with services lagging a long way behind. These all remain important, even as the boundaries between them become blurred (smartphones, for example, can represent all three), but innovation is also found in new markets, ways of organizing, and constructing means of producing value in business models. Innovation management addresses all these types of innovation.

Innovation has always been driven by new market and technological opportunities, but innovation emerges from many potential sources and has a multiplicity of influences. The stimulus to innovate, for example, may derive from new regulations or technical standards, competition forcing firms to develop new solutions, new funding prospects, collaborative partners, small entrepreneurial firms, or the ideas of employees across the organization. These combine to produce a complex and interrelated array of contributors to the innovation process.

Innovation extends well beyond the mechanisms that drive it—such as invention, creativity, and the imaginative recombination of existing ideas and technologies—or the processes that encourage its implementation, such as change management. Creativity contributes to the origination of ideas and invention entails showing how ideas work in practice. The classic Schumpeterian notion of innovation as the recombination and reconstitution of resources highlights the importance of merging existing ideas and artefacts in new ways. Innovation management requires knowledge of all these sources and of how ideas can be successfully applied. The application of ideas may involve learning and re-skilling, and change management that transitions people and organizations along pre-determined and well-charted paths, but is also often characterized

by experimentation, risk, and uncertainty. As pointed out in chapter 20 on innovation strategy by McGrath and Kim, change management is less of an issue for innovative organizations that continually adjust and renew their capabilities as a matter of course.

The extent of risk and uncertainty associated with innovation depends upon its ambition and amplitude. Incremental innovations occur in established markets, technologies, and ways of doing things close to an organization's existing activities. Radical innovations involve breakthroughs in markets, technologies, and ways of doing things very different from those supported by an organization's established resources and capabilities. Between these two levels on the innovation continuum are those substantial innovations that build upon existing activities, extending and diversifying them into new areas. Incremental innovations involve the renovation of existing products and processes and are the most common form of innovation. Radical innovations are rare, but can be highly consequential. Individual chapters in this book address the management of incremental and radical innovation, but the vast majority of chapters are concerned with those intermediate levels of innovation that require significant changes in resources and capabilities. They reflect the way the major concern of innovation management lies less with doing everyday things better or engaging in highly uncertain projects, and more with the controlled ambition and risk of doing challenging new things.

2. The Changing Nature of Innovation Management

Time is a crucial issue in understanding and managing innovation. The costs of investing in innovation are immediate, while the returns can be long term. The long-term benefits may create value unappreciated at the time of investment. The investment in underground railways and sewers in Victorian London produced billions of pounds of value 150 years later. Changes occur over time: today's incremental innovations may be based on yesterday's radical innovations, and these can occur quickly. One of the difficulties in studying innovation management is that all types of innovation can occur with remarkable speed: substantial new businesses and technologies can emerge in a very short time. Researchers studying the latest innovations may discover that their findings have been superseded by the time they publish. The innovation process itself, furthermore, also changes as a result of the application of new organizational approaches and technologies that speed up the manipulation of information and ideas, for example, by the Internet and social media. Research into innovation management has evolved as innovation processes change over time.

Joseph Schumpeter, the doyen of innovation economists, began his analysis of innovation in the early twentieth century predominantly focusing on the actions of individual entrepreneurs. The growth of formally organized research and development (R&D) departments in the 1920s and 1930s occurred during his lifetime, and his later works on the economics of innovation in the 1940s focused on the role of corporations. The transformational impact of research and analysis can also be seen historically. Adam Smith wrote of the advantages of the division of labour—the

specialization of replicable tasks—and his observations were shortly thereafter put to productive use by pioneers of the Industrial Revolution such as Matthew Boulton and Josiah Wedgwood.

The consequence of such research is seen in the history of the automotive industry. The development of mass production techniques for automobiles, epitomized by Henry Ford, led to research on improving productivity in industry more widely through further specialization using the 'time and motion' studies associated with F. W. Taylor and Gilbreth. In contrast to this approach, which generally led to the de-skilling of workers, the Quality of Working Life movement emerged in the 1970s, allied to experiments with multitasking in the Volvo Company in Sweden. Studies of Japanese car making and the Toyota production system—described as 'lean production'—in the 1980s inspired the replication of its practices, such as 'just in time' delivery of components and certain quality management techniques, around the world. Innovation and innovation management research continue to co-evolve, and they necessarily have to be studied in a dynamic and interrelated manner.

There are robust lessons for innovation management in past experiences, but as innovation outcomes and processes are continually evolving, understanding contemporary practices is crucial. Here the study of innovation management not only faces the problem of the uncertain progress of businesses and technologies, but also that of particular management fads, to which the field is especially vulnerable. The complexity of organizational problems is often in inverse proportion to the enthusiasm for finding simple or all-encompassing solutions to them. Innovation management has seen a plethora of supportive tools and techniques emerge, mostly originating from academic research into a few organizations and generalized into consulting offerings. Some of these, which will be described later in this book, have retained value, but most have at one time or another been oversold and used inappropriately. The challenge for innovation researchers is to determine and retain the value of the tried and tested, while maintaining interest in the new and emerging with sufficient degrees of circumspection and caution.

3. Merging Disciplines, Levels of Analysis, and Research Methods

As revealed by the diverse backgrounds of the contributors to this book, the study of innovation management draws on a wide range of academic disciplines. Authors in this volume are scientists, engineers, economists, historians, geographers, psychologists, sociologists, and students of management and organizations. This plurality is inevitable because innovation management has wide-ranging concerns. A major challenge for innovation management scholarship generally, and more particularly for this book, is to build synergies between its different aspects being studied.

There is considerable value in connecting practice and context. Although innovation management can be highly idiosyncratic, reflecting differences in an individual organization's markets, technologies, resources, and capabilities, it is broadly affected

by the wider context in which it occurs. Chapter 9 by Hargadon, on brokerage, shows how the genesis and impact of innovation are affected by the interrelationships between institutions, organizations, small teams, and individuals. Other research shows how the position of the organization in the industry and product life cycle affects the kind of innovation sought (Abernathy and Utterback, 1975). Whether or not organizations are part of particular technological trajectories (Dosi, 1982), or how their circumstances depend on the accumulation of particular assets, can be influential. Reaping returns to innovation depends on the extent to which organizations rely on the provision of complementary assets—the related resources needed to gain value from an innovation—by other organizations, and the method by which returns are appropriated (what Teece (1986) calls appropriability regimes).

Innovation also occurs in the context of various collections or systems of institutions and the character of connections within them. National innovation systems include the institutions of research, education, finance, and law, and the quality of relationships amongst their various contributors. These importantly include the nature of the relationships between users and suppliers, and those within geographical or industrial clusters. National and pan-national regulations are highly influential. History also matters. As shown by Fujimoto in Chapter 17 on Japanese innovation management, its practices owe much to the legacy of labour shortages after the Second World War.

Many studies of innovation management have addressed particular sectors or technologies. Much research in the 1980s, for example, focused particularly on the automotive industry, and there continues to be special interest in 'high-tech' sectors such as advanced engineering, information and communication technologies (ICT), and biotechnology. This has been balanced to some extent by the study of more traditional, but not necessarily less innovative sectors, such as construction. There remains a paucity of good studies of innovation management in service sectors, such as banking and insurance. Malerba and Adams in Chapter 10 discuss the important influence of sectoral differences on innovation management. Sectoral systems of innovation in ICT, for example, are in many ways unlike those in textiles. Using examples of pharmaceuticals, machine tools, and services, Malerba and Adams provide a framework that links knowledge and sources of innovation with the actors and institutions involved to explain the dynamics of innovative activity within and across sectoral boundaries. This framework is a valuable addition to the innovation manager's toolbox in helping analyse the context in which their organizations innovate.

Further analysis of services is provided by Tether in Chapter 30, which highlights the specific characteristics of services, including their intangible and perishable nature. Tether shows how services innovation differs from innovation in manufacturing, in that it is typified by frequent involvement by users and providers of complementary services, is less reliant on specific departments, such as R&D, and is more distributed with many diverse contributors. Many service innovations, he argues, involve business model innovation, and he offers a framework of stages and associated tools for services design.

The extent to which innovation management strategies and practices are transferable across sectors and technologies remains a germane question for researchers.

How do lessons about private, for profit innovation, for example, translate into areas of social innovation? Chapter 16 by Lawrence, Dover, and Gallagher argues that interest in managing social innovation has been growing, but there has not been a corresponding increase in research in the area. They review the existing literature around four themes that characterize understanding of social innovation: starting with social problems, focusing on novel solutions, varying potential organizing models, and benefiting beyond the innovators. They argue future research should recognize the construction of social problems and their historical and social embeddedness, and how the need for political and ethical considerations has to be taken into account.

Most research in innovation management has, furthermore, focused on US, European, and Japanese firms, and this needs to change (Dodgson et al., 2008). As Chapter 18 by Zhang shows, there has been remarkable growth of innovative capabilities in China. The Chinese model of innovation management is strongly influenced by government policies and China's culture, but through learning from multinational companies and developing their own practices, Chinese approaches to innovation provide an important future direction for the study of innovation management. One of the intriguing insights in the chapter by Zhang is the distinction between efficiency-led business models in the West and effectiveness-led models in China.

Decisions about innovation inevitably involve issues of finance. Whether it is concerned with levels and quality of venture capital, or the capacity of firms to raise capital in markets or invest retained earnings, the availability of finance is essential for innovation. Chapter 13 by Hughes places the issue of innovation funding within the broader context of national governance of capital markets and financial systems. Hughes shows the considerable variation in the balance of public and private funding of R&D, and draws on analysis of varieties of capitalism and systems of innovation to identify trends in financing. He also considers the impact of the 2008/9 financial crisis for the financing of innovation.

Case studies reveal a great deal about innovation management. There are rich case histories of both large multinational companies such as DuPont (Hounshell and Smith, 1988), Toyota (Fujimoto, 1999), Microsoft (Cusumano and Selby, 1995), and Corning (Graham and Shuldiner, 2001). The best of these illuminate how innovation complemented overarching corporate strategies, and provide insights and examples of the management practices used to innovate efficiently. Scope remains for many more case studies of innovation management in small firms, the especial challenges they face due to relative shortages of resources, and the advantages they possess in flexibility and responsiveness. Chapter 4 by McKelvey on science, technology, and business research discusses the importance of small firms as vehicles for transferring science into innovation. Studies of particular innovations, from the hovercraft (Rothwell and Gardiner, 1985) to the Internet (Tuomi, 2002), also throw light on effective management strategies and practices. These case studies do not have to be contemporary to be valuable, with many insights provided by great innovators such as Thomas Edison (Hargadon and Douglas, 2001) and Josiah Wedgwood (Dodgson, 2011). One of the most illustrative studies of organizational opposition to innovation is that of continuous aim gunfire

by the British and US navies, developed at the end of the nineteenth century (Morison, 1988). Case studies are also useful in examining the inevitable organizational and interpersonal tensions involved (Webb, 1992).

Surveys of numbers of innovations, R&D expenditures, and patents, produced by organizations such as the OECD and European Union, are useful from an innovation management perspective when they highlight the different contexts in which organizations innovate. One of the earliest and most original empirical studies of innovation—Project SAPPHO (Rothwell et al., 1974)—showed how the challenges of innovation differed between sectors. One of the problems with many studies of innovation management based on patent data is the frequent inappropriate association of patenting with innovation. Patenting is at best a proxy measure of an element of innovation that is important in some sectors and irrelevant in others. Innovation studies are fortunate nowadays to have access to the power of Social Networking Analysis (SNA) as a new method for studying innovation management. As discussed in Chapter 6 by Kastelle and Steen, by mapping connections between people, groups, and organizations, SNA provides one of the best tools for innovation managers. Kastelle and Steen show how new statistical methods that examine large networks and test hypotheses about network structures and dynamics have dramatically changed the theories and techniques of network analysis, and they provide a guide on how to conduct an analysis. They outline some of the benefits of SNA for innovation managers, which include the identification of organizational silos, finding hubs and key actors, locating isolated people and groups, and identifying bottlenecks.

The challenge for the study of innovation management lies in integrating qualitative findings from rich, idiosyncratic case studies examining the history, structure, strategy, and environment of particular organizations, with testable and generalizable findings from quantitative research.

Innovation Management Theory

The study of innovation management is driven by its practice. It is an applied field. There is no unified theory of innovation management, just as there is no unified theory of innovation. There are, however, diverse theories that can help explain various aspects of innovation management as a social and economic process. Elements of psychology, for example, explain the motivations of innovative individuals, while sociology explains the power relationships between and within groups and organizations that affect innovation as a social endeavour, and political science enlightens us about the influences institutions can exert. Organization theory tells us about how new fields of knowledge and effort are formed and institutionalized, and how practices are negotiated and become embedded. Our focus on the management of innovation as a purposive, instrumental activity leads us more towards theories in economics and strategic management, with a common concern to explain how resources

and capabilities are deployed and value is created through the introduction of new ideas. That is not to underestimate the value of other theories and the explanations and insights they offer, but it does reflect the value of three approaches—evolutionary economics, dynamic capabilities, and innovation management—that emphasize the connections between context, strategy, and practice. It also suggests their value compared to alternative, often deeply embedded, theories in the same field, such as neo-classical economics (Foster and Metcalfe, 2004) or strategy based on industrial structure analysis (see chapter 20 by McGrath and Kim).

By identifying the three analytical lenses—evolutionary economics, dynamic capabilities theory, and innovation management—it is possible to recognize several strands or connections that help frame understanding. These are shown in a highly simplified and stylized manner in Figure 1.1.

Evolutionary economics is concerned with the dynamic processes by which economies develop and change, and the transformational influences of entrepreneurship,

Evolutionary Economics	Dynamic Capabilities	Innovation Management
Create variety	**Search** for new market opportunities	**Create options**
New firms, technologies, and business models	Create, access, and mobilize resources needed to engage in new activity to exploit selected opportunities	Search for innovation opportunities: internally and externally
	Absorptive capacity	
Select and eliminate	**Create and capture value**	**Select innovations to pursue**
Decisions by investors, customers, regulators, partners	Devise business models to produce outcomes that deliver value	Strategic/risk assessment and choice
	Develop specific capabilities and generate revenue to sustain returns	**Configure and deploy**
	Complement activity of co-evolving organizations	Resources and capabilities
	Complementary assets	
	Protect patents, institute customer switching costs	**Capture value**
		Produce distinct advantages Create IPRs and standards
Propagate	**Adapt**	**Build capabilities**
Selected innovations Reinvest to create more variety	Capabilities to changing business environment	Across innovation portfolio
Learn	**Learn**	**Learn**
Dynamic improvements in economy through creative destruction	Organizational learning in routines	Evaluate returns and review performance

FIGURE 1.1 Analytical lenses

technological change, and recombinations of organizational routines (Nelson and Winter, 1982; Foster and Metcalfe, 2004). The historical periods of transformational changes associated with this pattern of development see massive economic and technological shifts and also profound changes in organizational structures, industrial relations, and skill patterns (Freeman and Soete, 1997). The virtues of capitalism, in the evolutionary economics approach, lie in the continual creation of variety in response to turbulence and uncertainty, from which markets and other mechanisms make selections, the most successful of which are propagated and re-innovated to create the resources for investing in new variety creation. Notable in this formulation is the preponderance of failure. Alongside the creation of new innovations, firms and technologies fail continually in a Schumpeterian process of creative destruction.

Dynamic capabilities theory is concerned with the capacity of organizations to reconstruct their resources (Teece, 2009) to fit with changing and uncertain environments. Various dynamic capabilities are analysed, including the capacity to search for new ideas, choose between them, and then create and capture value. A key aspect of these capabilities is their ability to adapt as business opportunities change. Notable in this formulation are the recognition of the importance of integrating with co-evolving institutions, such as collaborative partners, and the value capturing strategies of intellectual property protection and creation of high customer switching costs.

The innovation management lens is much more applied, yet it draws on a number of analytical frameworks, such as complementary assets (Teece, 1986) and absorptive capacity (Cohen and Levinthal, 1990), which also inform strategic capabilities theory. The development of a pharmaceutical, for example, requires access to the complementary assets of production expertise, knowledge of regulatory approval processes, and distribution networks, before it reaches the market. Absorptive capacity is the organizational equivalent of radio communication needing receivers as well as transmitters. Knowledge flows only when there is the capacity to receive it, and investments in R&D aid the capacity of organizations to absorb externally sourced knowledge. Notable in this formulation, and in contrast to the previous two lenses that are primarily concerned with outcomes and performance, this lens also includes analysis with an internal focus into the processes of configuring and deploying resources and capabilities within the organization.

All these lenses are dynamic, responding to contextual change and disruption, and involve the search for and creation of variety and options; selection from within that variety from which to deliver and capture value; and propagation of successful choices creating resources and learning with which to re-invest into the cycle. Each involves learning as a core process and outcome: at the level of the economy, in the capabilities and routines that organizations possess, and in improving the management of innovation. These ways of theorizing support definitions of innovation management that move beyond the continuous improvements that lead to reduction of variety and increases in predictability, and include those approaches that involve risk and experiment.

Innovation Management Practice

Organizations manage innovation, rather than leaving it to chance, by creating supportive structures, practices, and processes. Although the nomenclature varies, organizations define roles such as Chief Innovation Officer and Innovation Manager, and establish advisory bodies such as Innovation Boards. They have innovation strategies and plans, and offer incentives and rewards for innovators. Funds for internal venturing encourage entrepreneurship, intellectual property is protected by official policies, and prescribed project management processes guide decision-making. Resource allocation processes see budgets for innovation assigned in portfolio approaches with various time horizons, and R&D centres provide support for business units and options for the future.

These examples of management structures and practices are examined throughout this Handbook. They help explain the success of innovating organizations. But they only succeed when they accord with the contextual conditions in which organizations operate. Successful innovators furthermore manage in a way that balances the need to produce value through existing business that generate the resources that allow them at the same time to create opportunities to develop new ways of creating, delivering, and capturing value.

We now turn to five interrelated recurrent and enduring challenges of innovation management: dealing with disruption; balancing portfolios; integrating organizationally, technologically, and commercially; building advantage in intangible assets and activities; and encouraging creativity and playfulness. These represent a different order of challenges to the more general, day-to-day, management of budgets, projects, and personnel, and are essential to obtaining more long-term and sustainable advantage from innovation.

Recurrent Challenges

Dealing with Disruption

Disruption has many causes. The world is unfortunately not immune from extreme events—political, economic, environmental, geological, biological—that continually introduce new kinds of turbulence for organizations. Innovation is itself a major source of disruption for organizations, as competitors find ways of doing things better, cheaper, and faster. Competitors can increasingly benefit from global access to ideas, production capacities, and deregulated markets and from cheap and ubiquitous digital technologies. Essentially, as economic systems become ever more complex, interdependent and rapidly changing, the level of disruption that confronts organizations increases.

Disruption in this sense is not unexpected—it is inevitable—but its unpredictable manifestations mean it is something that organizations may not have planned for, have no ready response to, and cannot easily adjust their resources and capabilities to deal with.

Disruption occurs in business models and cost structures, such as the effect on telecommunications companies of providers of voice over the Internet services, or the consequences for high street stores of online shopping. Rapid market change can be disruptive, such as when competitors introduce superior offers, or products lose their appeal. Examples would be the smartphone replacing personal digital assistants, or the growing distaste for cigarettes in Europe. Changes in regulation can be disruptive, such as environmental controls on automobiles, or restrictions on the ability of banks to offer both retail and investment services. Technological change is a major source of disruption, especially when new platforms emerge as in the case of hard drive devices replacing CDs, or new methods of drug discovery by means of genetic engineering. The largest challenges emerge when different forms of disruption combine, such as the newspaper industry being confronted by electronic news sources. The consequences of disruption can sometimes be very painful because skills that were previously highly valued are no longer needed. Innovation management can involve making people redundant.

Balancing Portfolios

The bulk of most organizations' investments in innovation address small improvements. Archetypically, these continuous, incremental improvements mainly apply to day-to-day operations and improve performance with relatively low risk. Organizations that focus entirely on doing what they currently do slightly better are often exposed to innovative new entrants, therefore part of the portfolio of innovation investments and projects should aim to help the company diversify and grow new business by building upon and developing beyond existing capabilities. This involves taking risks. To create value through possessing options for an organization in a changing world, a relatively small proportion of most organizations' portfolios should be speculative, with high risks and potentially high rewards. Being capable of initiating or rapidly responding to radical, breakthrough technologies future-proofs organizations by having options and balance in the portfolio, and although risky, these risks are smaller than not having prospective possibilities for change. These more adventurous investments not only produce new knowledge, but also allow engagement with other innovation leaders around the world. Some highly innovative, often science-based, firms operate fully in this radical and unknown section of the portfolio, searching for breakthroughs with which they can trade. A simple representation of an innovation portfolio is shown in Figure 1.2.

A normal innovation management challenge is to balance the portfolio across the 45-degree axis on the diagram. The enduring challenge for most innovative organizations, however, is to invest in upper right hand areas of the diagram when organizational and managerial attention is inevitably directed towards existing activities in the bottom left that provide the core of the organization and deliver crucial objectives such as

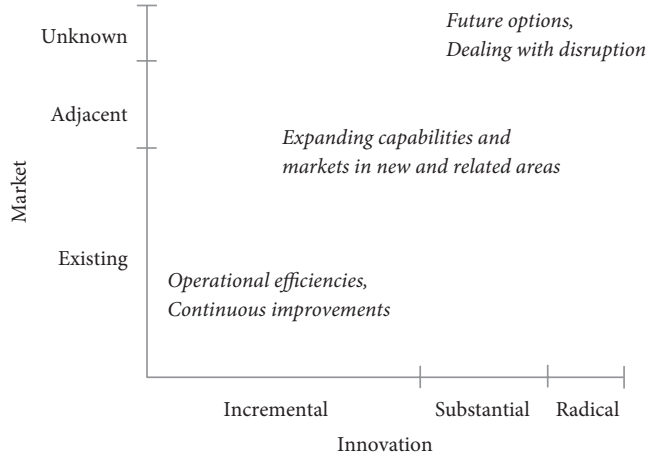

FIGURE 1.2 A simple innovation portfolio

income generation. There are, however, a wide variety of innovation management challenges and opportunities, such that the priority for some firms may be to concentrate their investments ever more deeply in existing capabilities when they provide a source of distinctive advantages.

Integrating the Innovation Process

In practice, ideas for innovation emerge from multiple sources and it often requires the collision and blending of many diverse insights into possibilities and opportunities. Encapsulating and focusing that diversity requires high levels of organizational, technological, and commercial integration.

Because innovation can derive from and involve many contributors, organizational integration within and between organizations, and between different professions, occupations, and skill sets, is a prerequisite for supportive and effective innovation processes. Many innovations occur within technological systems or architectures that require integration between modular components. They may also require connections between different vintages of technology, and integration between physical and digital technologies, for example in augmented reality, that supplements real world observations with computerized sounds, images, and senses. The capacity to unify diverse technical inputs is the key to technological integration, and there are supportive technologies and design tools to assist. The technology that produces a common digital platform for the integration of computer-aided design and manufacture has existed for decades, and new technologies assist the integration of all aspects of the innovation process. These require the management of tools for analysing 'big data': the vast amounts of data produced from scientific research, the

'Internet of things' created by ubiquitous sensors in devices such as Radio Frequency Identification and smartphones, and social networking technologies. As discussed in Chapter 19 by Dodgson and Gann, these 'innovation technologies' also rely on the management of simulation and modelling techniques and virtualization and visualization technologies that improve the speed and efficiency of developing and testing complicated systems.

Commercial integration ensures that innovations meet the requirements of customer and clients by delivering value to them in price, performance, or utility, and utilizes channels to market that the organization already has or can access. Supply chain integration ensures security of supply, and complementarity of components and standards.

Hargadon's chapter on brokerage argues innovation occurs through the process of recombining and integrating past knowledge and practices in new ways. Innovation occurs when individual practices and the organizational strategies to support them are integrated with the larger social structure. Using historical and contemporary cases, Hargadon identifies the central role of brokerage in explaining the generation and success of innovation, addressing key management questions such as continuing success in innovation and the virtues and challenges of diversity.

Fujimoto's chapter on innovation management in Japan combines insights from trade theory, architectural thinking in design theory, and an evolutionary framework of capability building. His contention is that, for a variety of historical reasons, Japan developed rich endowments in coordinative capabilities, such as teamwork of multi-skilled engineers, applied especially to coordination-intensive products, such as automobiles. These integrative abilities provide sources of great strength for relatively high-value, highly engineered products, but Fujimoto shows the shortcomings of this approach in modular, digital, and relatively cheaper products. He outlines a range of future strategic options for Japanese innovation management.

Managing Intangibles

In advanced economies, investment in intangible assets—knowledge and intellectual property, for example—exceeds that of tangibles, such as factories and equipment (Haskel and Wallis, 2013). Intangibles are commonly defined as things that cannot be seen or touched, and their management is often different from that of physical assets.

Broadly defined, a company's reputation, mindset, and culture for innovation are intangible assets. Other intangibles could include design and business models. When we consider that an organization that creates and delivers services—which comprise more than 70 per cent of gross domestic product in most developed economies—is creating and delivering an intangible, then the overall significance of managing intangibles is clear. These issues are examined by Verganti and Dell'Era in Chapter 8, Massa and

Tucci in Chapter 21, and Tether in Chapter 30. Services are also addressed in Chapter 10 by Malerba and Adams.

One of the biggest issues confronting the management of intangibles is the difficulty of measuring them. Progress in development cannot be observed in improved prototypes as, for example, in manufactured products. Innovation in services occurs as they are used in the market—innovation starts at the point of consumption rather than invention—so measuring inputs is less exact. Expenditures on R&D are readily accountable; customer engagement in new service development is less so. For these reasons the use of project management and marketing techniques in industrial innovation is limited. It explains why software companies often release their services in beta form to be developed and tested by use.

Encouraging Creativity and Play

Creativity is commonly seen as the origination of ideas, insights, and innovation as their successful application. Much of the management literature on creativity has tended to focus on individuals or the role of teams, addressing techniques to extract the best performance from them. These are crucial contributors, but the connection between creativity and innovation is so important that it is core to the strategic development of the firm. Creativity therefore needs to be considered within the strategies and practices that shape its manifestation as innovation. Chapter 7 by Leonard and Barton argues how creativity and innovation have a paradoxical relationship with knowledge. Whether at an individual, group, or organizational level, knowledge can both stimulate innovative ideas and prevent their fruition. Using concepts such as core rigidities and deep smarts, Leonard and Barton provide insights and guidance on ways to counter the downsides of knowledge and use its power to stimulate creativity and inspire people and organizations.

One way of connecting creativity and innovation is the notion of play (Dodgson et al., 2005). Play at work is important for individual and organizational performance. It encompasses those activities where people explore, template, model, prototype, rehearse, and tinker with new ideas, often in combination with others with different skills in stimulating environments where work rules are relaxed. Play, in this sense, is an antidote to the procedures and bureaucracy that inevitably develop in organizations over time and are anathema to innovation (Dodgson et al., 2013).

Jazz improvisation is a common metaphor used in the organization and management literature to reflect this appreciation of the nature of play (Meyer et al., 1998). Jazz provides an idiom for understanding the balance in the relationship between individuals as they collectively explore the unexpected within the confines of accepted styles and structures. It reflects the way that effective improvisation, seen as spontaneous experiment, actually reflects depth of experience and degrees of discipline by its players.

The notion of play also introduces the challenging high incidence of failure in innovation, which happens constantly around any ambitious ideas. Only a small proportion of

innovations being explored at any one time will ever succeed in the market. For many in organizations, especially those whose job it is to control expenditure and whose remuneration package depends on short-term performance, the remainder of these investments are often construed as failures. Such failures are, however, inevitable and provide valuable learning experiences.

Different Types of Innovation Process

Managing the many challenges of innovation requires the combination of resources in different business and organizational processes. To help frame analysis, six broad processes used to coordinate resources to create, deliver, and capture innovation are determined, each requiring different underlying management capabilities. Innovative organizations use most if not all of these types of process in different combinations.

Type 1—Research and technology led. These processes support the use of science, research, and technology as the stimulus to innovation in an organization. The key management capabilities required are selecting, conducting, and applying R&D and technology projects. A number of chapters in the Handbook inform us about this type of innovation process.

McKelvey in Chapter 4 on science, technology, and business innovation discusses the differences in the types of knowledge underlying each, the role of public financing, and the interactions between universities and business, including science in entrepreneurial firms and academic spin-offs. She discusses the motivations for public investments in science, and the specific demands of science-based industries and other sectors that rely on scientific research. Critical of a restricted 'technology transfer' model of university-business interactions, McKelvey argues for a more broad-based 'engagement' model. Amongst the key challenges for innovation management she identifies is the manner in which scientific advances are by definition unknown before research occurs, and while firms may wish to invest in the creation and use of knowledge, they are uncertain about the value of that knowledge.

Von Zedtwitz, Friesike, and Gassmann in Chapter 26, on managing R&D and new product development, explain the contributions these activities make, and describe their central elements. These include the product development funnel, R&D portfolio management, and the organization of R&D. The chapter discusses concepts such as the 'fuzzy front end' that provide valuable analytical and practical tools for innovation management.

Research and development is an increasingly globalized activity, and this is the focus of Chapter 27, by Håkanson, who outlines trends in the internationalization of R&D in multinational companies. Håkanson discusses the motivations behind decisions to perform R&D overseas, and the managerial issues that result. Firms internationalize their R&D for reasons varying from the adaptation of products to local market requirements to linking with global centres of basic science. The chapter discusses the managerial

implications of these different objectives in the systems, processes, and practices used by multinational firms.

The results of R&D and new product development feed into organizations' goods, processes, and services and can also be traded in markets for technology. Chapter 12, by Gambardella, Giuri, and Torrisi, outlines the size and characteristics of markets for technology, as organizations exploit their technology or outsource it from third parties using methods such as licensing, cross-licensing, and the sale of patents. This chapter examines the incentives firms have to participate in markets for technology, including the differences between those in large and small firms, and considers the barriers to technology trade. Gambardella, Giuri, and Torrisi argue that markets for technology are an important strategic consideration, increasing in size and range, and as a result are a significant issue for innovation management.

The strategic significance of intellectual property is a theme developed in Chapter 28 by Leiponen. She examines legal and competitive strategies to control and benefit from intellectual property and from technical standards that are crucial for the interoperability of many product and service systems. By examining the ICT industries in particular, Leiponen argues the need for business models that respond to weakening appropriability regimes. She shows how innovation strategies that encompass intellectual property are crucial as negotiations and litigation can determine the success or failure of innovations.

Type 2—Market-facing. These processes begin with understanding of the nature of market demand, and the organization of resources in response to market opportunities. Key management capabilities are collecting, analysing, and responding to information about markets, users, and consumers, and the capacity to make decisions on when to create and lead markets ahead of demand.

In Chapter 3, on marketing and innovation, Prabhu examines how marketing influences innovation both as a source of and location for innovation. As an innovation in marketing itself, Prabhu examines the who, what, and how questions that marketing helps answer for innovators. As a source of innovation, he explains how a firm's orientation towards its market affects the ways it innovates, and how marketing is a crucial element of the cross-functional coordination needed for successful innovation.

It has long been appreciated that innovations are enhanced by engagement with their users during the process of their development. Chapter 5 by Franke, on user innovation, argues that this practice is gaining momentum as the Internet provides information relevant for innovation ever more quickly and cheaply. Franke explains why users innovate, how they organize, and their motivations for sharing their innovations with other users. He describes three methods by which companies can benefit from user innovativeness, including ways of identifying lead users, toolkits for self-design, and crowdsourcing for solutions to particular problems.

Chapter 14 by Ozaki and Dodgson argues that innovation managers have to dig deeper than simply understanding why customers buy innovations, such as their functionality, utility, and price, and consider also how those innovations are consumed. This, they argue, requires understanding of consumers' underlying values, and more

emotional and socially contextual factors. Using a historical example, and modern cases of hybrid vehicles and green electricity tariffs, Ozaki and Dodgson discuss the complexities of the decision to consume innovation, and how better appreciation of these complexities improves the management of innovation.

Type 3—Internal coupling. To avail itself of market and/or technological opportunities, an organization needs the internal communications and connections between all its various contributors to aid the realization of an innovative outcome. The most important management capabilities in this type of process are communications and the capacity for feedback and iterations on projects. Also valuable are the abilities of people to combine their deep expertise in particular areas with a capacity to work effectively across different aspects of an organization's activities. Apart from R&D, marketing, and sales, other contributing domains of activity might include: intellectual property protection, prototyping and testing, and operations and servicing. Such coupling may involve cross-departmental coordination and budgets, and can draw on the different perspectives and skills of multidisciplinary and inter-departmental teams. A new product development project, for example, commonly includes representatives from marketing, R&D, and production and operations (see Chapter 3 by Prabhu and Chapter 26 Von Zedtwitz, Friesike, and Gassmann). These internal links can also be facilitated by the use of computer-assisted integration between design, development, and operations (see Chapter 19 by Dodgson and Gann).

In a related chapter, Chapter 24, Phillips discusses how different aspects of organizations affect innovation and argues for the importance of managing the organizational context when managing innovation. He identifies a number of mechanisms that can enhance integration and enable innovation, including leadership, culture, organizational structure, networks, and teams. The organizational context can either enhance innovation or impede it, depending on how well these aspects of organization are managed. In addition to aspects of organization that have been explored in the existing literature, he also speculates about the role of organizational identity, institutional context, and the organization's willingness and ability to adopt new practices in innovation.

Laursen and Foss in Chapter 25 emphasize the importance of extensive lateral and vertical organizational communications in their chapter on Human Resource Management (HRM) and innovation. They argue the value in combining these patterns of communications with high levels of delegated decision-making and use of particular reward systems in 'new' or 'modern' HRM practices. As the innovation process changes, for example, by being more distributed and inclusive, Laursen and Foss argue the need for HRM practices to change as well. They develop a model for considering the moderators and mediators of the relationship between innovation and HRM.

Chapter 31 by Davies argues that projects provide an important organizational form for innovation. Projects are a temporary organization and process established to create a novel or unique outcome. Davies argues how project management tools and techniques were developed to help select, plan, manage, and reduce the uncertainties associated with innovation. Distinguishing between optimal and adaptive models of project

management, he argues the latter are emerging as a new paradigm for understanding the relationship between project-based innovation and uncertainty. A fundamental means for internal organization, projects also provide key mechanisms of engagement with clients, customers, partners, and suppliers.

Type 4—External collaboration. These processes connect organizations with external parties as they search for, choose, and implement innovations. They may involve research links with universities and research institutes (see Chapter 4 by McKelvey), and collaboration with companies working in similar markets and technologies in various forms of consortia. Connections with customers and suppliers are important, and often the ability to work with demanding 'lead' customers is a stimulus to innovation (see Chapter 5 by Franke). The capacities to select partners within established value chains and work effectively with them are key management capabilities. The management of innovation in such processes additionally involves the ability to search widely for ideas within wider innovation ecosystems, select from them judiciously, manage the potentially increased contest over intellectual property rights, and ensure good information flow and cooperation within the broad ecology.

Autio and Thomas in Chapter 11, on innovation ecosystems, review how the concept has evolved and how it can be applied to the analysis, design, and implementation of innovation strategy. Their chapter provides insights into the boundaries, structures, and dynamics of innovation ecosystems and offers three theoretical lenses through which to examine them. Autio and Thomas argue that while a large body of research has addressed innovation ecosystems, study of their implications for innovation management remains in its infancy, providing rich future opportunities for scholars.

Firms belong in innovation ecosystems because they cannot innovate by themselves, and some of the connections firms make in order to innovate are especially intimate and involve mutual commitment of resources to agreed objectives. This is the definition of collaboration in Chapter 23, by Dodgson. Collaboration, he argues, contributes to an organization's ability to attain complementarities, encourage learning, develop capabilities, and deal with uncertainty and complexity. It is often a challenging process, Dodgson contends, and managing the inherent instabilities and tensions in collaboration requires careful partner selection and effective structuring and organization.

Type 5—Strategic integration. These processes provide the strategic overview for all other innovation processes, as they involve decisions about how innovation supports overall organizational objectives and what innovations to pursue. They encourage high levels of internal and external organizational integration in support of overall corporate objectives, rather than individual projects, and this may involve investments in coordinating technological infrastructure and platforms. It is strategic oversight that prevents organizations falling prey to the dangers of research and technology push when there is no market for its outcomes, and over-reliance on demand-pull processes where customers can be conservative and stifle potentially disruptive innovation. The ability to formulate and implement innovation strategy and encourage highly coordinated internal and external organizational support for innovation is a key management capability.

Chapter 20 by McGrath and Kim reveals the considerable shortcomings of mainstream theories of strategy when addressing innovation. The industrial organization and resource-based views of strategy, they argue, fail to account for the turbulence and dynamics in the 'hypercompetition' confronting contemporary firms. McGrath and Kim argue that in a world where competitive advantage is transient, and competitive threats can emerge from diverse and unexpected sources, new metrics of performance are required, greater account should be made of networks of people and organizations, and more attention should be paid to the role of the general manager.

Strategic integration within and across organizations is a theme in a number of other chapters, and is especially relevant in the chapters on business model innovation, platforms, design, and open innovation.

The relationships between business models and innovation have been an increasing focus of research attention. In Chapter 21, Massa and Tucci define business models as the rationale of how an organization creates, delivers, and captures value in relationship with a network of exchange partners. They argue business models represent both an important vehicle for innovation and a source of innovation in and of itself. Massa and Tucci examine business model innovation in three contexts: their design in newly formed organizations, reconfiguration in incumbents, and as a means of encouraging sustainability. They provide a synthesizing meta-framework and identify tools and perspectives of business models to assist innovation management.

The notion of design, as discussed in Chapter 8 by Verganti and Dell'Era, is fluid and slippery, and is commonly considered in a very restricted way. Recently, however, design has become better understood as a fundamentally integrative contributor to and source of innovation. Verganti and Dell'Era consider design as the form of things, as creative problem solving, and as the innovation of meaning, and focus on the latter as a means of understanding why people use things (a question also pursued with a different perspective by Ozaki and Dodgson). They develop the idea of design-driven innovation and its relationships with technology push and market pull innovation, and show how it offers a vital new paradigm for managing innovation through its power to interpret and envision meaning.

The capacity of a number of technologies to integrate the innovation process within and across organizations leads Dodgson and Gann in Chapter 19 to describe them in combination, as innovation technology. Another integrative concept is that of the platform that uses new technology and helps organize markets for innovation around them, thereby adding value. Using a number of cases of ICT companies, Gawer and Cusumano in Chapter 32 examine the implications of platforms for innovation management. They distinguish between internal, supply chain, and industry platforms, and consider their strategic implications. Gawer and Cusumano use examples of how platforms compete and evolve, and draw out lessons for where they can encourage and discourage innovation.

The concept of open innovation promises to leverage internal R&D and gain benefits from access to externally sourced innovation. As Alexy and Dahlander argue in Chapter 22, however, the level of interest of researchers in the subject is not matched

by the ease with which organizations develop successful open innovation strategies. They distinguish between four aspects of openness: acquiring, sourcing, selling, and revealing, and consider the conditions in which their combination is beneficial. By highlighting a number of influential contingencies on openness, Alexy and Dahlander guide understanding of its benefits and limitations.

Type 6—Future ready. These processes prepare organizations for the future by building their awareness of, and responsiveness to, changing business models and disruption in technologies, markets, regulations, demands for sustainability, and in general business circumstances. The continuity and success of organizations when confronted with disruption depends significantly on the ways in which they manage innovation; a theme developed in many chapters in this Handbook. Early sensing of potential disruption is extremely valuable, and may involve high degrees of openness, including deep immersion in the research community, keen observation of peripheral developments in start-up companies and competitors, and active engagement in the policy-making process in areas such as regulation. It involves understanding the nature of the innovation ecosystem in which the organization operates, what points of influence and control it possesses, and what levers organizations possess, such as mergers and acquisitions (M&A), to respond to opportunities.

The ability of M&A to increase innovation and enhance an organization's innovative capacity are some of the potential benefits discussed in Chapter 29, by Ahuja and Novelli. One of the key conclusions of this chapter is the need for more research into the subject of the impact on innovation of M&A in, for example, their capacity to improve future readiness. Ahuja and Novelli's theoretical and empirical review encompasses the managerial challenges of M&A, the diversity of views on their consequence for innovation, and their potential value.

Future ready innovation processes provide organizations with the adaptive capacity to continually deal with, and profit from, uncertainty and disruption.

Nowhere is the challenge of being future ready more important than in the area of sustainability. Berkhout in Chapter 15, on sustainable innovation management, outlines why environmental sustainability has become such a crucial innovation management concern. He identifies three main influences of technology on business environmental performance: sensing and providing information, improving efficiencies, and transforming resource-use and environmental impacts. He argues that because of the systemic complexities of environmental challenges, responses need to be transformative, requiring a mixture of old and new innovation capabilities, new business models, and linkages.

As Phillips discusses in his chapter, being future ready is also deeply dependent on leadership and culture. Culture shapes the degree to which an organization looks forward or focuses on the past, and also determines the rate of change and innovation that organizational members are comfortable dealing with. Leadership plays a similarly central role in the degree to which an organization is future ready. If leaders are forward-looking and provide the sort of transformational leadership that makes organizational members feel secure and empowered, then awareness of the need to change, ideas for innovation, and a willingness to change to meet future challenges will all increase.

Responses to disruption are unlikely to be completely autarkic, and inevitably involve external collaboration with customers and occasionally with government, for example through technical standards bodies. Preparedness for disruption depends on an organization's strategic appetite for risk and its taking early bets on potential developments. It rests upon openness, ability to use supportive technology, and experimenting with low cost and more 'inclusive' innovation that involves wider community involvement. Internally, the capacity of organizations to employ people whose energies are directed towards sensing external threats and opportunities, and then responding flexibly and quickly to them, is crucial for their future readiness.

Key management capabilities here are the management of less observable and measurable intangibles, such as organizational culture and mindset, service orientation and entrepreneurial spirit, and the encouragement of creativity and playfulness. Tolerance of failure is important for attracting people to work in adventurous ways, as is the provision of tools and techniques such as innovation technologies that allow quick and cheap failure, and effectively learning lessons when things do not go to plan. As intangibles are less readily measured, there is greater reliance for decision-making on judgement, expertise, experience, and intuition.

Conclusions

As this chapter suggests, the perspectives that are needed to understand innovation management are broad and diverse. To reflect this diversity the book is divided into four sections. The first part, including this and the following chapter, is offered by way of introduction to the subject. The second section addresses various sources of innovation. The third section analyses contextual influences on innovation management. The fourth and final section considers issues of strategy, management, and organization. Many chapters traverse sources, context, and practice, but are allocated according to their primary contributions.

The Handbook offers a rich collection of insights and cases on innovation management that not only capture what we know about this subject but what we do not know and need to know, and it offers an extensive range of suggestions on future research agendas. Innovation management is a field of research rich in significance and ripe for better understanding. It provides fertile ground for further exploration.

References

Abernathy, W. J., and Utterback, J. M. (1975). 'A Dynamic Model of Process and Product Innovation', *Omega*, 3(6): 639–56.

Cohen, W., and Levinthal, D. (1990). 'Absorptive Capacity: A New Perspective on Learning and Innovation', *Administrative Science Quarterly*, 35: 128–52.

Cusumano, M., and Selby, R. W. (1995). *Microsoft Secrets: How the World's Most Powerful Software Company Creates Technology, Shapes Markets and Manages People*. New York: The Free Press.

Dodgson, M. (2011). 'Exploring New Combinations in Innovation and Entrepreneurship: Social Networks, Schumpeter, and the Case of Josiah Wedgwood (1730–1795)', *Industrial and Corporate Change*, 20(4): 1119–51.

Dodgson, M., Gann, D., and Phillips, N. (2013). 'Organizational Learning and the Technology of Foolishness: The Case of Virtual Worlds in IBM', *Organization Science*, 24(5): 1358–76.

Dodgson, M., Gann, D., and Salter, A. (2005), *Think, Play, Do: Technology, Innovation and Organization*. Oxford: Oxford University Press.

Dodgson, M., Gann, D., and Salter, A. (2008). *The Management of Technological Innovation: Strategy and Practice*. Oxford: Oxford University Press.

Dosi, G. (1982). 'Technological Paradigms and Technological Trajectories: A Suggested Interpretation of the Determinants and Directions of Technical Change', *Research Policy*, 2 (3): 147–62.

Fagerberg, J., Mowery, D., and Nelson, R. (eds) (2005). *The Oxford Handbook of Innovation*. Oxford: Oxford University Press.

Foster, J., and Metcalfe, J. S. (2001). *Frontiers of Evolutionary Economics: Competition, Self-Organization and Innovation Policy*. Cheltenham: Edward Elgar.

Foster, J., and Metcalfe, J. S. (eds) (2004). *Evolution and Economic Complexity*. Cheltenham: Edward Elgar.

Freeman, C., and Soete, L. L. G. (1997). *The Economics of Industrial Innovation*. London: Pinter.

Fujimoto, T. (1999). *The Evolution of a Manufacturing System at Toyota*. Oxford: Oxford University Press.

Graham, M., and Shuldiner, A. (2001). *Corning and the Craft of Innovation*. New York: Oxford University Press.

Hargadon, A., and Douglas, Y. (2001). 'When Innovations Meet Institutions: Edison and the Design of the Electric Light', *Administrative Science Quarterly*, 46: 476–501.

Haskel, J., and Wallis, G. (2013). 'Public Support for Innovation, Intangible Investment and Productivity Growth in the UK Market Sector', *Economics Letters*. Amsterdam: Elsevier, 195–8.

Hounshell, D., and Smith, J. (1988). *Science and Corporate Strategy: Du Pont R&D, 1902–1980*. Cambridge: Cambridge University Press.

Meyer, A., Frost, P. J., and Weick, K. J. (1998). 'The Organization Science Jazz Festival: Improvisation as a Metaphor for Organizing (Overture)', *Organization Science*, 9(5): 540–2.

Morison, E. (1988). 'Gunfire at Sea: A Case Study of Innovation', in M. Tushman and W. Moore, *Readings in the Management of Innovation*. New York: Harper Business.

Nelson, R., and Winter, S. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Belknap Press, 437.

Rothwell, R., et al. (1974). 'SAPPHO Updated: Project SAPPHO, Phase II', *Research Policy*, 3: 258–91.

Rothwell, R., and Gardiner, P. (1985). 'Invention, Innovation, Re-innovation and the Role of the User: A Case Study of the British Hovercraft Development', *Technovation*, 3: 167–86.

Teece, D. (1986). 'Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy', *Research Policy*, 15: 285–305.

Teece, D. (2009). *Dynamic Capabilities and Strategic Management: Organizing for Innovation and Growth*. Oxford: Oxford University Press.

Tuomi, I. (2002). *Networks of Innovation: Change and Meaning in the Age of the Internet*. New York: Oxford University Press.

Webb, J. (1992). 'The Mismanagement of Innovation', *Sociology*, 26(3): 471–92.

CHAPTER 2

THE NATURE OF INNOVATION

AMMON SALTER AND OLIVER ALEXY

Introduction

The past fifty years has seen the growth of efforts by academics and practitioners around the world to better understand the nature, sources, and determinants of innovation. Research involves attempts to map, measure, and refine our understanding of how novelty is introduced into the economic system. Inspired originally by Schumpeter (1911, 1942), this field has moved beyond a narrow group of researchers at the margins of economics and sociology to become one of the major topics of interest across management, economics, sociology, and social psychology. Over this time, our understanding of innovation has become richer, more detailed, and refined (Martin, 2012). The goal of this chapter is to briefly review some of the lessons from this research programme.

Our approach to this review is to bring to the surface some 'stylized facts' that have emerged from the study of innovation. The concept of a 'stylized fact' was first proposed by Nicholas Kaldor (1957) to capture some of the main lessons of research on the economics of growth. A stylized fact is a simplified representation of a set of empirical findings. It should be essentially true, but may not fully apply to all settings. Looking at stylized facts helps to survey the broad area, without becoming lost in the small print. Or, as Kaldor put it, it allows one to 'concentrate on broad tendencies, ignoring individual detail' (Kaldor, 1961: 178).

A related way to understand a research discipline originates from Lakatos' description of the 'hard core' of a 'progressive' field of research (Lakatos, 1970). For Lakatos, a progressive area of research is open to stunning new facts, novel experiments, new sources of data and methods, and more precise predictions. At the centre of any field of research is a set of ideas that are widely held by members of the field. They may be captured by a set of stylized facts, a set of generalizations that most members of the field would subscribe to about the nature of knowledge within the field. These statements

represent the 'hard core' of a discipline, a focused set of ideas and understandings shared by members of a community of researchers. Of course, the hard core of ideas is not static and is open to change through new discoveries. As Lakatos suggested, a progressive field of research has a limited 'protective belt', an openness to new ideas or discoveries that may change the 'stylized facts' within the hard core of the field.

In this chapter, we build on these two conceptual tools to characterize our current understanding of the nature of innovation. We focus on the stylized facts at the hard core of innovation studies. We develop a set of statements that are based on consistently reoccurring results of decades of empirical research. Although these statements are not always true, they are liable to be true in most cases. In doing so, we try to quickly and effectively summarize what has been learnt about innovation over the past fifty years. Or, as a student commented to their history professor, they wanted 'more years with fewer words' (Gaddis, 2005: viii).

We would suggest that the stylized facts below are held in broad agreement by innovation researchers and are largely uncontroversial. Going beyond this safe ground, we highlight several occurrences of new ideas that have put in doubt existing 'facts' or even created changing perceptions of the nature of innovation, such as the shifting attention away from 'the firm' as the central actor in the innovation process towards distributed or community-based models of innovation. We suggest newly emergent ways of innovating present challenges to previous conceptions of innovation and in turn open a wide range of different research topics.

Innovation in Historical Perspective

The interest in the nature of innovation is not new. In 1772, Samuel Johnson complained to Sir William Scott that 'the age is running mad after innovation; and all the business of the world is to be done in a new way; men are to be hanged in a new way; Tyburn itself is not safe from the fury of innovation' (Boswell, 1791).[1] And shortly thereafter, the events of the French Revolution only further confirmed Johnson's insight through a significant innovation introduced in the early 1790s: the 'guillotine'. Previously, France had used the 'breaking wheel' for executions, which inflicted immense pain before causing death. Similarly agonizing were other methods in use at the time, such as hanging or beheading by the sword. For its inventor, the guillotine had several advantages over the past methods of execution: it was efficient, instantaneous, and pain-free. For the French Revolutionaries, it offered a new, more humane way of ensuring justice. Like most successful innovations, it had a long life. The guillotine stayed in use in France until the late twentieth century, when the last person (a convicted murderer) was executed in 1977, almost 200 years after its first development.

Over the past thirty years, the interest in innovation in the popular press, governments, and business firms has accelerated, creating a crescendo of concern and enthusiasm for innovation. In 1999, *The Economist* described innovation as 'the industrial

religion of the late 20th century'.[2] Nowadays, innovation features as a prominent buzzword amongst heads of states—take the following example from US president Barack Obama:[3]

> Now, history should be our guide. The United States led the world's economies in the 20th century because we led the world in innovation. Today, the competition is keener; the challenge is tougher; and that's why innovation is more important than ever. That's the key to good, new jobs in the 21st century. That's how we will ensure a high quality of life for this generation and future generations.

At the same time, underneath all this enthusiasm for innovation, a greater understanding of how innovation happens and what impact it has on economic development has emerged. A recent summary by Martin (2012) provides an overview of some of the most cited papers and books on the topic.

The Hard Core of Innovation Studies

Innovation and Growth

By its capacity to increase the rate of productivity growth in the economy, innovation is one of the main driving forces of economic growth. Estimates of the contribution of innovation originally focused on the 'residual'—that share of economic growth that could not be accounted for by capturing the increasing quantity and quality of labour and capital inputs in the economic system. Solow's (1957) early estimates placed 87.5 per cent of economic growth in the residual, which he referred to as 'technical change'. This approach was widely criticized, however, for treating innovation as a leftover, something that was unmeasured. New growth theory, developed in the early 1980s, sought to more fully incorporate the effects of innovation in growth accounting (Romer, 1986, 1990). This approach involved the development of new models that reflect the informational properties of ideas, their non-rivalry,[4] and potential for reuse. These models showed that innovations influence growth primarily by generating spillovers: the transfer of an idea from one place to another at little or no economic cost to the actor receiving the idea.

Although new growth theory helped to more effectively model the contribution of innovation to economic development, it still left its measurement relatively unattended. Some scholars, however, have been trying to measure more effectively the contributions of major technological changes, such as the Internet or the Information and Communications Technology (ICT) revolution on productivity (e.g. Brynjolfsson, 1993). This work showed that much of the surge of productivity growth in the USA in the 1990s was driven by the adoption of ICT by downstream sectors, such as retailing. In effect, it was the use of ICT by Wal-Mart and other large retailers that induced significant productivity improvements. Moreover, the major change in the nature of

productivity in the semiconductor sector, the centre of the technological revolution of the 1980s and 1990s, was itself responsible for a significant portion of the productivity gains of this period.

In the 2000s, scholars have sought to capture business firms' investment in intangibles, such as R&D, organizational change, and marketing, and link these investments to economic growth. Using surveys of firm expenditures on these intangibles, it was possible to estimate what share of the growth of productivity was accounted for by investments in innovation. This research showed that almost two-thirds of productivity growth between 1999 and 2006 could be accounted for by investments in intangibles or innovation (Haskel et al., 2010). This evidence provided strong support for the idea that innovation plays an important role in shaping economic development when measured directly alongside changes in the levels and quality of capital and labour. It also helped to renew interest in the measurement of the contribution of innovation to economic development, leading to an increase in new growth accounting approaches that measure and map the contribution of innovation (Acemoglu et al., 2012; Marrano et al., 2009).

Stylized fact 1: Innovation plays a major role in productivity growth.

Combinatorial Power of Innovation

Schumpeter, the father of the study of innovation, suggested that innovation should be defined as 'new combinations' (Schumpeter, 1911, 1942). His idea was that most innovations are not novel in themselves; they are novel combinations of elements that already exist. The main challenge for the innovator in this context is not to think of something new, but to find a new combination of existing things. This is not to suggest that novelty does not enter the system through the development of new technologies, processes, or ways of organizing, but that such novelty is primarily a process of recombining existing elements in new ways. A clear example of this is the case of the development of the assembly line and Model T Ford, widely acknowledged as one of the most significant innovations of the twentieth century. Specifically, Ford's innovation involved a new combination of four elements—the electric motor, continuous flow production, assembly line, and interchangeable parts (Hargadon, 2003). But as Henry Ford himself commented,

> I invented nothing new. I simply assembled into a car the discoveries of other men behind whom were centuries of work… Had I worked fifty or ten or even five years before, I would have failed. So it is with every new thing. Progress happens when all the factors that make for it are ready, and then it is inevitable. To teach that a comparatively few men are responsible for the greatest forward steps of mankind is the worst sort of nonsense. (Greenleaf, 1961, citing an article from the *New Outlook*, 1934)

Thus, for (almost) every innovation, it is possible to look to its pre-history, and the series of ideas, attempts, and failures which are similar in nature and scope. This means that a single innovation is not an isolated event; it springs from the body of materials,

experiments, and ideas of previous innovative efforts (Edgerton, 2008). Changes in a single component or module may allow individuals or organizations to create a new way of integrating systems or increasing systems performance dramatically by rearranging the relationships between their different elements.

This combinatorial perspective suggests that the rate and direction of innovation in an industry or market is largely influenced by the potential for the development of new combinations. When the scope for novelty through recombination is exhausted, the speed and pace of innovation slows. Yet, the scope for novelty through recombination is considerable, and much greater than the space for creation of novelty through the introduction of new discoveries. This is because the scope for recombination is almost infinite, as distinct elements can be endlessly combinable to yield new and valuable products, processes, and services (Kogut and Zander, 1992). Although it is often lamented that much of the space for innovation is exhausted, it may reflect perceptions of the opportunity for recombination. A major combinatorial breakthrough may spur a series of related combinations, which, in turn, can unleash a cluster of further innovations. The iPhone, for example, helped to create a new market for thousands of small, innovative software applications. This suggests that one should be wary about claims of the saturation of innovation in a market, as such slowing down of innovation may create the potential for subsequent effort and opportunity to introduce novelty through recombination.

Stylized fact 2: Most innovation involves new combinations of existing elements, bodies of knowledge or technology.

Pervasiveness of Innovation

It is a common perception that innovation is highly concentrated in a few, leading high technology sectors. Research shows that the pace and direction of innovation differs across sectors, with some sectors moving more quickly to introduce new products, processes, and services than other sectors. In part, the pace of innovation can be captured by measures of investment, such as investments in R&D (Griliches, 1981; Griliches et al., 1991) or skilled labour (Cohen and Levinthal, 1989; Leiponen, 2005), or in the churn of the industry, such as the number of new firms and exits of old firms (Abernathy and Utterback, 1978; Klepper, 1997). It also reflects the potential for recombination. Yet, research on the innovation process highlights that innovation is pervasive across all parts of the economic system. Although it is conventional to assign industries into buckets with labels, such as 'high tech' or 'innovative', it is clear that many sectors are home to significant processes of what Schumpeter described as the creative destruction associated with innovation.

Differences in the pace of innovation should not lead away from looking for innovation in all parts of the economic system. Even traditional, slow-moving sectors can be home to important innovations and have been transformed by the development of

new products, processes, and ways of working. For example, the use of CATIA, a software system originally created to design fighter airplanes, provided the key tool to allow Frank Gehry to create the Guggenheim Museum in Bilbao (Boland et al., 2007; Dodgson et al., 2005). This technology created a 'wake of innovation' across different parts of the process of constructing a building, including changes in manufacturing, design, and fire and safety. By using CATIA, Gehry Partners could visualize complex structures in a comprehensible form and communicate clearly with customers, collaborators, and subcontractors about interfaces, materials, and eventual cost estimates for their designs. Another example is the mass diffusion of mobile phones across the world, providing a wide range of opportunities to create financial services for millions of people in sub-Saharan Africa and Latin America with no formal bank account (Dodgson et al., 2013).

Stylized fact 3: Innovation is pervasive throughout the economic system.

The Pace of Innovation

Although the pace of innovation differs across sectors and time, a fundamental fact of innovation is that most changes in our knowledge and technology are evolutionary in nature. These changes come about through the introduction of incremental or modest improvements in existing products, processes, and services. Radical innovations generate attention and excitement, capturing the interest of the popular press and consumers. Yet, the vast bulk of corporate investment and management effort is directed towards incremental innovation, looking for opportunities to make small improvements in existing products, processes, and services. Since developing entirely new products, processes, and services is costly and uncertain, major innovators usually put most of their effort into improving what they already have. Organizations, such as Procter & Gamble and Unilever, relentlessly seek incremental ways of making their products more attractive by changing their colour and smell, packaging and positioning on the shelf. These firms have major investments in brands, such as Ariel or Tide, large manufacturing facilities, dedicated R&D teams, and strong supplier and distribution channels. Building up these assets is expensive and many large firms are loath to change their routines around them unless they are forced to by competitive pressure or they have an opportunity which is simply too great to pass up. As a result, they tend to focus on the tried and tested, directing innovative efforts to short-term, near market innovations that will help leverage past investments and offer little risk (Leonard-Barton, 1992).

Incremental innovative efforts can have significant effects. Leading automotive production facilities, for example, can aim for a yearly target of 10 per cent improvement in operational efficiency per year (Womack et al., 1990). Much of these efficiency gains are achieved thanks to Kaizen, a relentless pursuit of small improvements in production systems. Such a factory would double its productivity every seven years and triple productivity every eleven years. Another case of the power of incremental innovation

is the ability of major airports in Europe to dramatically expand their ability to handle passengers without an increase in runway capacity. London Heathrow, for example, increased its passengers per year from 5 million to over 50 million, even though it has used only two runways for the past thirty years. The increase in air traffic and capacity was brought about by a persistent pursuit of minor improvements in airport operational efficiency, including changing the queuing system for planes, developing spill-off runways to move planes off the runway more quickly, and training pilots to land and quickly exit the main runway (Tether and Metcalfe, 2003). This suggests that, in the medium term, even small changes can have a major impact on economic output.

The importance of incremental innovation does not limit the economic impact of more radical innovation. Radical innovation—which is often defined by a shift in the performance-price ratio by a factor of five or even ten—can spur the generation of new industries and lead to a long progression of incremental innovations. Attempts to measure the frequency of radical innovation have suggested that in most industries radical innovations are infrequent, occurring every thirty years (Anderson and Tushman, 1990; Tushman and Anderson, 1986). In part, this is reflected in the fact that in the USA only 20 per cent of industries underwent a major shake-up in market share of large incumbents (McGahan, 2004). This means workers entering the average industry may work their entire lives without ever experiencing a radical innovation happening in their industry. In turn, it seems the most critical radical innovations to the economic system are those that have a wide range of applications across *different* industries, what are sometimes referred to as 'general purpose technologies' (Helpman, 1998). A clear example of such an innovation was Fritz Haber and Carl Bosch's development of synthetic nitrogen, creating new, more powerful weapons and fertilizers. These fertilizers enabled a dramatic increase in food production worldwide, helping to feed the world's population as it soared from 1.6 billion in 1911 to almost 7 billion in 2011.

The challenge for organizations is that sources and timing of the emergence of a radical innovation are unpredictable and even unknowable. Industry experts often fail to see radical innovations within their sectors and the history of innovation is littered with estimates of the future state of the world that are almost always badly wrong. The difficulty of anticipating a radical innovation is that their effects are not simply quantitative in nature; they are usually qualitative in character. They do not modify the way something is done; they often totally transform it. As a result, radical innovations are hard to anticipate and prepare for. Even though large firms account for a significant share of radical innovation (Christensen, 1997; Tellis et al., 2009), they often fail to reap the advantages of these breakthroughs. For example, in 1992, IBM developed the world's first smartphone, called Simon. It had a touchscreen, and email and organized diary functionality. But it was others, such as RIM, Apple, and Samsung, that were able to commercially exploit this idea. Moreover, since large firms have heavy investments in incremental efforts, they often struggle to respond to radical changes in their markets. They may listen too closely to their current customers (Christensen, 1997), be unwilling

to cannibalize their existing assets (Tellis et al., 2009), or unwilling to change in their current business models and routines (Tripsas and Gavetti, 2000).

Stylized fact 4: Most change brought about through innovation is evolutionary, incremental adaptations of existing elements, products, and technologies.

Stylized fact 5: Radical and revolutionary changes are rare and largely unknowable.

Innovation is Relational

The early years of the study of innovation were dominated by stories of heroic inventors, such as Thomas Edison or Alfred Nobel. Inventors, such as Nobel created whole new industries on the basis of their discoveries, such as nitro-glycerine and later dynamite. Alfred Nobel himself clearly fits the image of a lone inventor. He worked almost entirely by himself in his lab at the bottom of his Paris mansion. He was a difficult and lonely character, with few friends and passions outside of his work. He carefully guarded his inventions and the practices he used to arrive at them. When he shared his ideas with others, it usually ended badly in protracted legal disputes over priority, including a lengthy court case in England with English chemist Frederick Abel over the invention of cordite. His inventions were radical and had applications across a range of industries, including mining and railways, and in warfare. They also allowed Nobel to create a global industrial empire spanning seventy countries, and provided resources upon his death for the launching of the richest prize for science, medicine, and peace (Brown, 2005).

Even modern accounts of innovation tend to privilege the exploits of individuals. Apple's success in the early twentieth century is commonly seen as the direct result of Steve Jobs and his passion for design and relentless pursuit of innovation.

Although all new ideas emerge from the inspirational efforts of individuals, innovation is primarily a relational activity, in that it requires interaction between different people, teams, and functions to be successfully achieved. Individuals may provide the spark and direction to allow great innovation to emerge, but it is usually teams that do the hard graft of turning ideas into innovations. In the case of Apple, for example, Jobs was able to draw on the operational skills of Tim Cook and the design flair of Jonathan Ive, along with the rest of the Apple team. Indeed, research has shown that an individual's ability to generate good, innovative ideas is profoundly shaped by their social capital: the goodwill and resources they can draw upon from their personal contacts (Burt 2005). This effect is also strong for teams and organizations. Organizations that can draw upon ideas, resources, and support from other organizations have greater potential for developing innovations and they also have greater opportunities to capture value from these innovative efforts (Ahuja, 2000; Burt, 2009; Powell et al., 1996).

The relational character of innovation is already reflected in the fact that its value is based on customers' and users' reactions to it. An innovation by itself has no value; it is only the consumer or business demand that innovation creates that leads to value

creation and later value capture. In this respect, early customers and lead users provide the seeds to enable the spread and development of innovations and engagement of these users is a critical first step in building up interest in an innovation (Rogers, 2003; von Hippel, 1988, 2005).

Innovations also typically require close coordination with suppliers to design and create critical components. Apple's first iPod, for example, relied closely on Toshiba providing a high storage memory chip to enable it to hold many more songs than competing music players. It also needed Sony and other music rights holders to agree to sell their copyrighted music through the iTunes music store. New products and processes also have to be aligned to regulations and standards of performance and health and safety, which may be subject to lengthy and critical reviews. Obtaining approval for a new drug requires years of patient and careful preparation to convince government agencies, such as the US Food and Drug Administration or the UK National Institute for Clinical Excellence, of the efficacy and value of the new medicine compared to alternatives. Innovations may also require firms to work with competitors and universities to help sustain a new area of development. When the engineering design company Arup, for example, sought to expand the market for fire engineering services, it found considerable hostility by insurers, builders, and regulators to its innovations, such as using elevators for egress in extreme situations. Only by sharing its technology with competitors and universities did it create a wider community of fire engineering practitioners to judge and validate its own work (Dodgson et al., 2007). In addition, innovators may need to reach out to external communities to sustain and develop their products. Propellerhead Software, a Sweden-based computer music program, has created a vibrant community of musicians who rely on its software. It allows its users to develop modifications to its main program and incorporates these modifications in subsequent generations of the software (Jeppesen and Frederiksen, 2006).

Stylized fact 6: Innovation is relational and usually involves collaboration between two or more parties.

Unpacking Creativity, Invention, and Innovation

In an attempt to explain the nature of innovation, many researchers have focused on the source of creativity and novelty arising from individuals (see Chapter 7 by Leonard and Barton). Much of this research focuses on the creativity of individuals, with creativity seen as the ability to develop 'novel' and 'useful' ideas. In turn, creativity related to innovation comes from a person's innate skills and abilities and the human mind is a wonderful instrument for creative endeavours. Everyone has the potential for creative outputs (Boden, 2004), but some individuals possess greater likelihood of achieving an innovation than others. Some of this ability may be innate, based on an individual's genetic make-up partly inherited from their biology (Nicolaou et al., 2008), but much of it is based on personal experience, training, and effort.

To explore the sources of creativity, researchers have sought to probe the character of inventors and innovators. To this end, research has sought to understand how individuals' psychology and perceptions of their environment shape their likelihood of developing creative ideas. This research shows that individuals with a strong self-determination or intrinsic motivation are able to generate greater creative output (Amabile, 1983; Deci and Ryan, 1985). Moreover, an individual's perception of whether the organizational climate supports creative output strongly influences the likelihood they will generate new and useful ideas (Scott and Bruce, 1994). In addition, individuals need to work in teams with empathic leaders, who tolerate failure and provide them with a degree of safety to undertake activities that break away from the norm (Edmondson, 1999).

Creative ideas may provide the wellspring of inventions, but creativity is not always directed towards invention and later innovation. Many creative ideas have no practical application and although useful may fail to lead to innovation. In this sense, creativity is input to the development of an invention, a novel idea that has practical application. Inventions may be of sufficient novelty that they can be used to apply for a patent, granting the inventor a period of exclusivity of the use of this idea. However, even if patented, most inventions do not succeed in being translated into innovations. Of the total share of inventions eventually patented, for example, only a few will be of significant financial value. The patent system only requires that an invention have a potential usefulness and therefore it is up to the inventor or holder of the patent to make the additional effort to turn a practical idea into a commercially useful product, process, or service. In this sense, innovations are the rarest of ideas, those ideas that can be commercialized or implemented to allow the developer of the ideas to capture value from their efforts.

Stylized fact 7: Creativity is as critical to invention, as invention is to innovation, but these concepts are separate and distinct elements of the innovation process.

Capturing Returns from Innovation

The literature on innovation studies can further tell us why capturing the returns from innovation is not easy (see Chapter 12 by Gambardella et al., and Chapter 28 by Leiponen). Partly, this is because these returns are highly skewed. For many classes of innovative activities, one finds that a very small number of activities, projects, or events account for the lion's share of the total returns (Scherer et al., 2000). It is not uncommon in an R&D portfolio, for example, for 10 per cent of projects to account for 90 per cent of all the total returns. In part, this skewness is a result of the uncertainty—the 'unknown unknowns'—of investments in innovative efforts. It also reflects the cumulative advantages that small differences in the early stages of development of an innovation can make to its eventual success. In this sense, the field of innovation is concerned with finding 'black swans', rare events that capture significant returns (Fleming, 2007). An example

of such skewness can be seen in Microsoft's long-term investment in R&D over a period of ten years, which was widely perceived in the consumer electronics industry to be a costly failure. Except, of course, that in 2010 Microsoft launched Kinect, which sold 8 million units in its first sixty days on the market.

Innovation research has further taught us that the skills required to generate innovation differ significantly from the skills required to capture their returns. In fact, many innovators find that the returns to their innovative efforts are captured by others. This pattern can be seen for a range of different industries, as the organizations that originate an innovation lose out to skilled competitors. Examples abound. Royal Crown Cola first developed a diet soft drink, yet saw Pepsi and Coca-Cola—its bitter rivals—profit from this innovation rather than itself. The first Magnetic Resonance Imaging product was developed by EMI, yet GE and Siemens become the dominant players in the market. Xerox in its PARC lab developed the first graphical user interface for the personal computer, but saw first Apple and then later Microsoft exploit this idea for commercial gain.

A key explanation of these patterns comes from the work of David Teece, captured in his profiting from innovation framework (Teece, 1986). Teece suggested that the ability of firms to gain from an innovation is a function of their ability to capture the value of their intellectual property as well as the nature of knowledge in their industry. Although intellectual property protection such as patents can be effective mechanisms to stop other firms from copying an innovation, patents are imperfect and many skilled rivals can invent around them. Moreover, small, new firms who lack bargaining power may find that their ideas are simply taken from them because they lack the legal resources or firepower to enforce their intellectual property. Teece cites the example of Robert Kearns, later captured in the film *Flash of Genius*, who developed the first intermittent windshield wiper. Kearns later found that the idea was copied by Ford and, subsequently, by Chrysler. He was unable to find legal support to challenge this infringement, as few lawyers were willing to take on the mighty Ford. It was only by learning the law and representing himself that he was able to secure an eventual victory in a lengthy and costly court battle. Although he was eventually successful, the ordeal damaged his health and family relationships.

Teece's approach points to the industrial environment—what he called the 'appropriability regime' of an industry—that shapes the links between innovators and the returns to innovation. The appropriability regime covers the nature of knowledge in an industry as industries with complex, cumulative patterns of knowledge development are hard to penetrate by new entrants as opposed to industries that rely on new knowledge and/or new combinations of existing knowledge (Levin et al., 1987; Pisano and Teece, 2007; Winter, 1987). It also reflects the availability and effectiveness of intellectual property protection mechanisms (Cohen et al., 2000). In addition, Teece highlights the importance of complementary assets, tangible or intangible items required to enable a successful commercialization of an invention, such as marketing or sales forces or manufacturing capability. He points out that, in many cases, ownership of complementary assets determines who eventually gets to benefit from innovation. In particular, he

shows that complementary assets often reside with large firms, with whom innovators will need to partner in order to have any hope of commercial success.

Stylized fact 8: Most innovators fail to capture returns from their innovative efforts and capturing returns from innovation requires different skills from creating innovations.

Varieties of Innovation

Innovations come in many forms and types. Scholars have sought to characterize both the degree and type of innovation, and it sometimes seems there is a whole industry of academics and consultants putting new words in front of the word innovation. The most critical distinction lies in the end points in the continuum between incremental and radical innovations, which speaks to the degree of change introduced by an innovation into the economic system.

Types of innovation also differ. A classic distinction in innovation studies is between product and process innovations. Product innovations are easy to identify, as they involve the creation and launch of new goods and services. In contrast, process innovations are often silent, hidden from public view as they involve changes in operations, tasks, and ways of working in organizations. Process innovations do not require changes in the nature of the product. For example, the development of float glass manufacturing revolutionized the productivity of glass making, but the product—glass—remained largely the same. In this sense, process innovations are largely cost-reducing, as they involve ways of producing a given good or service with lower levels of inputs (Utterback, 1994).

Alongside the distinction between product and process innovation, scholars have suggested that innovations may be architectural or modular (Henderson and Clark, 1990). Architectural innovation involves changes in the interfaces between different components or aspects of knowledge. They do not themselves require the development of new products or processes, but may lead to significantly new ways of bringing together elements of a product or system. An example of architectural innovation is the movement from tricycles towards two-wheel 'safety' cycles. In contrast, modular innovation involves significant changes in a single component of a product, such as a bicycle light, but these changes do not affect the way a component works with other components. Here, efficiency-driven organizations specializing in advancing the components of their systems have a clear advantage in driving forward a technology along its trajectory. A simple example would be the use of new rechargeable battery in a 'phone.

Christensen (1997) describes the situation in which incumbents fail in the face of seemingly easy-to-handle innovation. His concept of disruptive innovation describes how companies that continuously improve their products to satisfy customers may eventually end up providing products that are over-performing for the needs of the markets in which they are offered. In this situation, firms may be vulnerable to be attacked from below by other companies offering inferior products, which are, however, 'good enough' for consumers and which beat incumbents on price or a previously irrelevant

performance dimension. Christensen illustrates how listening too closely to current customers led industry leaders who were actually often the inventors of disruptive innovations to choose *not* to bring them to the market. This was because of concerns current customers would not like them, or fears over lower margins and cannibalization of their other products. He shows how disruptive innovations led to a repeated change in industry leadership in the hard-disk drive industry over several generations of products and further uses it to explain the competitive dynamics caused by the introduction of hydraulics in the excavator industry.

Finally, the last decade has seen the emergence and acceptance of several new categories of innovation—such as for example open innovation (Chesbrough, 2003, and see Chapter 22 by Alexy and Dahlander). Given the prominence associated with the 'discovery' of a new type of innovation, we would not hesitate to predict a further increase in 'new types' of innovation over the years to come. We also see increased research into important new frameworks for analysing innovation, such as platforms (see Chapter 32 by Gawer and Cusumano) and ecosystems (see Chapter 11 by Autio and Thomas).

Stylised fact 9: There is a vast array of different types of innovation.

Patterns of Innovative Activity

Since the earliest studies of innovation, scholars have tried to explore patterns of activity that reoccur periodically. Schumpeter, for example, picked up Kondratieff's concept of the long wave, which illustrated that economic growth, based on innovative activity, would proceed in waves of about fifty years of length. Great inventions, such as the steam engine, steel, electrical engineering, the automobile, computers, and biotechnology, have been suggested to represent transformative underlying technologies.

Patterns have also been found with individual technologies. Here, Abernathy and Utterback's concept of the product life cycle (PLC) features most prominently (Abernathy and Utterback, 1978). The PLC argues that over the lifetime of a technology, firms place varying levels of emphasis on product and process innovation. In the initial 'fluid' stage, firms propose an array of different products and designs incorporating the new technology. In the 'transitional' stage, a dominant product design emerges, and while not necessarily the highest performing product configuration, this design becomes a commonly accepted standard by producers and consumers. Accordingly, the rate of product innovation decreases and efforts begin to focus on variants of the design, while at the same time the first significant investments into process innovations are made. Finally, in the 'specific' stage, the product has moved on to become a commodity, and concerns about production cost are dominant. Hereafter, product innovation activities are limited, and innovative activity mainly revolves around the optimization of process technologies. Whereas the concept of the PLC has been widely confirmed for a variety of industries, several extensions and criticisms exist. For example, Klepper's work argued when the marginal advantages of additional

investments in process versus product R&D is reached, there is a rush for scale and an industry shake-out (e.g. Klepper, 1997). In addition, Barras (1986, 1990) points out that for services innovation, especially financial services, the PLC sometimes applies in reverse: first, process technologies need to be established and standardized that then facilitate the generation of new services upon them. Barras argues that this is due to fundamental differences between product and service innovation, which reside in their co-terminality, intangibility, and low capital intensity. Other authors, however, have pointed out a wide range of examples for the standard PLC also applying to services industries.

Finally, there are strong complementarities between different types of innovation. Service innovation can create opportunities for product innovation, processes for new products, and new products for new processes. Evidence from innovation surveys finds strong complementarities between different types of innovation. They are both often present simultaneously and the creation of multiple complementary forms of innovation at the same time can help stimulate greater firm performance (Damanpour and Gopalakrishnan, 2001).

Stylised fact 10: There are 'regular' patterns in innovative activity over time, and strong complementarities between different types of innovation.

The Geography of Innovation

Despite the fact that innovative activity is becoming an increasingly global and interconnected phenomenon (see below as well as Chapter 27 by Håkanson), innovation tends to remain 'sticky' to particular places. Innovation investments and outputs tend to be concentrated in global centres, where leading actors congregate, mingle, and compete.

Within organizations, co-location of individuals is still a crucial mechanism to enable the effective flow of knowledge between people who have to work together to produce innovation. As a result, organizations give careful attention to the design of their R&D and development facilities to create 'spaces for innovation', hoping to maximize exchange and cross-fertilization. When BMW constructed a new R&D facility, for example, it sought to ensure that engineers working on related problems were no more than 25 metres from one another. One reason for this need to be close is that knowledge itself can often be characteristic as 'sticky' (von Hippel, 1994); difficult to express and transfer, and contextually dependent. Anticipated users of a planned product may, for example, be unable to articulate their own needs plausibly when asked by marketers, and only explore them by actually using or modifying a product themselves. von Hippel goes on to argue how this sticky nature of knowledge might even lead to predict where innovation comes from and who profits from it, in particular emphasizing the role of users as the actual source of innovation when sticky information resides with them (see Chapter 5 by Franke).

Beyond the level of the organization, the sticky nature of knowledge implies that certain types of knowledge will not travel far. In particular, valuable knowledge spillovers have a clear tendency to only bridge small geographic distances. Also, collaborative activity between firms benefits from face-to-face interaction to facilitate knowledge exchange and transfer. And finally, even investments in innovative activity, for example venture capital, have a clear local bias (Sorenson and Stuart, 2001). All in all, it is clear that to a certain degree, innovation remains a face-to-face business in which geography plays a crucial role (Storper and Venables, 2004).

In turn, this also implies that regional and national differences in how innovation is fostered and supported may matter significantly, and specifically innovation is affected by the variance in institutional set-ups that govern interactions between firms and individuals (Lundvall, 1992). The sheer existence of a patent system and different configurations thereof may shape domestic and foreign investment in R&D. Moreover, varying institutions may give rise to different inputs into the innovation process, whether they are supportive or less helpful. The German manufacturing sector, for example, is famed for powerful work councils and long-term employment and a highly skilled labour force, whereas UK manufacturing firms are more strongly controlled by management, feature shorter-term employment, and have tended to employ more workers in lower-skilled jobs.

Certain national and regional innovation systems are notorious for their ability to become successful launch pads for innovation. At the national level, the famous example of nationally organized catch-up strategies in Korea and Taiwan highlight the potential of these efforts (Hobday, 1995; Kim, 1997). At the regional level, clusters may emerge into hotspots of innovative activity. Silicon Valley or the Boston region in the USA are powerhouses for ground-breaking, first-to-world products and services (Saxenian, 1994). In contrast, regions in Italy and Chile are famed for having sustained excellence in the traditional shoe-making or wine industry, respectively, for decades (Boschma and Frenken, 2007; Giuliani and Bell, 2005). Other prominent examples include the USA's Hollywood, India's Bollywood, or Nigeria's Nollywood in the movie industry. These examples also highlight the need to balance tight local links with global pipelines to ensure diversity in both knowledge inputs as well as pathways to markets (Bathelt et al., 2004; Powell et al., 1996).

Stylized Fact 11: Innovation is a 'sticky' activity in which location matters.

The Organizational Routines of Innovation

Research has sought to understand what types of organizational routines support innovation. Originally, this work started with an attempt to understand what makes a 'technologically progressive firm', highlighting the importance of organic, fluid organizational structures to support innovation (Burns and Stalker, 1961). At the same time, this work highlighted that mechanisms or formal structures could help regulate and

regularize innovative efforts, ensuring that processes and products could be replicated and scaled up. This tension has long been at the heart of innovation management, with attempts to develop organizational routines that support the creation and development of new ideas as well as enabling their execution and delivery. One solution to this challenge is to create separate organizational structures to support different forms of innovation; one unit for exploring creative, radical new ideas and another for the exploiting and developing of incremental improvements in existing ideas (Tushman and O'Reilly, 1996). In doing so, an organization would be ambidextrous, taking advantage of both models of innovative support. Indeed, this organizational model has been widely adopted by firms, which often create separate organizational units for different innovative tasks with contrasting work and human resources practices.

Organizations have sought to develop routines to support creativity. These include providing autonomy for innovators, possibly by providing a share of time for individuals to work outside their official project plans. They have also nurtured a tolerance of failure and culture of forgiveness for those individuals or teams that attempt to achieve innovation but fail. They seek to create fluid and dynamic teams that bring together disciplines and functions. In particular, innovative organizations have adopted integrated product development teams, including representatives of different departments to help work together on a R&D project. They also seek to refresh team membership, and ensure that they display an openness to outsiders (Leonard and Swap, 1999).

Another critical routine for innovative organizations has been the development of tools to manage and select R&D projects. The alternative is that efforts to generate ideas by letting a thousand flowers bloom may lead to a garden of weeds (Kanter et al., 1997). Since resources are always limited and the costs of scaling up any idea are liable to be high, organizations need to think very carefully about how they choose and manage ideas. In R&D management, the development of stage-gate systems that create a series of stop-go decision gates provides an opportunity for organizations to reflect on R&D projects at different stages of their maturity (Cooper, 1990, 2001). Moreover, these projects can be judged against one another and a range of criteria, such as potential market value, costs of development, and so on. Using multi-criteria assessment to judge the quality of projects helps to avoid the tendency within organizations to rely on 'gut-feel' about the value of projects. These tools also help to avoid the danger than firms overcommit to single projects and help to ensure a good allocation of resources between products at different stages and with different degrees of radicalness.

Attempts to assess the value of R&D projects before they are completed are useful, but often problematic. Good projects may be killed by internal stage-gate process as they go against established ways of working, leading to a tendency to short-term, incremental efforts. Even techniques that offer statements about the financial value of a project are based on expected returns and costs, estimates that are liable to suffer from dangers of bias and misstatement.

Stylized fact 12: There is a clear set of organizational routines that can help organizations to better manage the innovation process.

The Protective Belt of Innovation Studies

Early work on the nature of innovation focused mostly on innovation driven by technical change, usually in the manufacturing sector. There were some obvious reasons for this. The industrial revolution is often seen to be driven by technological changes—embodied in inventions such as the steam engine or the spinning jenny. Yet, the industrial revolution was also the result of social, political, and economic changes, and it does not lend itself to simplistic and often misleading explanations of economic development based on technological determinism (Mokyr, 2004).

In addition, part of the focus on technical change in the study of innovation was driven by measurement. The main measurement instruments of innovation studies—R&D surveys, patents, and academic publications—all tend to focus on the generation and use of new scientific and technological knowledge. Since the measurement tools concentrate on this topic, researchers and governments have done likewise, tending to focus on innovation in the 'measured' sectors where there is considerable R&D, patenting, and publications. Indeed, much of the modern focus of research on innovation has focused on pharmaceuticals, semiconductors, and biotechnology industries, all sectors whose innovative efforts are captured by the current toolkit of innovation studies. This approach has created numerous blind spots for the research tradition, and created opportunities for researchers to develop new ideas in areas that are distant from the conventional focus on the generation and use of scientific and technological knowledge.

One idea that has begun to penetrate the protective belt of innovation studies is that managers and researchers should not give primacy to technological innovation over other types of innovation. It is clear that many innovations are not primarily 'technological' in nature. For instance, most service innovations are largely organizational, involving new ways of bringing together information and creative routines (Gallouj and Weinstein, 1997). These services require deep knowledge of a range of systems, and the ability to integrate diverse sets of activities in new and productive ways. Dell's success in the 1990s and early 2000s, for example, was driven by its strong electronic commerce systems, such as websites and telephone ordering. These systems allowed it to bypass conventional sales channels to directly interface with customers. In addition, over the past ten years, Xerox has transformed itself from an organization focused on the development of hardware and technology to a solution provider, with more than half of its sales arising from services. Much of the sales of Xerox now arise from activities that have little or nothing to do with photocopiers. As the Dell and Xerox cases attest, building a successful business model can be a tremendous stimulus to innovation (Chesbrough, 2011, and see Chapter 21 by Massa and Tucci).

A second area of activity that has been open to a major shift in thinking is the role of R&D in the innovation process. In the early stages of the study of innovation, capturing investment in R&D by governments, firms, and universities represented a major breakthrough in our understanding and, since 1965, this information has been

collected systematically across the developed world (OECD 2002). Yet, it was clear early on that R&D only captures a modest share of total economic and social investment in innovation, and that R&D investment and resulting inventive outputs such as patents were at best incomplete predictors of innovation and growth (Griliches, 1981; Griliches et al., 1991). This is true for countries as well as companies. And with increasing levels of connectedness due to phenomena such as the Internet or globalization, many corporations have shifted away from an R&D-led model of innovation, focusing on more open and distributed models (Chesbrough, 2003; von Hippel, 2005). Although it is clear that R&D is a still a critical resource for firms to develop new products, services, and processes and to learn about the efforts of others (Cohen and Levinthal, 1989, 1990), there are other mechanisms that support innovation and learning that operate within the firm. Accordingly, companies have also sought to capture information on their expenditures on different types of intangibles, such as customer goodwill, networks, and brands. They have also moved away from focusing on the level of R&D expenditure as a measure of corporate vitality and growth. It is also clear that there is no direct link between expenditures on R&D and corporate performance, as many firms compete effectively against large R&D spenders although they spend much less on R&D. Over a period of five years, for example, Apple spent less than a third on R&D than Nokia, yet was able to overcome Nokia's dominance of the mobile 'phone market.

These shifts in corporate perspectives towards the salience of R&D have not always been reflected in government thinking. Many governments remained focused on expenditures on R&D as a key measure of national innovative effort. It is common for major countries to adopt targets for R&D spending as a share of the economy. The European Union, for example, has a target of spending 3 per cent of Gross Domestic Product on R&D in 2020, which is the same target it sought to achieve in 2010, but failed to reach.

A problem with R&D is that it misses out on much of the investment in services innovation, especially in critical and growing sectors such as professional services. Generally, the notion of R&D is often based on the idea of corporate research labs coalescing the efforts of scientists and engineers to develop new knowledge. Yet, many other people and functions are involved in knowledge production and the creation of novelty in the economic system, including management consultants, designers, or software programmers. Many of the activities of these individuals are not captured by conventional R&D measurements and therefore by focusing on R&D we are looking at the tip of the iceberg when it comes to social and economic investment on innovation. Software development, for example, is a hugely important part of the banking industry, but it cannot be easily accounted for by traditional R&D reporting categories. The scale of this measurement problem was recently demonstrated in the UK, where attempts were made to capture the total level of expenditures on intangibles in the economy. These estimates showed that R&D accounted for only 9 per cent of total intangible investment, dwarfed by expenditures on software development, organizational development, and training (Haskel et al., 2010). As result, attention has been newly focused on the measuring and refining of understanding of other firm investments that shape innovative outcomes,

shifting attention away from R&D as the central mechanism that supports innovation in the economic system.

The third break from the past in the study of innovation concerns the role of the firm in the innovation process. Traditionally, the study of innovation saw the firm as the central actor in the process of innovation, as it was assumed that firms provided the means to create, diffuse, and capture value from innovative efforts. Yet, with the advent of more collaborative and distributed models of innovation (Chesbrough, 2003; von Hippel, 1988, 2005), it is not clear that the firm is always the most critical actor in the innovation process. Innovations are increasingly the product of collaborations between a range of actors, including users, universities, firms, and governments. The decline of the salience of the firm in creating and capturing value from innovation reflects in part the way that innovations increasingly rely on complex knowledge, sourced from a range of actors. As a result, firms rely on greater levels of collaboration to generate and commercialize their ideas. ARM, a UK-based design-based semiconductor firm, for example, relies on a network of collaborators that includes over 300 different chipmakers, designers, and chip users. This ecosystem supports a range of developments outside the direct control of ARM, but provides a rich pool of resources to facilitate the development of ARM chip designs (Garnsey et al., 2008). Moreover, it is now easier for organizations that seek to profit from an innovation to find partners to help them in the manufacturing, delivery, service, and support of their products. This deepening of the innovative division of labour allows organizations to become more specialized at those parts of the value chain that they are best able to contribute to (Arora et al., 2001; Gambardella et al., 2007). In addition, organizations are increasingly utilizing third parties to help them innovate, including investing in crowdsourcing, innovation intermediaries, and co-creation with customers. All of these changes at the heart of the innovation process suggest that the firm of today rarely controls its own destiny when it comes to innovation, and that its innovative potential is largely determined not by the assets and knowledge it holds, but by its ability to draw upon resources, knowledge, and skills from others.

A fourth area of change to our understanding of innovation has been about the nature of public and private knowledge. Traditionally, studies of innovation have assumed that firms develop private knowledge, whereas universities develop public knowledge. Yet, the past twenty years have altered this perspective. On one side, universities are increasingly seeking to patent their discoveries and profit from them by licensing them to established firms or establishing university spinouts. In part, this commercial effort has been driven by government pressures on university finances, but also expectations that universities were missing out on significant sources of potential funding. Although the returns to university patenting have been relatively modest, the movement of universities to create private knowledge has altered the division of labour between universities and firms in the innovation process (Mowery et al., 2001; Nelson and Nelson, 2002). No longer can it be assumed that new knowledge created at universities is freely available for firms to use. Instead, this knowledge is increasingly accessible only by signing collaborative agreements or through direct licensing.

At the same time, firms have become more and more active in creating public knowledge. They publish in the scientific literature (Hicks, 1995). They may donate patents to support open source software and devote resources to helping build, sustain, and develop these communities (Alexy and Reitzig, 2013). They also join forces with their competitors to help develop public repositories of knowledge, such as Merck, Eli Lilly, and GlaxoSmithKline (GSK)'s support for the Structural Genomics Consortium (Perkmann, 2009). As a result, the openness of new knowledge cannot be determined just by looking at whether it was created by public or private organizations and, as a result, the landscape of the knowledge for innovation has become complex and layered.

As the level of research and interest in innovation has increased, we could expect more breakthroughs and changes to our understanding of its nature. As a progressive science, the study of innovation is open to the 'creative destruction' of its hard core of stylized facts. With the advent of new, richer, and more powerful information sources on the nature of innovative efforts by public and private actors, there is a significant opportunity to transform what is known about innovation to assist its management.

Notes

1. A notorious site in London where hangings took place.
2. From 18 February 1999. See also <http://www.economist.com/node/186620>.
3. Speech given in August 2009 in Elkhart County, Indiana. See also <http://www.whitehouse.gov/blog/Spurring-Innovation-Creating-Jobs/>.
4. That is, their ownership by one party does not preclude access to them by another.

References

Abernathy, W. J., and Utterback, J. M. (1978). 'Patterns of Industrial Innovation', *Technology Review*, 80: 41–7.

Acemoglu, D., Gancia, G., and Zilibotti, F. (2012). 'Competing Engines of Growth: Innovation and Standardization', *Journal of Economic Theory*, 147(2): 570–601.

Ahuja, G. (2000). 'Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study', *Administrative Science Quarterly*, 45(3): 425–55.

Alexy, O., and Reitzig, M. (2013). 'Private-Collective Innovation, Competition, and Firms' Counterintuitive Appropriation Strategies', *Research Policy*, 42(4): 895–913.

Amabile, T. M. (1983). *The Social Psychology of Creativity*. New York: Springer.

Anderson, P., and Tushman, M. L. (1990). 'Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change', *Administrative Science Quarterly*, 35(4): 604–33.

Arora, A., Fosfuri, A., and Gambardella, A. (2001). *Markets for Technology*. Cambridge, MA: MIT Press.

Barras, R. (1986). 'Towards a Theory of Innovation in Services', *Research Policy*, 15(4): 161–73.

Barras, R. (1990). 'Interactive Innovation in Financial and Business Services: The Vanguard of the Service Revolution', *Research Policy*, 19(3): 215–37.

Bathelt, H., Malmberg, A., and Maskell, P. (2004). 'Clusters and Knowledge: Local Buzz, Global Pipelines and the Process of Knowledge Creation', *Progress in Human Geography*, 28(1): 31–56.

Boden, M. A. (2004). *The Creative Mind: Myths and Mechanisms*, 2nd edn. London: Routledge.

Boland, R. J., Lyytinen, K., and Yoo, Y. (2007). 'Wakes of Innovation in Project Networks: The Case of Digital 3-d Representations in Architecture, Engineering, and Construction', *Organization Science*, 18(4): 631–47.

Boschma, R. A., and Frenken, K. (2007). 'Applications of Evolutionary Economic Geography', in K. Frenken (ed.), *Applied Evolutionary Economics and Economic Geography*. Cheltenham: Edward Elgar.

Boswell, J. (1791). *The Life of Samuel Johnson, LL.D*. London: Henry Baldwin for Charles Dilly.

Brown, S. R. (2005). *A Most Damnable Invention*. Toronto: Viking Canada.

Brynjolfsson, E. (1993). 'The Productivity Paradox of Information Technology', *Communications of the ACM*, 36(12): 66–77.

Burns, T., and Stalker, G. M. (1961). *The Management of Innovation*. London: Tavistock.

Burt, R. S. (2005). *Brokerage and Closure: An Introduction to Social Capital*. New York: Oxford University Press.

Burt, R. S. (2009). *Neighbor Networks: Competitive Advantage Local and Personal*. New York: Oxford University Press.

Chesbrough, H. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Press.

Chesbrough, H. (2011). *Open Services Innovation: Rethinking your Business to Grow and Compete in a New Era*. San Francisco: John Wiley & Sons.

Christensen, C. M. (1997). *The Innovator's Dilemma*. Boston: Harvard Business School Press.

Cohen, W. M., and Levinthal, D. A. (1989). 'Innovation and Learning: The Two Faces of R & D', *Economic Journal*, 99(397): 569–96.

Cohen, W. M., and Levinthal, D. A. (1990). 'Absorptive Capacity: A New Perspective on Learning and Innovation', *Administrative Science Quarterly*, 35(1): 128–52.

Cohen, W. M., Nelson, R. R., and Walsh, J. P. (2000) (February). Protecting their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or not)'. Available at <http://www.nber.org/papers/w7552> (accessed 7 April 2006).

Cooper, R. G. (1990). 'Stage-Gate Systems: A New Tool for Managing New Products', *Business Horizons*, 33(3): 44–54.

Cooper, R. G. (2001). *Winning at New Products: Accelerating the Process from Idea to Launch*, 3rd edn. New York: Basic Books.

Damanpour, F., and Gopalakrishnan, S. (2001). 'The Dynamics of the Adoption of Product and Process Innovations in Organizations', *Journal of Management Studies*, 38(1): 45–65.

Deci, E. L., and Ryan, R. M. (1985). *Intrinsic Motivation and Self-Determination in Human Behaviour*. New York: Plenum.

Dodgson, M., Gann, D., and Salter, A. (2005). *Think, Play, Do: Technology, Innovation, and Organization*. Oxford: Oxford University Press.

Dodgson, M., Gann, D., and Salter, A. (2007). ' "In case of fire, please use the elevator": Simulation Technology and Organization in Fire Engineering', *Organization Science*, 18(5): 849–64.

Dodgson, M., Gann, D., Wladawsky-Berger, I., and George, G. (2013). 'From the Digital Divide to Inclusive Innovation: The Case of Digital Money', RSA Pamphlet, Royal Society of Arts, London.

Edgerton, D. (2008). 'The Charge of Technology', *Nature*, 455(7216): 1030–1.

Edmondson, A. (1999). 'Psychological Safety and Learning Behavior in Work Teams', *Administrative Science Quarterly*, 44(2): 350–83.

Fleming, L. (2007). 'Breakthroughs and the "Long Tail" of Innovation', *MIT Sloan Management Review*, 49(1): 69–74.

Gaddis, J. L. (2005). *The Cold War*. London: Penguin Books.

Gallouj, F., and Weinstein, O. (1997). 'Innovation in Services', *Research Policy*, 26: 537–56.

Gambardella, A., Giuri, P., and Luzzi, A. (2007). 'The Market for Patents in Europe', *Research Policy*, 36(8): 1163–83.

Garnsey, E., Lorenzoni, G., and Ferriani, S. (2008). 'Speciation through Entrepreneurial Spin-off: The Acorn-ARM Story', *Research Policy*, 37(2): 210–24.

Giuliani, E., and Bell, M. (2005). 'The Micro-Determinants of Meso-Level Learning and Innovation: Evidence from a Chilean Wine Cluster', *Research Policy*, 34(1): 47–68.

Greenleaf, W. (1961). *Monopoly on Wheels*. Detroit: Wayne State University Press.

Griliches, Z. (1981). 'Market Value, R&D, and Patents', *Economics Letters*, 7(2): 183–7.

Griliches, Z., Hall, B. H., and Pakes, A. (1991). 'R&D, Patents, and Market Value Revisited: Is There a Second (Technological Opportunity) Factor?', *Economics of Innovation and New Technology*, 1(3): 183–201.

Hargadon, A. B. (2003). *How Breakthroughs Happen: The Surprising Truth About How Companies Innovate*. Cambridge, MA: Harvard Business School Press.

Haskel, J., Clayton, T., Goodridge, P., Pesole, A., Barnett, D., Chamberlain, G., Jones, R., Khan, K., and Turvey, A. (2010) (February). 'Innovation, Knowledge Spending and Productivity Growth in the UK: Interim Report for Nesta Innovation Index Project. Available at <http://spiral.imperial.ac.uk/bitstream/10044/1/5279/1/Haskel%202010-02.pdf> (accessed 26 November 2011).

Helpman, E. (1998). *General Purpose Technologies and Economic Growth*. Cambridge, MA: MIT Press.

Henderson, R. M., and Clark, K. B. (1990). 'Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms', *Administrative Science Quarterly*, 35(1): 9–30.

Hicks, D. (1995). 'Published Papers, Tacit Competencies and Corporate Management of the Public/Private Character of Knowledge', *Industrial and Corporate Change*, 4(2): 401–24.

Hobday, M. (1995). *Innovation in East Asia: The Challenge to Japan*. London: Elgar.

Jeppesen, L. B., and Frederiksen, L. (2006). 'Why Do Users Contribute to Firm-Hosted User Communities? The Case of Computer-Controlled Music Instruments', *Organization Science*, 17(1): 45–63.

Kaldor, N. (1957). 'A Model of Economic Growth', *Economic Journal*, 67(268): 591–624.

Kaldor, N. (1961). 'Capital Accumulation and Economic Growth', in F. A. Lutz and D. C. Hague (eds), *The Theory of Capital*. London: MacMillan, 177–222.

Kanter, R. M., Kao, J., and Wiersema, F. (1997). *Innovation: Breakthrough Thinking at 3M, DuPont, GE, Pfizer, and Rubbermaid*. New York: HarperCollins.

Kim, L. (1997). *Imitation to Innovation: The Dynamics of Korea's Technological Learning*. Boston: Harvard Business School Press:

Klepper, S. (1997). 'Industry Life Cycles', *Industrial and Corporate Change*, 6(1): 145–81.

Kogut, B., and Zander, U. (1992). 'Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology', *Organization Science*, 3(3): 383–97.

Lakatos, I. (1970). 'Falsification and the Methodology of Scientific Research Programmes', in I. Lakatos and A. Musgrave (eds), *Criticism and the Growth of Knowledge*. Cambridge: Cambridge University Press, 91–196.

Leiponen, A. (2005). 'Skills and Innovation', *International Journal of Industrial Organization*, 23(5–6): 303–23.

Leonard, D., and Swap, W. (1999). *When Sparks Fly: Igniting Creativity in Groups*. Boston: Harvard Business School Press.

Leonard-Barton, D. (1992). 'Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development', *Strategic Management Journal*, 13: 111–25.

Levin, R. C., Klevorick, A. K., Nelson, R. R., and Winter, S. G. (1987). 'Appropriating the Returns from Industrial-Research and Development', *Brookings Papers on Economic Activity*, 3: 783–831.

Lundvall, B. (1992). *National Systems of Innovation: Towards a Theory of Innovation and Interaction Learning*. London: Pinter.

McGahan, A. M. (2004). *How Industries Evolve: Principles for Achieving and Sustaining Superior Performance*. Boston: Harvard Business School Press.

Marrano, M. G., Haskel, J., and Wallis, G. (2009). 'What Happened to the Knowledge Economy? ICT, Intangible Investment, and Britain's Productivity Record Revisited', *Review of Income and Wealth*, 55(3): 686–716.

Martin, B. (2012). 'The Evolution of Science Policy and Innovation Studies', *Research Policy*, 41(7): 1219–39.

Mokyr, J. (2004). *The Gifts of Athena: Historical Origins of the Knowledge Economy*. Princeton: Princeton University Press.

Mowery, D. C., Nelson, R. R., Sampat, B. N., and Ziedonis, A. A. (2001). 'The Growth of Patenting and Licensing by U.S. Universities: An Assessment of the Effects of the Bayh-Dole Act of 1980', *Research Policy*, 30(1): 99–119.

Nelson, R. R., and Nelson, K. (2002). 'Technology, Institutions, and Innovation Systems', *Research Policy*, 31(2): 265–72.

Nicolaou, N., Shane, S., Cherkas, L., Hunkin, J., and Spector, T. D. (2008). 'Is the Tendency to Engage in Entrepreneurship Genetic?', *Management Science*, 54(1): 167–79.

OECD (2002). *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*, 6th edn. Paris: OECD.

Perkmann, M. (2009). 'Trading off Revealing and Appropriating in Drug Discovery: The Role of Trusted Intermediaries', *Academy of Management Proceedings*: 1–6.

Pisano, G. P., and Teece, D. J. (2007). 'How to Capture Value from Innovation: Shaping Intellectual Property and Industry Architecture', *California Management Review*, 50(1): 278.

Powell, W. W., Koput, K. W., and Smith-Doerr, L. (1996). 'Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology', *Administrative Science Quarterly*, 41(1): 116–45.

Rogers, E. M. (2003). *Diffusion of Innovations*, 5th edn. New York: Free Press.

Romer, P. M. (1986). 'Increasing Returns and Long-Run Growth', *Journal of Political Economy*, 94(5): 1002–37.

Romer, P. M. (1990). 'Endogenous Technological Change', *Journal of Political Economy*, 98(5): S71–S102.

Saxenian, A. L. (1994). *Regional Advantage: Culture and Communication in Silicon Valley and Route 128*. Cambridge, MA: Harvard University Press.

Scherer, F. M., Harhoff, D., and Kukies, J. (2000). 'Uncertainty and the Size Distribution of Rewards from Innovation', *Journal of Evolutionary Economics*, 10: 175–200.

Schumpeter, J. A. (1911). *Theorie der wirtschaftlichen Entwicklung: Eine Untersuchung über Unternehmergewinn, Kapital, Kredit, Zins und den Konjunkturzyklus*. Berlin: Dunkler & Humblot.

Schumpeter, J. A. (1942). *Capitalism, Socialism, and Democracy*. New York: Harper and Brothers.
Scott, S. G., and Bruce, R. A. (1994). 'Determinants of Innovative Behavior: A Path Model of Individual Innovation in the Workplace', *Academy of Management Journal*, 37(3): 580–607.
Solow, R. M. (1957). 'Technical Change and the Aggregate Production Function', *Review of Economics and Statistics*, 39(3): 312–20.
Sorenson, O., and Stuart, T. E. (2001). 'Syndication Networks and the Spatial Distribution of Venture Capital Investments', *American Journal of Sociology*, 106(6): 1546–88.
Storper, M., and Venables, A. J. (2004). 'Buzz: Face-to-Face Contact and the Urban Economy', *Journal of Economic Geography*, 4(4): 351–70.
Teece, D. J. (1986). 'Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy', *Research Policy*, 15(6): 285–305.
Tellis, G. J., Prabhu, J. C., and Chandy, R. K. (2009). 'Radical Innovation across Nations: The Preeminence of Corporate Culture', *Journal of Marketing*, 73(1): 3–23.
Tether, B. S., and Metcalfe, J. S. (2003). 'Horndal at Heathrow? Capacity Creation through Co-operation and System Evolution', *Industrial and Corporate Change*, 12(3): 437–76.
Tripsas, M., and Gavetti, G. (2000). 'Capabilities, Cognition, and Inertia: Evidence from Digital Imaging', *Strategic Management Journal*, 21(10–11): 1147–61.
Tushman, M. L., and Anderson, P. (1986). 'Technological Discontinuities and Organizational Environments', *Administrative Science Quarterly*, 31(3): 439.
Tushman, M. L., and O'Reilly III, C. A. (1996). 'Ambidextrous Organizations: Managing Evolutionary and Revolutionary Change', *California Management Review*, 38(4): 8–30.
Utterback, J. M. (1994). *Mastering the Dynamics of Innovation*. Boston: Harvard Business School Press.
von Hippel, E. (1988). *The Sources of Innovation*. New York: Oxford University Press.
von Hippel, E. (1994). ' "Sticky Information" and the Locus of Problem Solving: Implications for Innovation', *Management Science*, 40(4): 429–39.
von Hippel, E. (2005). *Democratizing Innovation*. Cambridge, MA: MIT Press.
Winter, S. G. (1987). 'Knowledge and Competence as Strategic Assets', in D. J. Teece (ed.), *The Competitive Challenge Strategies for Industrial Innovation and Renewal*. Cambridge, MA: Ballinger, 159–84.
Womack, J. P., Jones, D. T., and Roos, D. (1990). *The Machine that Changed the World*. New York: Maxwell Macmillan International.

PART II

THE SOURCES OF INNOVATION