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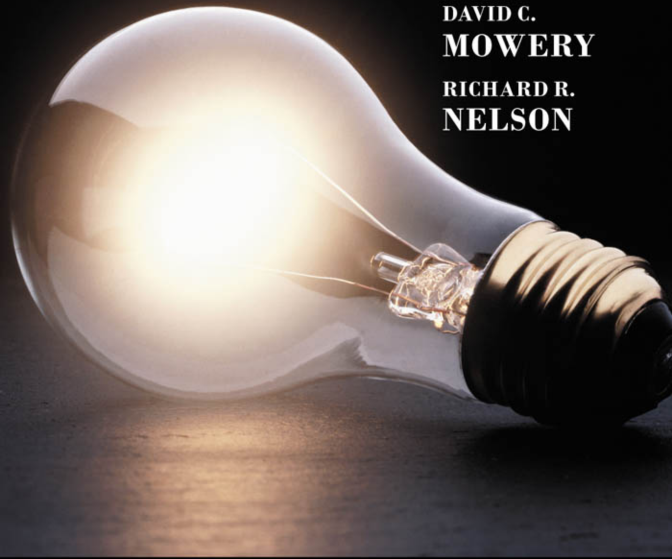

The Oxford Handbook *of* INNOVATION

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OXFORD
UNIVERSITY PRESS

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Great Clarendon Street, Oxford OX2 6DP

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 in

Oxford New York

Auckland Cape Town Dar es Salaam Hong Kong Karachi
Kuala Lumpur Madrid Melbourne Mexico City Nairobi
New Delhi Shanghai Taipei Toronto

With offices in

Argentina Austria Brazil Chile Czech Republic France Greece
Guatemala Hungary Italy Japan Poland Portugal Singapore
South Korea Switzerland Thailand Turkey Ukraine Vietnam

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Published in the United States
by Oxford University Press Inc., New York

First published 2005
First published in paperback 2006

British Library Cataloguing in Publication Data
Data available

Library of Congress Cataloging in Publication Data
Data available

Typeset by SPI Publisher Services, Pondicherry, India
Printed in Great Britain
on acid-free paper by
Ashford Colour Press Limited,
Gosport, Hampshire

ISBN 0–19–926455–4 978–0–19–926455–1
ISBN 0–19–928680–9 (Pbk.) 978–0–19–928680–5 (Pbk.)

1 3 5 7 9 10 8 6 4 2

Preface

In a famous poem, “The Blind Men and the Elephant,” John Godfrey Saxe (1816–87) described what may happen when different observers approach the same phenomenon from rather different starting points. In the poem Saxe lets one of the blind men approach the elephant’s side. The man finds it to be “very like a wall.” Another fits around its leg and concludes that it resembles a tree. And so on. They end up disputing “loud and long.” Saxe drew the following moral:

> So oft in theologic wars,
> The disputants, I ween,
> Rail on in utter ignorance
> Of what each others mean,
> And prate about an Elephant
> Not one of them has seen!

The point is, of course, that each “disputant” has a valid insight, but needs to combine it with the insights of others to reach a holistic understanding. If we substitute “innovation” for the elephant and the “social scientists from different disciplines” for the blind men, we come close to understanding the motives that led to the creation of this handbook. Innovation is a multifaceted phenomenon that cannot be easily squeezed into a particular branch of the social sciences or the humanities. Consequently, the rapidly increasing literature on innovation is characterized by a multitude of perspectives based on—or cutting across—existing disciplines and specializations. There is a danger, however, that scholars studying innovation do it from starting points so different that they become unable to—or not interested in—communicating with each other, preventing the development of a more complete understanding of the phenomenon.

The purpose of this volume is to contribute to a holistic understanding of innovation. The volume includes twenty-one carefully selected and designed contributions, each focusing on a specific aspect of innovation, as well as an introductory essay that sets the stage for the chapters that follow. The authors are leading academic experts on their specific topics, and include economists, geographers, historians, psychologists, and sociologists. Some contributors have engineering degrees in addition to their social science degree. Each chapter can be read separately, but most readers will benefit from reading the introductory essay first. Readers interested in pursuing further study on specific topics will find suggestions for additional reading (marked with asterisks) in the reference list at the end of each chapter.

As with all books there is a history behind it. In fact there are several. There is a long history, related to how innovation studies have evolved over the years. Many of the contributions presented here, Chapter 1 in particular, give elements of that story. The shorter history begins in the mid-1990s with the big impetus to innovation research in Europe provided by the "Framework" programmes of the European Commission. Having participated actively in this research for some time, several of the contributors to this volume became interested in establishing a network that could support discussion and evaluation of its results. For this purpose Jan Fagerberg organized in 1999, with the support of the Norwegian Research Council, an international network for innovation studies that met occasionally to discuss selected topics within innovation research. The meetings of this group led to a proposal for a book reflecting our current knowledge on innovation. Oxford University Press was contacted and welcomed the idea. Economic support from the European Commission and the Norwegian Research Council made it possible for the contributors to meet twice to exchange ideas and comment on each other contributions, greatly enhancing the quality and consistency of the volume.

One of the central participants in the network that led to this volume was Keith Pavitt, Professor at SPRU (University of Sussex) and editor of *Research Policy*, the leading journal in the field. With a background in both engineering and economics, Keith was one of the pioneers in cross-disciplinary research on innovation. Characterized by a "fact-finding" approach and a lack of respect for received "grand theories" not supported by solid evidence, he influenced generations of younger researchers and helped put innovation studies on its current "issue-driven," empirically oriented track. Keith enthusiastically supported this book initiative, very quickly (before anybody else) circulated a full draft of a chapter and participated actively in the discussions during the first workshop in Lisbon in November 2002. He died unexpectedly shortly afterwards. The editors and contributors dedicate this book to his memory.

J.F., D.M., R.N.

Oslo, Berkeley, and New York
January 2004

Acknowledgements

Without financial support from the Norwegian Research Council (projects 131468/510 and 139867/510) and the European Commission (the TEARI project—HPSE-CT-2002-60052) this book would not have been realized. We thank Trygve Lande and Helge Rynning from Norwegian Research Council and Nicholaus Kastrinos from the European Commission for their cooperation. The Centre for Technology, Innovation, and Culture (TIK), University of Oslo gave Jan Fagerberg a leave of absence to start working with this project, which he spent at ISEG, Technical University of Lisbon. He would also like to thank ISEG and the Gulbenkian Foundation for helping to make this possible. Similarly, David Mowery would like to thank the Division of Research of the Harvard Business School for a Bower Fellowship during 2003–4 that aided his work on this volume. Manuel Godinho of ISEG helped organize the first workshop in Lisbon in November 2002, and Bart Verspagen of ECIS (University of Eindhoven) similarly assisted in organizing the second workshop in Roermond in June 2003. In addition to the contributors several people participated in these workshops and contributed to the progress of the work, we would particularly like to mention Fulvio Castellacci, João Caraca, Maureen McKelvey, Sandro Mendonça, Richard Stankiewicz, and Mona Wibe. During the final phases of preparing the manuscript for publication, Mike Hobday, Chris Freeman, Ian Miles, and Susan Lees provided invaluable assistance in editing, proofreading, and preparing Keith Pavitt's chapter for publication. During the final phase Charles McCann provided valuable advice to the non-English/American authors. Ovar Andreas Johansson at TIK was a very efficient and helpful project assistant. At Oxford University Press David Musson and Matthew Derbyshire were inspiring and patient partners.

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CHAPTER 1

INNOVATION

A GUIDE TO THE LITERATURE

JAN FAGERBERG

1.1 Introduction[1]

Innovation is not a new phenomenon. Arguably, it is as old as mankind itself. There seems to be something inherently "human" about the tendency to think about new and better ways of doing things and to try them out in practice. Without it, the world in which we live would look very, very different. Try for a moment to think of a world without airplanes, automobiles, telecommunications, and refrigerators, just to mention a few of the more important innovations from the not-too-distant past. Or—from an even longer perspective—where would we be without such fundamental innovations as agriculture, the wheel, the alphabet, or printing?

In spite of its obvious importance, innovation has not always received the scholarly attention it deserves. For instance, students of long-run economic change used to focus on factors such as capital accumulation or the working of markets, rather than on innovation. This is now changing. Research on the role of innovation in economic and social change has proliferated in recent years, particularly within the social sciences, and with a bent towards cross-disciplinarity. In fact, as illustrated in Figure 1.1, in recent years the number of social-science publications focusing on innovation has increased much faster than the total number of such publications.

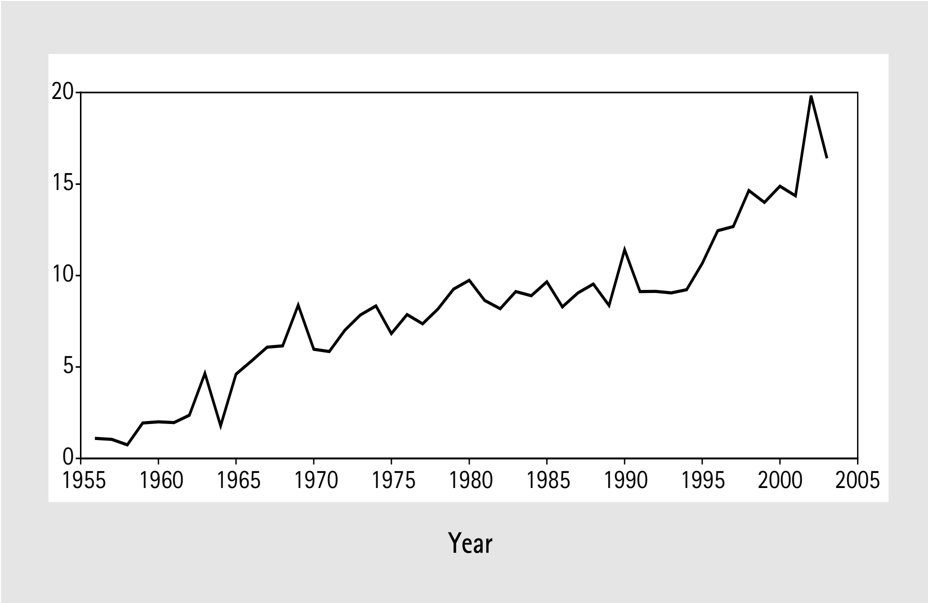

Fig. 1.1 Scholarly Articles with "Innovation" in the title, 1955–2004 (per 10,000 social science articles)

Note: The source is the ISI Web of Knowledge, Social Sciences Citation Index (SSCI).

As a result, our knowledge about innovation processes, their determinants and social and economic impact has been greatly enhanced.

When innovation studies started to emerge as a separate field of research in the 1960s, it did so mostly outside the existing disciplines and the most prestigious universities. An important event in this process was the formation in 1965 of the Science Policy Research Unit (SPRU) at the University of Sussex (see Box 1.1). The name of the center illustrates the tendency for innovation studies to develop unde other (at the time more acceptable?) terms, such as, for instance, "science studies" or "science policy studies." But as we shall see in the following, one of the main lessons from the research that came to be carried out is that science is only one among several ingredients in successful innovation. As a consequence of these findings, not only the focus of research in this area but also the notions used to characterize it changed. During the late twentieth/early twenty-first century, a number of new research centers and departments have been founded, focusing on the role of innovation in

Box 1.1 SPRU, Freeman, and the spread of innovation studies

SPRU—Science Policy Research Unit—at the University of Sussex, UK was founded in 1965 with Christopher Freeman as its first director. From the beginning, it had a cross-disciplinary research staff consisting of researchers with backgrounds in subjects as diverse as economics, sociology, psychology, and engineering. SPRU developed its own cross-disciplinary Master and Ph.D. programs and carried out externally funded research, much of which came to focus on the role of innovation in economic and social change. It attracted a large number of young scholars from other countries who came to train and work here.

The research initiated at SPRU led to a large number of projects, conferences, and publications. *Research Policy*, which came to be the central academic journal in the field, was established in 1972, with Freeman as the first editor (he was later succeeded by Keith Pavitt, also from SPRU). Freeman's influential book, *The Economics of Industrial Innovation*, was published two years later, in 1974, and has since been revised twice. In 1982, the book, *Unemployment and Technical Innovation*, written by Freeman, Clark, and Soete, appeared, introducing a systems approach to the role of innovation in long-term economic and social change. Freeman later followed this up with an analysis of the national innovation system in Japan (Freeman 1987). He was also instrumental in setting up the large, collaborative IFIAS project which in 1988 resulted in the very influential book, *Technical Change and Economic Theory*, edited by Dosi, Freeman, Nelson, Silverberg, and Soete (both Dosi and Soete were SPRU Ph.D. graduates).

In many ways, SPRU came to serve as a role model for the many centers/institutes within Europe and Asia that were established, mostly from the mid-1980s onwards, combining cross-disciplinary graduate and Ph.D. teaching with extensive externally funded research. Most of these, as SPRU itself, were located in relatively newly formed (so-called "red-brick") universities, which arguably showed a greater receptivity to new social needs, initiatives, and ideas than the more inert, well-established academic "leaders," or at other types of institutions such as business or engineering schools. SPRU graduates were in many cases instrumental in spreading research and teaching on innovation to their own countries, particularly in Europe.

economic and social change. Many of these have a cross-disciplinary orientation, illustrating the need for innovation to be studied from different perspectives. Several journals and professional associations have also been founded.

The leaning towards cross-disciplinarity that characterizes much scholarly work in this area reflects the fact that no single discipline deals with all aspects of innovation. Hence, to get a comprehensive overview, it is necessary to combine insights from several disciplines. Traditionally, for instance, economics has dealt primarily with the allocation of resources to innovation (in competition with other ends) and its economic effects, while the innovation process itself has been more or less treated as a "black box." What happens within this "box" has been left to scholars from other disciplines. A lot of what happens obviously has to do with learning, a central topic in cognitive science. Such learning occurs in organized settings (e.g. groups, teams, firms, and networks), the working of which is studied within disciplines such as sociology, organizational science, management, and business studies. Moreover, as economic geographers point out, learning processes tend to be linked to specific contexts or locations. The way innovation is organized and its localization also undergo important changes through time, as underscored by the work within the field of economic history. There is also, as historians of technology have pointed out, a specific technological dimension to this; the way innovation is organized, as well as its economic and social effects, depends critically on the specific nature of the technology in question.

Two decades ago, it was still possible for a hard-working student to get a fairly good overview of the scholarly work on innovation by devoting a few years of intensive study to the subject. Not any more. Today, the literature on innovation is so large and diverse that even keeping up-to-date with one specific field of research is very challenging. The purpose of this volume is to provide the reader with a guide to this rapidly expanding literature. We do this under the following broad headings:

I Innovation in the Making
II The Systemic Nature of Innovation
III How Innovation Differs
IV Innovation and Performance.

Part One focuses on the process through which innovations occur and the actors that take part: individuals, firms, organizations, and networks. As we will discuss in more detail below, innovation is by its very nature a systemic phenomenon, since it results from continuing interaction between different actors and organizations. Part Two outlines the systems perspective on innovation studies and discusses the roles of institutions, organizations, and actors in this process at the national and regional level. Part Three explores the diversity in the manner in which such systems work over time and across different sectors or industries. Finally, Part Four examines the broader social and economic consequences of innovation and the associated policy issues. The remainder of this chapter sets the stage for the discussion that follows by giving a broad overview of some of the central topics in innovation studies (including conceptual issues).

1.2 What is Innovation?

An important distinction is normally made between invention and innovation.[2] Invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out into practice. Sometimes, invention and innovation are closely linked, to the extent that it is hard to distinguish one from another (biotechnology for instance). In many cases, however, there is a considerable time lag between the two. In fact, a lag of several decades or more is not uncommon (Rogers 1995). Such lags reflect the different requirements for working out ideas and implementing them. While inventions may be carried out anywhere, for example in universities, innovations occur mostly in firms, though they may also occur in other types of organizations, such as public hospitals. To be able to turn an invention into an innovation, a firm normally needs to combine several different types of knowledge, capabilities, skills, and resources. For instance, the firm may require production knowledge, skills and facilities, market knowledge, a well-functioning distribution system, sufficient financial resources, and so on. It follows that the role of the innovator,[3] i.e. the person or organizational unit responsible for combining the factors necessary (what the innovation theorist Joseph Schumpeter (see Box 1.2) called the "entrepreneur"), may be quite different from that of the inventor. Indeed, history is replete with cases in which the inventor of major technological advances fails to reap the profits from his breakthroughs.

Long lags between invention and innovation may have to do with the fact that, in many cases, some or all of the conditions for commercialization may be lacking. There may not be a sufficient need (yet!) or it may be impossible to produce and/or market because some vital inputs or complementary factors are not (yet!) available. Thus, although Leonardo da Vinci is reported to have had some quite advanced ideas for a flying machine, these were impossible to carry out in practice due to a lack of adequate materials, production skills, and—above all—a power source. In fact, the realization of these ideas had to wait for the invention and subsequent commercialization (and improvement) of the internal combustion engine.[4] Hence, as this example shows, many inventions require complementary inventions and innovations to succeed at the innovation stage.

Another complicating factor is that invention and innovation is a continuous process. For instance, the car, as we know it today, is radically improved compared to the first commercial models, due to the incorporation of a very large number of different inventions/innovations. In fact, the first versions of virtually all significant innovations, from the steam engine to the airplane, were crude, unreliable versions of the devices that eventually diffused widely. Kline and Rosenberg (1986), in an influential paper, point out:

> it is a serious mistake to treat an innovation as if it were a well-defined, homogenous thing that could be identified as entering the economy at a precise date—or becoming available at a precise point in time.... The fact is that most important innovations go through drastic changes in their lifetimes—changes that may, and often do, totally transform their economic significance. The subsequent improvements in an invention after its first introduction may be vastly more important, economically, than the initial availability of the invention in its original form. (Kline and Rosenberg 1986: 283)

Thus, what we think of as a single innovation is often the result of a lengthy process involving many interrelated innovations. This is one of the reasons why

Box 1.2 The innovation theorist Joseph Schumpeter

Joseph Schumpeter (1883–1950) was one of the most original social scientists of the twentieth century. He grew up in Vienna around the turn of the century, where he studied law and economics. For most of his life he worked as an academic, but he also tried his luck as politician, serving briefly as finance minister in the first post-World War I (socialist) government, and as a banker (without much success). He became professor at the University of Bonn in 1925 and later at Harvard University in the USA (1932), where he stayed until his death. He published several books and papers in German early on, among these the *Theory of Economic Development*, published in 1911 and in a revised edition in English in 1934. Among his most well-known later works are *Business Cycles* in two volumes (from 1939), *Capitalism, Socialism and Democracy* (1943), and the posthumously published *History of Economic Analysis* (1954).

Very early he developed an original approach, focusing on the role of innovation in economic and social change. It was not sufficient, Schumpeter argued, to study the economy through static lenses, focusing on the distribution of given resources across different ends. Economic development, in his view, had to be seen as a process of qualitative change, driven by innovation, taking place in historical time. As examples of innovation he mentioned new products, new methods of production, new sources of supply, the exploitation of new markets, and new ways to organize business. He defined innovation as "new combinations" of existing resources. This combinatory activity he labeled "the entrepreneurial function" (to be fulfilled by "entrepreneurs"), to which he attached much importance. One main reason for the important role played by entrepreneurs for successful innovation was the prevalence of inertia, or "resistance to new ways" as he phrased it, at all levels of society that entrepreneurs had to fight in order to succeed in their aims. In his early work, which is sometimes called "Schumpeter Mark I," Schumpeter focused mostly on individual entrepreneurs. But in later works he also emphasized the importance of innovation in large firms (so-called "Schumpeter Mark II"), and pointed to historically oriented, qualitative research (case studies) as the way forward for research in this area.

In his analysis of innovation diffusion, Schumpeter emphasized the tendency for innovations to "cluster" in certain industries and time periods (and the derived effects on growth) and the possible contribution of such "clustering" to the formation of business cycles and "long waves" in the world economy (Schumpeter 1939). The latter suggestion has been a constant source of controversy ever since. No less controversial, and perhaps even better known, is his inspired discussion of the institutional changes under capitalism (and its possible endogenous transformation into "socialism") in the book *Capitalism, Socialism and Democracy* (1943).

Sources: Swedberg 1991; Shionoya 1997; Fagerberg 2003.

many students of technology and innovation find it natural to apply a systems perspective rather than to focus exclusively on individual inventions/innovations.

Innovations may also be classified according to "type." Schumpeter (see Box 1.2) distinguished between five different types: new products, new methods of production, new sources of supply, the exploitation of new markets, and new ways to organize business. However, in economics, most of the focus has been on the two first of these. Schmookler (1966), for instance, in his classic work on "Invention and Economic Growth," argued that the distinction between "product technology" and "production technology" was "critical" for our understanding of this phenomenon (ibid. 166). He defined the former type as knowledge about how to *create or improve* products, and the latter as knowledge about how to *produce* them. Similarly, the terms "product innovation" and "process innovation" have been used to characterize the occurrence of new or improved goods and services, and improvements in the ways to produce these good and services, respectively.[5] The argument for focusing particularly on the distinction between product and process innovation often rests on the assumption that their economic and social impact may differ. For instance, while the introduction of new products is commonly assumed to have a clear, positive effect on growth of income and employment, it has been argued that process innovation, due to its cost-cutting nature, may have a more ambiguous effect (Edquist et al. 2001; Pianta in this volume). However, while clearly distinguishable at the level of the individual firm or industry, such differences tend to become blurred at the level of the overall economy, because the product of one firm (or industry) may end up as being used to produce goods or services in another.[6]

The focus on product and process innovations, while useful for the analysis of some issues, should not lead us ignore other important aspects of innovation. For instance, during the first half of the twentieth century, many of the innovations that made it possible for the United States to "forge ahead" of other capitalist economies were of the organizational kind, involving entirely new ways to organize production and distribution (see Bruland and Mowery in this volume, while Lam provides an overview of organizational innovation). Edquist et al. (2001) have suggested dividing the category of process innovation into "technological process innovations" and "organizational process innovations," the former related to new types of machinery, and the latter to new ways to organize work. However, organizational innovations are not limited to new ways to organize the process of production within a given firm. Organizational innovation, in the sense used by Schumpeter,[7] also includes arrangements across firms such as the reorganization of entire industries. Moreover, as exemplified by the case of the USA in the first half of the previous century, many of the most important organizational innovations have occurred in distribution, with great consequences for a whole range of industries (Chandler 1990).

Another approach, also based on Schumpeter's work, has been to classify innovations according to how radical they are compared to current technology (Freeman and Soete 1997). From this perspective, continuous improvements of the type referred to above are often characterized as "incremental" or "marginal" innovations,[8] as opposed to "radical" innovations (such as the introduction of a totally new type of machinery) or "technological revolutions" (consisting of a cluster of innovations that together may have a very far-reaching impact). Schumpeter focused in particular on the latter two categories, which he believed to be of greater importance. It is a widely held view, however, that the cumulative impact of incremental innovations is just as great (if not greater), and that to ignore these leads to a biased view of long run economic and social change (Lundvall et al. 1992). Moreover, the realization of the economic benefits from "radical" innovations in most cases (including those of the airplane and the automobile, discussed earlier) requires a series of incremental improvements. Arguably, the bulk of economic benefits come from incremental innovations and improvements.

There is also the question of how to take different contexts into account. If A for the first time introduces a particular innovation in one context, while B later introduces the same innovation in another, would we characterize both as innovators? This is a matter of convention. A widely used practice, based on Schumpeter's work, is to reserve the term innovator for A and characterize B as an imitator. But one might argue that, following Schumpeter's own definition, it would be equally consistent to call B an innovator as well, since B is introducing the innovation for the first time in a new context. This is, for instance, the position taken by Hobday (2000) in a discussion of innovation in the so-called "newly industrializing countries" in Asia.[9] One might object, though, that there is a qualitative difference between (*a*) commercializing something for the first time and (*b*) copying it and introducing it in a different context. The latter arguably includes a larger dose of imitative behavior (imitation), or what is sometimes called "technology transfer." This does not exclude the possibility that imitation may lead to new innovation(s). In fact, as pointed out by Kline and Rosenberg (1986, see Box 1.3), many economically significant innovations occur while a product or process is diffusing (see also Hall in this volume). Introducing something in a new context often implies considerable adaptation (and, hence, incremental innovation) and, as history has shown, organizational changes (or innovations) that may significantly increase productivity and competitiveness (see Godinho and Fagerberg in this volume).[10]

Box 1.3 What innovation is not: the linear model

Sometimes it easier to characterize a complex phenomenon by clearly pointing out what it is NOT. Stephen Kline and Nathan Rosenberg did exactly this when they, in an influential paper from 1986, used the concept "the linear model" to characterize a widespread but in their view erroneous interpretation of innovation.

Basically, "the linear model" is based on the assumption that innovation is applied science. It is "linear" because there is a well-defined set of stages that innovations are assumed to go through. Research (science) comes first, then development, and finally production and marketing. Since research comes first, it is easy to think of this as the critical element. Hence, this perspective, which is often associated with Vannevar Bush's programmatic statements on the organization of the US research systems (Bush 1945), is well suited to defend the interests of researchers and scientists and the organizations in which they work.

The problems with this model, Kline and Rosenberg point out, are twofold. First, it generalizes a chain of causation that only holds for a minority of innovations. Although some important innovations stem from scientific breakthroughs, this is not true most of the time. Firms normally innovate because they believe there is a commercial need for it, and they commonly start by reviewing and combining existing knowledge. It is only if this does not work, they argue, that firms consider investing in research (science). In fact, in many settings, the experience of users, not science, is deemed to be the most important source of innovation (von Hippel 1988; Lundvall 1988). Second, "the linear model" ignores the many feedbacks and loops that occur between the different "stages" of the process. Shortcomings and failures that occur at various stages may lead to a reconsideration of earlier steps, and this may eventually lead to totally new innovations.

1.3 Innovation in the Making

Leaving definitions aside, the fundamental question for innovation research is of course to explain how innovations occur. One of the reasons innovation was ignored in mainstream social science for so long was that this was seen as impossible to do. The best one could do, it was commonly assumed, was to look at innovation as a random phenomenon (or "manna from heaven," as some scholars used to phrase it). Schumpeter, in his early works, was one of the first to object to this practice. His own account of these processes emphasized three main aspects. The first was the fundamental uncertainty inherent in all innovation projects; the second was the need to move quickly before somebody else did (and reap the potential economic reward). In practice, Schumpeter argued, these two aspects meant that the standard behavioral rules, e.g., surveying all information, assessing it, and finding the "optimal" choice, would not work. Other, quicker ways had to be found. This in his view involved leadership and vision, two qualities he associated with entrepreneurship. The third aspect of the innovation process was the prevalence of "resistance to new ways"—or inertia—at all levels of society, which threatened to destroy all novel initiatives, and forced entrepreneurs to fight hard to succeed in their projects. Or as he put it: "In the breast of one who wishes to do something new, the forces of habit raise up and bear witness against the embryonic project" (Schumpeter 1934: 86). Such inertia, in Schumpeter's view, was to some extent endogenous, since it reflected the embedded character of existing knowledge and habit, which, though "energy-saving," tended to bias decision-making against new ways of doing things.

Hence, in Schumpeter's early work (sometimes called "Schumpeter Mark I") innovation is the outcome of continuous struggle in historical time between individual *entrepreneurs*, advocating novel solutions to particular problems, and *social* *inertia*, with the latter seen as (partly) endogenous. This may, to some extent, have been an adequate interpretation of events in Europe around the turn of the nineteenth century. But during the first decades of the twentieth century, it became clear to observers that innovations increasingly involve teamwork and take place within larger organizations (see Bruland and Mowery (Ch. 13), Lam (Ch. 5), and Lazonick (Ch. 2) in this volume). In later work, Schumpeter acknowledged this and emphasized the need for systematic study of "cooperative" entrepreneurship in big firms (so-called "Schumpeter Mark II"). However, he did not analyze the phenomenon in much detail (although he strongly advised others to).[11]

Systematic theoretical and empirical work on innovation-projects in firms (and the management of such projects) was slow to evolve, but during the last decades a quite substantial literature has emerged (see chapters by Pavitt and Lam in this volume). In general, research in this area coincides with Schumpeter's emphasis on uncertainty (Nelson and Winter 1982; Nonaka and Takeuchi 1995; Van de Ven et al. 1999). In particular, for potentially rewarding innovations, it is argued, one may simply not know what are the most relevant sources or the best options to pursue (still less how great the chance is of success).[12] It has also been emphasized that innovative firms need to consider the potential problems that "path dependency" may create (Arthur 1994). For instance, if a firm selects a specific innovation path very early, it may (if it is lucky) enjoy "first mover" advantages. But it also risks being "locked in" to this specific path through various self-reinforcing effects. If in the end it turns out that there actually existed a superior path, which some other firm equipped with more patience (or luck) happened to find, the early mover may be in big trouble because then, it is argued, it may simply be too costly or too late to switch paths. It has been suggested, therefore, that in the early phase of an innovation project, before sufficient knowledge of the alternatives is generated, the best strategy may simply be to avoid being "stuck" to a particular path, and remain open to different (and competing) ideas/solutions. At the level of the firm, this requires a "pluralistic leadership" that allows for a variety of competing perspectives (Van de Ven et al. 1999), in contrast to the homogenous, unitary leader style that, in the management literature, is sometimes considered as the most advantageous.[13]

"Openness" to new ideas and solutions? is considered essential for innovation projects, especially in the early phases. The principal reason for this has to do with a fundamental characteristic of innovation: that every new innovation consists of a new combination of existing ideas, capabilities, skills, resources, etc. It follows logically from this that the greater the variety of these factors within a given system, the greater the scope for them to be combined in different ways, producing new innovations which will be both more complex and more sophisticated. This evolutionary logic has been used to explain why, in ancient times, the inhabitants of the large Eurasian landmass came to be more innovative, and technologically sophisticated, than small, isolated populations elsewhere around the globe (Diamond 1998). Applied mechanically on a population of firms, this logic might perhaps be taken to imply that large firms should be expected to be more innovative than small firms.[14] However, modern firms are not closed systems comparable to isolated populations of ancient times. Firms have learnt, by necessity, to monitor closely each other's steps, and search widely for new ideas, inputs, and sources of inspiration. The more firms on average are able to learn from interacting with external sources, the greater the pressure on others to follow suit. This greatly enhances the innovativeness of both individual firms and the economic systems to which they belong (regions or countries, for instance). Arguably, this is of particular importance for smaller firms, which have to compensate for small internal resources by being good at interacting with the outside world. However, the growing complexity of the knowledge bases necessary for innovation means that even large firms increasingly depend on external sources in their innovative activity (Granstrand, Patel, and Pavitt, 1997; and in this volume: Pavitt; Powell and Grodal; Narula and Zanfei).

Hence, cultivating the capacity for absorbing (outside) knowledge, so-called "absorptive capacity" (Cohen and Levinthal 1990), is a must for innovative firms, large or small. It is, however, something that firms often find very challenging; the "not invented here" syndrome is a well-known feature in firms of all sizes. This arguably reflects the cumulative and embedded character of firm-specific knowledge. In most cases, firms develop their knowledge of how to do things incrementally. Such knowledge, then, consists of "routines" that are reproduced through practice ("organizational memory": Nelson and Winter 1982). Over time, the organizational structure of the firm and its knowledge base typically co-evolve into a set-up that is beneficial for the day-to-day operations of the firm. It has been argued, however, that such a set-up, while facilitating the daily internal communication/interaction of the firm, may in fact constrain the firm's capacity for absorbing new knowledge created elsewhere, especially if the new external knowledge significantly challenges the existing set-up/knowledge of the firm (so-called "competence destroying technical change": Tushman and Anderson 1986). In fact, such problems may occur even for innovations that are created internally. Xerox, for instance, developed both the PC and the mouse, but failed to exploit commercially these innovations, primarily because they did not seem to be of much value to the firm's existing photo-copier business (Rogers 1995).

Thus organizing for innovation is a delicate task. Research in this area has, among other things, pointed to the need for innovative firms to allow groups of people within the organization sufficient freedom in experimenting with new solutions (Van de Ven 1999), and establishing patterns of interaction within the firm that allow it to mobilize its entire knowledge base when confronting new challenges (Nonaka and Takeuchi 1995; Lam, Ch. 5 in this volume). Such organizing does not stop at the gate of the firm, but extends to relations with external partners. Ties to partners with whom communication is frequent are often called "strong ties," while those that are more occasional are denoted as "weak ties" (Granovetter 1973; see Powell and Grodal, Ch. 3 in this volume). Partners linked together with strong ties, either directly, or indirectly via a common partner, may self-organize into (relatively stable) networks. Such networks may be very useful for managing and maintaining openness. But just as firms can display symptoms of path-dependency, the same can happen to established networks, as the participants converge to a common perception of reality (so-called "group-think"). Innovative firms therefore often find it useful to also cultivate so-called "weak ties" in order to maintain a capacity for changing its orientation (should it prove necessary).

1.4 The Systemic Nature of Innovation

As is evident from the preceding discussion, a central finding in the literature is that, in most cases, innovation activities in firms depend heavily on external sources. One recent study sums it up well: "Popular folklore notwithstanding, the innovation journey is a collective achievement that requires key roles from numerous entrepreneurs in both the public and private sectors" (Van de Ven et al. 1999: 149). In that particular study, the term "social system for innovation development" was used to characterize this "collective achievement." However, this is just one among several examples from the last decades of how system concepts are applied to the analysis of the relationship between innovation activities in firms and the wider framework in which these activities are embedded (see Edquist, Ch. 7 in this volume).

One main approach has been to delineate systems on the basis of technological, industrial, or sectoral characteristics (Freeman et al. 1982; Hughes 1983; Carlsson and Stankiewicz 1991; Malerba, Ch. 14 in this volume) but, to a varying degree, to include other relevant factors such as, for instance, institutions (laws, regulations, rules, habits, etc.), the political process, the public research infrastructure (universities, research institutes, support from public sources, etc.), financial institutions, skills (labor force), and so on. To explore the technological dynamics of innovation, its various phases, and how this influences and is influenced by the wider social, institutional, and economic frameworks has been the main focus of this type of analysis. Another important approach in the innovation-systems literature has focused on the spatial level, and used national or regional borders to distinguish between different systems. For example, Lundvall (1992) and Nelson et al. (1993) have used the term "national system of innovation" to characterize the systemic interdependencies within a given country (see Edquist in this volume), while Braczyk et al. (1997) similarly have offered the notion of "regional innovation systems" (see Asheim and Gertler, Ch. 11 in this volume). Since the spatial systems are delineated on the basis of political and administrative borders, such factors naturally tend to play an important role in analyses based on this approach, which has proven to be influential among policy makers in this area, especially in Europe (see Lundvall and Borrás, Ch. 22 in this volume). (Part II of this volume analyzes some of the constituent elements of such systems in more detail.[15])

What are the implications of applying a system perspective to the study of innovation? Systems are—as networks—a set of activities (or actors) that are interlinked, and this leads naturally to a focus on the working of the linkages of the system.[16] Is the potential for communication and interaction through existing linkages sufficiently exploited? Are there potential linkages within the system that might profitably be established? Such questions apply of course to networks as well as systems. However, in the normal usage of the term, a system will typically have more "structure" than a network, and be of a more enduring character. The structure of a system will facilitate certain patterns of interaction and outcomes (and constrain others), and in this sense there is a parallel to the role of "inertia" in firms. A dynamic system also has feedbacks, which may serve to reinforce—or weaken—the existing structure/functioning of the system, leading to "lock in "(a stable configuration), or a change in orientation, or—eventually—the dissolution of the system. Hence, systems may—just as firms—be locked into a specific path of development that supports certain types of activities and constrains others. This may be seen as an advantage, as it pushes the participating firms and other actors in the system in a direction that is deemed to be beneficial. But it may also be a disadvantage, if the configuration of the system leads firms to ignore potentially fruitful avenues of exploration. The character of such processes will be affected by the extent to which the system exchanges impulses with its environment. The more open a system is for impulses from outside, the less the chance of being "locked out" from promising new paths of development that emerge outside the system. It is, therefore, important for "system managers"—such as policy makers—to keep an eye on the openness of the system, to avoid the possibility of innovation activities becoming unduly constrained by self-reinforcing path-dependency.

Another important feature of systems that has come into focus is the strong complementarities that commonly exist between the components of a system. If, in a dynamic system, one critical, complementary component is lacking, or fails to progress or develop, this may block or slow down the growth of the entire system. This is, as pointed out earlier, one of the main reasons why there is often a very considerable time lag between invention and innovation. Economic historians have commonly used concepts such as "reverse salients" and "bottlenecks" to characterize such phenomena (Hughes 1983; Rosenberg 1982). However, such constraints need not be of a purely technical character (such as, for instance, the failure to invent a decent battery, which has severely constrained the diffusion of electric cars for more than century), but may have to do with lack of proper infrastructure, finance, skills, etc. Some of the most important innovations of this century, such as electricity and automobiles (Mowery and Rosenberg 1998), were dependent on very extensive infrastructural investments (wiring and roads/distribution-systems for fuel, respectively). Moreover, to fulfil the potential of the new innovation, such investments often need to be accompanied by radical changes in the organization of production and distribution (and, more generally, attitudes: see Perez 1983, 1985; Freeman and Louçâ 2001). There are important lessons here for firms and policy makers. Firms may need to take into account the wider social and economic implications of an innovation project. The more radical an innovation is, the greater the possibility that it may require extensive infrastructural investments and/or organizational and social change to succeed. If so, the firm needs to think through the way in which it may join up with other agents of change in the private or public sector. Policy makers, for their part, need to consider what different levels of government can do to prevent "bottlenecks" to occur at the system level in areas such as skills, the research infrastructure, and the broader economic infrastructure.

1.5 How Innovation Differs

One of the striking facts about innovation is its variability over time and space. It seems, as Schumpeter (see Box 1.2) pointed out, to "cluster," not only in certain sectors but also in certain areas and time periods. Over time the centers of innovation have shifted from one sector, region, and country to another. For instance, for a long period the worldwide center of innovation was in the UK, and the productivity and income of its population increased relative to its neighboring countries, so that by the mid-nineteenth century its productivity (and income) level was 50 per cent higher than elsewhere; at about the beginning of the twentieth century the center of innovation, at least for the modern chemical and electrical technologies of the day, shifted to Germany; and now, for a long time, the worldwide center of innovation has been in the USA, which during most of the twentieth century enjoyed the highest productivity and living standards in the world. As explained by Bruland and Mowery in this volume, the rise of the US to world technological leadership was associated with the growth of new industries, based on the exploitation of economies of scale and scope (Chandler 1962, 1990) and mass production and distribution.

How is this dynamic to be explained? Schumpeter, extending an earlier line of argument dating back to Karl Marx,[17] held technological competition (competition through innovation) to be the driving force of economic development. If one firm in a given industry or sector successfully introduces an important innovation, the argument goes, it will be amply rewarded by a higher rate of profit. This functions as a signal to other firms (the imitators), which, if entry conditions allow, will "swarm" the industry or sector with the hope of sharing the benefits (with the result that the initial innovator's first mover advantages may be quickly eroded). This "swarming" of imitators implies that the growth of the sector or industry in which the innovation occurs will be quite high for a while. Sooner or later, however, the effects on growth (created by an innovation) will be depleted and growth will slow down.

To this essentially Marxian story Schumpeter added an important modification. Imitators, he argued, are much more likely to succeed in their aims if they improve on the original innovation, i.e., become innovators themselves. This is all the more natural, he continued, because one (important) innovation tends to facilitate (induce) other innovations in the same or related fields. In this way, innovation–diffusion becomes a creative process—in which one important innovation sets the stage for a whole series of subsequent innovations—and not the passive, adaptive process often assumed in much diffusion research (see Hall in this volume). The systemic interdependencies between the initial and induced innovations also imply that innovations (and growth) "tend to concentrate in certain sectors and their surroundings" or "clusters" (Schumpeter 1939: 100–1). Schumpeter, as is well known, looked at this dynamic as a possible explanatory factor behind business cycles of various lengths (Freeman and Louçâ 2001).

This simple scheme has been remarkably successful in inspiring applications in different areas. For instance, there is a large amount of research that has adapted the Marx–Schumpeter model of technological competition to the study of industrial growth, international trade, and competitiveness,[18] although sometimes, it must be said, without acknowledging the source for these ideas. An early and very influential contribution was the so-called "product-life-cycle theory" suggested by Vernon (1966), in which industrial growth following an important product innovation was seen as composed of stages, characterized by changing conditions of and location of production.[19] Basically what was assumed was that the ability to do product innovation mattered most at the early stage, in which there were many different and competing versions of the product on the market. However, with time, the product was assumed to standardize, and this was assumed to be accompanied by a greater emphasis on process innovation, scale economics, and cost-competition. It was argued that these changes in competitive conditions might initiate transfer of the technology from the innovator country (high income) to countries with large markets and/or low costs. Such transfers might also be associated with international capital flows in the form of so-called foreign direct investments (FDIs), and the theory has therefore also become known as a framework for explaining such flows (see Narula and Zanfei in this volume).

The "product-life-cycle theory," attractive as it was in its simplicity, was not always corroborated by subsequent research. While it got some of the general conjectures (borrowed from Schumpeter) right, the rigorous scheme it added, with well-defined stages, standardization, and changing competitive requirements, was shown to fit only a minority of industries (Walker 1979; Cohen 1995). Although good data are hard to come by, what emerges from empirical research is a much more complex picture,[20] with considerable differences across industrial sectors in the way this dynamic is shaped. As exemplified by the taxonomy suggested by Pavitt (see Box 1.4), exploration of such differences ("industrial dynamics") has evolved into one of the main areas of research within innovation studies (see in this volume:

Box 1.4 What is high-tech? Pavitt's taxonomy

The degree of technological sophistication, or innovativeness, of an industry or sector is something that attracts a lot of interest, and there have been several attempts to develop ways of classifying industries or sectors according to such criteria. The most widely used in common parlance is probably the distinction between "high-tech," "medium-tech," and "low-tech," although it is not always clear exactly what is meant by this. Often it is equated with high, medium, and low R&D intensity in production (or value added), either directly (in the industry itself) or including R&D embodied in machinery and other inputs. Based on this, industries such as aerospace, computers, semiconductors, telecommunications, pharmaceuticals, and instruments are commonly classified as "high-tech," while "medium-tech" typically include electrical and non-electrical machinery, transport equipment, and parts of the chemical industries. The remaining, "low-tech," low R&D category, then, comprises industries such as textiles, clothing, leather products, furniture, paper products, food, and so on (Fagerberg 1997; see Smith in this volume for an extended discussion).

However, while organized R&D activity is an important source of innovation in contemporary capitalism, it is not the only one. A focus on R&D alone might lead one to ignore or overlook innovation activities based on other sources, such as skilled personnel (engineers, for instance), learning by doing, using, interacting, and so forth. This led Pavitt (1984) to develop a taxonomy or classification scheme which took these other factors into account. Based a very extensive data-set on innovation in the UK (see Smith in this volume), he identified two ("high-tech") sectors in the economy, both serving the rest of the economy with technology, but very different in terms of how innovations were created. One, which he labeled "science-based," was characterized by a lot of organized R&D and strong links to science, while another—so-called "specialized suppliers" (of machinery, instruments, and so on)—was based on capabilities in engineering, and frequent interaction with users. He also identified a scale-intensive sector (transport equipment, for instance), also relatively innovative, but with fewer repercussions for other sectors. Finally, he found a number of industries that, although not necessarily non-innovative in every respect, received most of their technology from other sectors.

An important result of Pavitt's analysis was the finding that the factors leading to successful innovation differ greatly across industries/ sectors. This obviously called into question technology or innovation polices that only focused on one mechanism, such as, for instance, subsidies to R&D.

Ch. 14 by Malerba; Ch. 15 by VonTunzelmann and Acha; Ch. 16 by Miles). Inspired, to a large extent, by the seminal work by Nelson and Winter (see Box 1.5), research in this area has explored the manner in which industries and sectors differ in terms of their internal dynamics (or "technological regimes": see Malerba and Orsenigo 1997), focusing, in particular, on the differences across sectors in knowledge bases, actors, networks, and institutions (so called "sectoral systems": see Malerba, Ch. 14 in this volume). An important result from this research is that, since the factors that influence innovation differ across industries, policy makers have to take such differences into account when designing policies. The same policy (and policy instruments) will not work equally well everywhere.

Box 1.5 Industrial dynamics—an evolutionary interpretation

The book *An Evolutionary Theory of Economic Change* (1982) by Richard Nelson and Sidney Winter is one of the most important contributions to the study of innovation and long run economic and social change. Nelson and Winter share the Schumpeterian focus on "capitalism as an engine of change." However, building on earlier work by Herbert Simon and others (so-called "procedural" or "bounded" rationality), Nelson and Winter introduce a more elaborate theoretical perspective on how firms behave. In Nelson and Winter's models, firms' actions are guided by routines, which are reproduced through practice, as parts of the firms' "organizational memory." Routines typically differ across firms. For instance, some firms may be more inclined towards innovation, while others may prefer the less demanding (but also less rewarding) imitative route. If a routine leads to an unsatisfactory outcome, a firm may use its resources to search for a new one, which—if it satisfies the criteria set by the firm—will eventually be adopted (so-called "satisficing" behavior).

Hence, instead of following the common practice in much economic theorizing of extrapolating the characteristics of a "representative agent" to an entire population (so-called "typological thinking"), Nelson and Winter take into account the social and economic consequences of interaction within populations of heterogeneous actors (so-called "population thinking"). They also emphasize the role of chance (the stochastic element) in determining the outcome of the interaction. In the book, these outcomes are explored through simulations, which allow the authors to study the consequences of varying the value of key parameters (to reflect different assumptions on technological progress, firm behavior, etc.). They distinguish between an "innovation regime," in which the technological frontier is assumed to progress independently of firms' own activities (the "science based" regime), and another in which technological progress is more endogenous and depends on what the firms themselves do (the "cumulative" regime). They also vary the ease/difficulty of innovation and imitation.

Nelson and Winter's work has been an important source of inspiration for subsequent work on "knowledge-based firms," "technological regimes," and "industrial dynamics," and evolutionary economics more generally, to mention some important topics.

Sources: Nelson and Winter 1982; Andersen 1994; Fagerberg 2003.

1.6 Innovation and Economic Performance

The Marx–Schumpeter model was not intended as a model of industrial dynamics; its primary purpose was to explain long run economic change, what Schumpeter called "development." The core of the argument was (1) that technological competition is the major form of competition under capitalism (and firms not responding to these demands fail), and (2) that innovations, e.g. "new combinations" of existing knowledge and resources, open up possibilities for new business opportunities and future innovations, and in this way set the stage for continuing change. This perspective, while convincing, had little influence on the economics discipline at the time of its publication, perhaps because it did not lend itself easily to formal, mathematical modeling of the type that had become popular in that field. More recently, however, economists (Romer 1990), drawing on new tools for mathematical modeling of economic phenomena, have attempted to introduce some of the above ideas into formal growth models (so-called "new growth theory" or "endogenous growth theory").[21]

In developing this perspective, Schumpeter (1939) was, as noted, particularly concerned with the tendency of innovations to "cluster" in certain contexts, and the resulting structural changes in production, organization, demand, etc. Although these ideas were not well received by the economic community at the time, the big slump in economic activity worldwide during the 1970s led to renewed attention, and several contributions emerged viewing long run economic and social change from this perspective. Both Mensch (1979) and Perez (1983, 1985), to take just two examples, argued that major technological changes, such as, for instance, the ICT revolution today, or electricity a century ago, require extensive organizational and institutional change to run their course. Such change, however, is difficult because of the continuing influence of existing organizational and institutional patterns. They saw this inertia as a major growth-impeding factor in periods of rapid technological change, possibly explaining some of the variation of growth over time (e.g. booms and slumps) in capitalist economies. While the latter proposition remains controversial, the relationship between technological, organizational, and institutional change continues to be an important research issue (Freeman and Louçã 2001), with important implications both for the analysis of the diffusion of new technologies (see Hall in this volume) and the policy discourse (see Lundvall and Borras in this volume).

Although neither Marx nor Schumpeter applied their dynamic perspective to the analysis of cross-national differences in growth performance, from the early 1960s onwards several contributions emerged that explore the potential of this perspective for explaining differences in cross-country growth. In what came to be a very influential contribution, Posner (1961) explained the difference in economic growth between two countries, at different levels of economic and technological development, as resulting from two sources: innovation, which enhanced the difference, and imitation, which tended to reduce it. This set the stage for a long series of contributions, often labeled "technology gap" or "north–south" models (or approaches), focusing on explaining such differences in economic growth across countries at different levels of development (see Fagerberg 1994, 1996 for details). As for the lessons, one of the theoretical contributors in this area summed it up well when he concluded that: "Like Alice and the Red Queen, the developed region has to keep running to stay in the same place" (Krugman 1979: 262).

A weakness of much of this work was that it was based on a very stylized representation of the global distribution of innovation, in which innovation was assumed to be concentrated in the developed world, mainly in the USA. In fact, as argued by Fagerberg and Godinho in this volume, the successful catch-up in technology and income is normally not based only on imitation, but also involves innovation to a significant extent. Arguably, this is also what one should expect from the Schumpeterian perspective, in which innovation is assumed to be a pervasive phenomenon. Fagerberg (1987, 1988) identified three factors affecting differential growth rates across countries: innovation, imitation, and other efforts related to the commercial exploitation of technology. The analysis suggested that superior innovative activity was the prime factor behind the huge difference in performance between Asian and Latin American NIC countries in the 1970s and early 1980s. Fagerberg and Verspagen (2002) likewise found that the continuing rapid growth of the Asian NICs relative to other country groupings in the decade that followed was primarily caused by the rapid growth in the innovative performance of this region. Moreover, it has been shown (Fagerberg 1987; Fagerberg and Verspagen 2002) that, while imitation has become more demanding over time (and hence more difficult and/or costly to undertake), innovation has gradually become a more powerful factor in explaining differences across countries in economic growth.

1.7 What do we Know about Innovation? And what do we Need to Learn more about?

Arguably, we have a good understanding of the role played by innovation in long run economic and social change, and many of its consequences:

- The function of innovation is to introduce novelty (variety) into the economic sphere. Should the stream of novelty (innovation) dry up, the economy will settle into a "stationary state" with little or no growth (Metcalfe 1998). Hence, innovation is crucial for long-term economic growth.
- Innovation tends to cluster in certain industries/sectors, which consequently grow more rapidly, implying structural changes in production and demand and, eventually, organizational and institutional change. The capacity to undertake the latter is important for the ability to create and to benefit from innovation.
- Innovation is a powerful explanatory factor behind differences in performance between firms, regions, and countries. Firms that succeed in innovation prosper, at the expense of their less able competitors. Innovative countries and regions have higher productivity and income than the less innovative ones. Countries or regions that wish to catch up with the innovation leaders face the challenge of increasing their own innovation activity (and "absorptive capacity") towards leader levels (see Godinho and Fagerberg in this volume).

Because of these desirable consequences, policy makers and business leaders alike are concerned with ways in which to foster innovation. Nevertheless, in spite of the large amount of research in this area during the past fifty years, we know much less about why and how innovation occurs than what it leads to. Although it is by now well established that innovation is an organizational phenomenon, most theorizing about innovation has traditionally looked at it from an individualistic perspective, as exemplified by Schumpeter's "psychological" theory of entrepreneurial behavior (Fagerberg 2003). Similarly, most work on cognition and knowledge focuses on individuals, not organizations. An important exception was, of course, Nelson and Winter (1982), whose focus on "organizational memory" and its links to practice paved the way for much subsequent work in this area.[22] But our understanding of how knowledge—and innovation—operates at the organizational level remains fragmentary and further conceptual and applied research is needed.

A central finding in the innovation literature is that a firm does not innovate in isolation, but depends on extensive interaction with its environment. Various concepts have been introduced to enhance our understanding of this phenomenon, most of them including the terms "system" or (somewhat less ambitious) "network." Some of these, such as the concept of a "national system of innovation," have become popular among policy makers, who have been constrained in their ability to act by lack of a sufficiently developed framework for the design and evaluation of policy. Still, it is a long way from pointing to the systemic character of innovation processes (at different levels of analysis), to having an approach that is sufficiently developed to allow for systematic analysis and assessment of policy issues. Arguably, to be really helpful in that regard, these system approaches are in need of substantial elaboration and refinement (see the chapter by Edquist in this volume).

One obstacle to improving our understanding is that innovation has been studied by different communities of researchers with different backgrounds, and the failure of these communities to communicate more effectively with one another has impeded progress in this field. One consequence of these communication difficulties has been a certain degree of "fuzziness" with respect to basic concepts, which can only be improved by bringing these different communities together in a constructive dialogue, and the present volume should be seen as a contribution towards this aim. Different, and to some extent competing, perspectives should not always be seen as a problem: many social phenomena are too complex to be analyzed properly from a single disciplinary perspective. Arguably, innovation is a prime example of this.

Notes

1. I wish to thank my fellow editors and contributors for helpful comments and suggestions. Thanks also to Ovar Andreas Johansson for assistance in the research, Sandro Mendonça for his many creative inputs (which I unfortunately have not have been able to follow to the extent that he deserves), and Louise Earl for good advice. The responsibility for remaining errors and omissions is mine.
2. A consistent use of the terms invention and innovation might be to reserve these for the first time occurrence of the idea/concept and commercialization, respectively. In practice it may not always be so simple. For instance, people may very well conceive the same idea independently of one another. Historically, there are many examples of this; writing, for instance, was clearly invented several times (and in different cultural settings) throughout history (Diamond 1998). Arguably, this phenomenon may have been reduced in importance over time, as communication around the globe has progressed.
3. In the sociological literature on diffusion (i.e. spread of innovations), it is common to characterize any adopter of a new technology, product, or service an innovator. This then leads to a distinction between different types of innovators, depending on how quick they are in adopting the innovation, and a discussion of which factors might possibly explain such differences (Rogers 1995). While this use of the terminology may be a useful one in the chosen context, it clearly differs from the one adopted elsewhere. It might be preferable to use terms such as "imitator" or "adopter" for such cases.
4. Similarly for automobiles: while the idea of a power-driven vehicle had been around for a long time, and several early attempts to commercialize cars driven by steam, electricity, and other sources had been made, it was the incorporation of an internal combustion engine driven by low-cost, easily available petrol that made the product a real hit in the market (Mowery and Rosenberg 1998).
5. A somewhat similar distinction has been suggested by Henderson and Clark (1990). They distinguish between the components (or modules) of a product or service and the way these components are combined, e.g. the product "design" or "architecture." A change only in the former is dubbed "modular innovation," change only in the latter "architectural innovation." They argue that these two types of innovation rely on different types of knowledge (and, hence, create different challenges for the firm).

6. In fact, many economists go so far as to argue that the savings in costs, following a process innovation in a single firm or industry, by necessity will generate additional income and demand in the economy at large, which will "compensate" for any initial negative effects of a process innovation on overall employment. For a rebuttal, see Edquist 2001 and Pianta, Ch. 21 in this volume.
7. Schumpeter 1934: 66.
8. In the sociological literature on innovation, the term "reinvention" is often used to characterize improvements that occur to a product or service, while it is spreading in a population of adopters (Rogers 1995).
9. In the Community Innovation Survey (CIS) firms are asked to qualify novelty with respect to the context (new to the firm, industry or the world at large). See Smith in this volume for more information about these surveys.
10. Kim and Nelson (2000*a*) suggest the term "active imitation" for producers who, by imitating already existing products, modify and improve them.
11. For instance, in one of his last papers, he pointed out: "To let the murder out and start my final thesis, what is really required is a large collection of industrial and locational monographs all drawn up according to the same plan and giving proper attention on the one hand to the incessant historical change in production and consumption functions and on the other hand to the quality and behaviour of leading personnel" (Schumpeter 1949/1989: 328).
12. Even in cases where the project ultimately is successful in aims, entrepreneurs face the challenge of convincing the leadership of the firm to launch it commercially (which may be much more costly than developing it). This may fail if the leadership of the firm has doubts about its commercial viability. It may be very difficult for management to foresee the economic potential of a project, even if it is "technically" successful. Remember, for instance, IBM director Thomas Watson's dictum in 1948 that "there is a world market for about five computers" (Tidd et al. 1997: 60)!
13. "A unified homogenous leadership structure is effective for routine trial-and-error learning by making convergent, incremental improvements in relatively stable and unambiguous situations. However, this kind of learning is a conservative process that maintains and converges organizational routines and relationships towards the existing strategic vision . . . although such learning is viewed as wisdom in stable environments, it produces inflexibility and competence traps in changing worlds" (Van de Ven et al. 1999: 117).
14. It would also imply that large countries should be expected to be more innovative than smaller ones, consistent with, for instance, the prediction of so-called "new growth" theory (Romer 1990). See Verspagen in this volume.
15. See, in particular, Ch. 10 by Granstrand (intellectual property rights), Ch. 8 by Mowery and Sampat (universities and public research infrastructure), and Ch. 9 by O'Sullivan (finance).
16. This is essentially what was suggested by Porter (1990).
17. See Fagerberg 2002, 2003 for a discussion of this "Marx–Schumpeter" model.
18. See Fagerberg (1996), Wakelin (1997), and Cantwell, Ch. 20 in this volume for overviews of some of this literature.
19. For a more recent analysis in this spirit, with a lot of empirical case-studies, see Utterback (1994).

20. Available econometric evidence suggests that innovation, measured in various ways (see Smith in this volume), matters in many industries, not only those which could be classified as being in the early stage of the product-cycle (Soete 1987; Fagerberg 1995).
21. For an overview, see Aghion and Howitt (1998). See also the discussion in Fagerberg (2002, 2003), and Ch. 18 by Verspagen in this volume.
22. For a discussion of the role of different types of knowledge in economics, including the organizational dimension, see Cowan et al. (2000) and Ancori et al. (2000).

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PART I

INNOVATION IN THE MAKING

Introduction to Part I

Most innovations occur in firms or other types of organizations. The contributions in this section survey our current knowledge on the organizational structure and context of the process of innovation. Chapter 2, by Lazonick, provides a historical perspective on the development of innovative firms, from the small and medium-sized firms of the First Industrial Revolution through the multi-divisional diversified industrial firms of the US and Japan in the twentieth century to the current debate on the "New Economy" and network-based business models. Powell and Grodal deal more extensively with the role of networks in innovation in the subsequent chapter. Chapter 4, by Pavitt, discusses innovation processes within firms, and uses an extensive survey of the relevant literature to provide an analytical perspective on the factors affecting the performance and management of innovation within the large firm. A complementary chapter by Lam (Chapter 5) focuses on firms' experiences with organizational innovation. Finally, Chapter 6 by Smith deals with an indispensable prerequisite for the study of innovation, the measurement of innovation-related activities, particularly in firms.

CHAPTER 2

THE INNOVATIVE FIRM

WILLIAM LAZONICK

2.1 Introduction

What makes a firm innovative? How have the characteristics of innovative firms changed over time? To address these questions, one requires a conceptual framework for analyzing how a firm transforms productive resources into goods and services that customers want at prices they can afford. To make this productive transformation, a firm must engage in three generic activities: strategizing, financing, and organizing. The types of strategy, finance, and organization that support the innovation process change over time and can vary markedly across industrial activities and institutional environments at any point in time. The innovative firm must, therefore, be analyzed in comparative–historical perspective. This chapter presents and illustrates a framework for analyzing the "social conditions of innovative enterprise" in the comparative–historical experiences of the advanced economies.

Section 2.2 builds upon prominent theories of the innovative firm to derive the "social conditions of innovative enterprise" framework. Section 2.3 focuses on the regional agglomerations of capabilities, now known as "Marshallian industrial districts," that, by the late nineteenth century, had enabled Britain to emerge as the world's first industrial nation. Section 2.4 provides a perspective on the emergence and growth of the US managerial corporation that propelled the US economy to international industrial leadership during the first half of the twentieth century.[1]

Over the past few decades, the greatest challenges to the US managerial corporation have come from Japan. Section 2.5 identifies the social conditions of innovative enterprise that have characterized the Japanese model, while Section 2.6 outlines the distinctive characteristics of the US New Economy firm that has gained competitive advantage in a number of critical product markets in the information and communication technology (ICT) industries. Section 2.7 draws some general conclusions from this essay's comparative–historical perspective concerning strategy, finance, and organization in the innovative firm, and the methodology for studying these phenomena.

2.2 Social Conditions of Innovative Enterprise

Firms strategize when they choose the product markets in which they want to compete and the technologies with which they hope to be competitive. Firms finance when they make investments to transform technologies and access markets that can only be expected to generate revenues sometime in the future. Firms organize when they combine resources in the attempt to transform them into saleable products. To strategize, finance, and organize is not necessarily to innovate. By definition, innovation requires learning about how to transform technologies and access markets in ways that generate higher quality, lower cost products. Learning is a social activity that renders the innovation process uncertain, cumulative, and collective (O'Sullivan 2000*b*). The innovation process is uncertain because, by definition, what needs to be learned about transforming technologies and accessing markets can only become known through the process itself. By investing in learning, an innovative strategy confronts the uncertain character of the innovation process. The innovation process is cumulative when learning cannot be done all at once; what is learned today provides a foundation for what can be learned tomorrow. Investments in cumulative learning, therefore, require sustained, committed finance. The innovation process is collective when learning cannot be done alone; learning requires the collaboration of different people with different capabilities. Investments in collective learning, therefore, require the integration of the work of these people into an organization.

What is the theory of the firm that can comprehend how strategizing, financing, and organizing can support the innovation process? Over the past century, the theoretical efforts of economists have focused mainly on the optimizing firm rather than the innovating firm. The optimizing firm takes as given technological capabilities and market prices (for inputs as well as outputs), and seeks to maximize profits on the basis of these technological and market constraints. In sharp contrast, in the attempt to generate higher quality, lower cost products than had previously been available, and thus differentiate itself from competitors in its industry, the innovating firm seeks to transform the technological and market conditions that the optimizing firm takes as "given" constraints. Hence, rather than constrained optimization, the innovating firm engages in what I call "historical transformation," a mode of resource allocation that requires a theoretical perspective on the processes of industrial and organizational change (Lazonick 2002*a*).

The distinction between the innovating and optimizing firm is implicit in the work of Alfred Marshall, whose *Principles of Economics*, published in eight editions between 1890 and 1920, placed the theory of the firm at the center of economic analysis. Although Marshall's followers used his arguments to construct the theory of the optimizing firm that remains entrenched in economics textbooks, Marshall (1961: 315) himself displayed considerable insight into the dynamics of the innovating firm, as revealed in the following passage:

> An able man, assisted by some strokes of good fortune, gets a firm footing in the trade, he works hard and lives sparely, his own capital grows fast, and the credit that enables him to borrow more capital grows still faster; he collects around him subordinates of more than ordinary zeal and ability; as his business increases they rise with him, they trust him and he trusts them, each of them devotes himself with energy to just that work for which he is specially fitted, so that no high ability is wasted on easy work, and no difficult work is entrusted to unskillful hands. Corresponding to this steadily increasing economy of skill, the growth of his firm brings with it similar economies of specialized machines and plants of all kinds; every improved process is quickly adopted and made the basis of further improvements; success brings credit and credit brings success; success and credit help to retain old customers and to bring new ones; the increase of his trade gives him great advantages in buying; his goods advertise one another and thus diminish his difficulty in finding a vent for them. The increase of the scale of his business increases rapidly the advantages which he has over his competitors, and lowers the price at which he can afford to sell.

What then constrains the growth of such a firm? In *Industry and Trade*, published in 1919, Alfred Marshall acknowledged that over the previous decades the large-scale enterprise had become dominant in advanced nations such as the United States and Germany. He invoked, however, the aphorism, "shirtsleeves to shirtsleeves in three generations" (Marshall 1961: 621) to explain the limit to the growth of the firm that would prevent a small number of large firms from dominating an industry. An owner-entrepreneur of exceptional ability would found and build a successful firm. In the second generation, control would pass to descendants who could not be expected to have the capabilities or drive of the founder, and as a result the firm would grow more slowly or even stagnate. The third generation would lose touch with the innovative legacy of the first generation, and the firm would wither away in the face of new entrepreneurial competition.

Writing in the first decades of the twentieth century, Joseph Schumpeter (1934) also focused on the innovative entrepreneur who, by creating "new combinations" of productive resources, could disrupt the "circular flow of economic life as conditioned by given circumstances." In effect, Schumpeter was arguing that, through entrepreneurship, which he called the "fundamental phenomenon of economic development," innovating firms could challenge optimizing firms, and thereby drive the development of the economy. In 1911, when he first published *The Theory of Economic Development* (in German), Schumpeter, like Marshall, viewed the innovative firm as the result of the entrepreneurial work of an extraordinary individual. Over the subsequent decades, however, as Schumpeter observed the actual development of the leading economies, he came to see the large corporation as the innovating firm, engaged in what he called a process of "creative destruction"; the creation of new modes of productive transformation destroyed existing modes that had themselves been the result of innovative enterprise in the past.

In *Capitalism, Socialism, and Democracy*, first published in 1942, Schumpeter (1950: 118, 132) argued that "technological 'progress' tends, through systemization and rationalization of research and management, to become more effective and sure-footed" as it is undertaken as "the business of teams of trained specialists who turn out what is required and make it work in predictable ways." In a series of major works, Alfred Chandler (1962, 1977, 1990) documented the rise of the managerial corporation in the United States from the last decades of the nineteenth century, the evolution of its multidivisional structure from the 1920s, and the emergence of managerial enterprise in Britain and Germany. In *The Theory of the Growth of the Firm*, first published in 1959, Edith Penrose (1995) conceptualized the modern corporate enterprise as an organization that administers a collection of human and physical resources. People contribute labor services to the firm, not merely as individuals, but as members of teams who engage in learning about how to make best use of the firm's productive resources—including their own.

At any point in time, this learning endows the firm with experience that gives it productive opportunities unavailable to other firms, even in the same industry, that have not accumulated the same experience. The accumulation of innovative experience enables the firm to overcome the "managerial limit" that in the theory of the optimizing firm causes the onset of increasing costs and constrains the growth of the firm (Penrose 1995: chs. 5, 7, and 8). The innovating firm can transfer and reshape its existing productive resources to take advantage of new market opportunities. Each move into a new product market enables the firm to utilize unused productive services accumulated through the process of organizational learning. These unused productive services can provide a foundation for the growth of the firm, through both in-house complementary investments in new product development and the acquisition of other firms that have already developed complementary productive services.

From the 1980s many business school academics, working in the strategy area, cited Penrose's 1959 book as an intellectual foundation for a "resource-based" view of the firm. Resource-based theory focused on the characteristics of valuable resources that one firm possessed and that competitor firms found it difficult to imitate. Resource-based theory, however, provided no perspective on why and how some firms rather than others accumulated valuable and inimitable resources, or indeed what made these resources valuable and inimitable (see Lazonick 2002*a*). Independently of the resource-based perspective, however, Richard Nelson and Sidney Winter (1982) fashioned a theory of the persistence of the large industrial corporation based on organizational capabilities, characterized by tacit knowledge and embedded in organizational routines, thus adding a cumulative dimension to the theory of the firm. Drawing on a highly eclectic set of sources from a number of disciplines, Bruce Kogut and Udo Zander (1996: 502) argued that "[f]irms are organizations that represent social knowledge of coordination and learning," thus emphasizing the collective dimension in the theory of the firm.

In "Why Do Firms Differ, and How Does It Matter?" Nelson (1991: 72) argued that "it is organizational differences, especially differences in abilities to generate and gain from innovation, rather than differences in command over particular technologies, that are the source of durable, not easily imitable, differences among firms. Particular technologies are much easier to understand, and imitate, than broader firm dynamic capabilities." David Teece, Gary Pisano, and Amy Shuen (1997: 516) defined "dynamic capabilities as the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments." They also argued that the firm's strategy entails choosing among and committing to long-term paths or trajectories of competence development (Teece at al. 1997: 524). Whereas the firm's asset positions determine its competitive advantage at any point in time and its evolutionary path constrains the types of industrial activities in which a firm can be competitive, its organizational processes transform the capabilities of the firm over time.

While Teece et al. (1997: 519) stressed the importance of learning processes that are "intrinsically social and collective," their dynamic capabilities perspective lacks social content. The framework does not ask what types of people are able and willing to make the strategic investments that can result in innovation, how these strategic decision makers mobilize the necessary financial resources, and how they create incentives for those people within the firm's hierarchical and functional division of labor to cooperate in the implementation of the innovative strategy. These questions about the roles of strategizing, financing, and organizing in the innovating firm are at the center of what Mary O'Sullivan and I have called the "social conditions of innovative enterprise" perspective (Lazonick and O'Sullivan 2000; O'Sullivan 2000*b*; Lazonick 2002*b*).

This perspective asks how and under what conditions the exercise of strategic control ensures that the enterprise seeks to grow using the collective processes and along the cumulative paths that are the foundations of its distinctive competitive success. The perspective emphasizes the role of human agency in determining whether and how the enterprise accumulates innovative capability, and thus adds an explicitly social dimension to work on "dynamic capabilities." Specifically, strategic control determines how strategic decision makers choose to build on "asset positions"; financial commitment determines whether the enterprise will have the resources available to it to persist along an "evolutionary path" to the point where its accumulation of innovative capability can generate financial returns; and organizational integration determines the structure of incentives that characterize "organizational processes" that can transform individual actions and individual capabilities (including those of strategic managers) into collective learning.

Of central importance to the accumulation and transformation of capabilities in knowledge-intensive industries is the skill base in which the firm invests in pursuing its innovative strategy. Within the firm, the division of labor consists of different functional specialties and hierarchical responsibilities. At any point in time a firm's functional and hierarchical division of labor defines its skill base. In the effort to generate collective and cumulative learning, those who exercise strategic control can choose how to structure the skill base, including how employees move around and up the functional and hierarchical division of labor over the course of their careers. At the same time, however, the organization of the skill base will be constrained by both the particular learning requirements of the industrial activities in which the firm has chosen to compete and the alternative employment opportunities of the personnel for whom the firm must compete.

In cross-national comparative perspective, the skill base that enterprises employ to transform technologies and access markets can vary markedly even in the same industrial activity during the same historical era, with different innovative outcomes. Precisely because innovative enterprise depends on social conditions, the development and utilization of skill bases that occur in one institutional environment may not, at a point in time at least, be possible in another institutional environment. Moreover, even within the same industry and same nation, dynamic capabilities that yielded innovative outcomes in one historical era may become static capabilities that inhibit innovative responses in a subsequent historical era.

The innovative firm requires that those who exercise strategic control be able to recognize the competitive strengths and weaknesses of their firm's existing skill base and, hence, the changes in that skill base that will be necessary for an innovative response to competitive challenges. These strategic decision makers must also be able to mobilize committed finance to sustain investment in the skill base until it can generate higher quality, lower cost products than were previously available. As the following comparative–historical syntheses illustrate, given strategic control and financial commitment, the essence of the innovative firm is the organizational integration of a skill base that can engage in collective and cumulative learning.

2.3 The British Industrial District

In last half of the nineteenth century, Britain became known as the "workshop of the world." Britain's position in the world economy owed much to its mercantile power, developed through global commerce and related wars with other leading nations over the previous centuries. Mercantilism gave British industry access to world product markets and sources of raw materials, but it was the transformation of production from the late eighteenth century that enabled Britain to emerge as the world's leading (and indeed first) industrial nation.

In the late nineteenth century, Britain's productive power resided in industrial districts that, for building machines and using them to manufacture products as varied as cloth and ships, possessed an immense accumulation of capabilities. Beyond evening courses at local "mechanics' institutes," formal vocational or professional education played no role in the development of Britain's skilled labor force. Nor did British industry make use of corporate, university, or government research labs to develop new technology. Regionally based on-the-job apprenticeship arrangements, through which craft workers passed on their skills to the next generation, constituted in effect the "national innovation system" of the world's first industrial economy.

What accounts for the importance of the craft worker for Britain's industrial leadership? While the mechanization of the factory was a central feature of the British industrial revolution—and in its time a wonder of the world—the standardization of materials and the automation of machinery that British industry achieved during its industrial revolution were, in historical retrospect, incipient. Skilled craft workers maintained critical roles in keeping imperfect machinery in motion and ensuring high levels of throughput of work-in-progress made from imperfect materials. Within the firm, experienced workers typically were responsible for training younger workers in the craft, supervising their work, and coordinating the flow of work through the production process. In some industries, the central employment relation took the form of an internal subcontract system; for example, in the cotton spinning industry, employers paid piece-rates to senior workers, known as "self-acting minders," who in turn trained, supervised, and paid time wages to junior workers known as "piecers" and "doffers." In the metalworking industries, specialized workers such as "turners" and "fitters" were generally classified as "engineers," an appellation that in the British context signified membership in the "labor aristocracy" of skilled production workers (Lazonick 1990: chs. 1–6).

The localized, on-the-job character of skill formation was the major factor underlying the growth of industrial districts that made use of particular specialized craft skills. As Alfred Marshall (1961: 271) famously put it, in the British industrial districts "mysteries of the trade become no mysteries; but are as it were in the air." In periods of strong product-market demand, the ready availability of specialized craft labor induced new specialized manufacturing firms, often founded by craft workers themselves, to set up in these districts. The growth of a district induced other firms to invest in regionally specific communication and distribution facilities for the supply of materials, the transfer of work-in-progress across vertically specialized firms, and the marketing of output.

Regional concentration encouraged vertical specialization, which in turn eased firm entry into a particular speciality, thus resulting in high levels of horizontal competition. Firms could be owned and managed by the same people; there was no need to invest in the types of managerial organization that by the late nineteenth century were becoming central to the growth of firms in the United States, Germany, and Japan. In the industrial districts, economies of scale were, as Marshall argued, external, rather than internal, to the firm.

As producers and users of machinery, craft workers constituted the prime source of innovation in a particular region. Over time they devised incremental technological and organizational improvements that, through the local trade press (including workers' newspapers) as well as the movement of workers (especially trained apprentices) to new employers, diffused across firms in the district. Some specialized engineering firms distinguished themselves through in-house learning. But even the strongest of these firms—for example, the textile machinery firm of Platt Brothers based in Oldham—did no in-house R&D, and from the last half of the nineteenth century generated no significant technological innovations. Their strength resided in their employment of craft labor that could flexibly produce customized machines for many different types of users (Farnie 1990).

The importance of localized craft labor to the innovative capabilities of local firms meant that it was the industrial district, and often a particular town within a district, not the individual firm, that constituted the learning entity. At the firm level, craft workers made countless "strategic" decisions to improve products and processes. For both individual firms and the district as a whole, the fixed costs of developing this source of innovation were, in historical and comparative perspective, low. At the same time, craft-oriented employment systems encouraged a high level of utilization of the plant and equipment in place. Union bargains protected the tenure and remuneration of senior workers who, paid by the piece, were willing to work long, hard, and steady. The inducement for junior workers, typically paid time wages, was that they could eventually join the aristocracy of labor. There is evidence that, within an industrial district, those localities in which negotiated piece-rate bargains shared productivity gains between employees and employers on a stable and equitable basis saw the fastest growth in productivity and market share (Lazonick 1990: chs. 3–5; Huberman 1996).

Based on craft organization, British industrial districts were highly innovative (see also Bruland and Mowery, this volume). The fact that it was the industrial district as a whole, rather than the individual enterprise within it, that was the innovating entity gave rise to the notion that differences among firms in an industrial activity were unimportant to economic performance, and indeed that they could all be characterized by depicting a "representative firm" that optimized subject to given technological and market constraints. Within the Marshallian perspective, even innovation at the district level did not require strategic direction, since the industrial arts were "in the air." Indeed, Marshall (1919: 600–1) described the organization of the Lancashire cotton textile industry, with its high degrees of horizontal competition and vertical specialization, as "perhaps the present instance of concentrated organisation mainly automatic." Yet just as Marshall was writing these words, the cotton textile industry, which had accounted for one-quarter of British exports on the eve of World War I, entered into a long-run decline from which it never recovered, and the other major British industrial districts suffered a similar fate (Elbaum and Lazonick 1986).

From the late 1970s, however, the notion of the "Marshallian industrial district" as a driver of innovative enterprise saw an academic resurgence, based on the rapid growth during the 1960s and 1970s of many highly specialized and localized districts in what became known as "the Third Italy" (Brusco 1982; Sabel 1982; Becattini 1990). On the basis of this experience, a number of US academics, headed by Charles Sabel, Michael Piore, and Jonathan Zeitlin, posited a new model of "flexible specialization" as an alternative to mass production on the US corporate model (Piore and Sabel 1984; Sabel and Zeitlin 1985). The industrial activities of the districts of the Third Italy focused on, among other things, textiles, footwear, and light machinery, just as the British districts had done. Large numbers of vertically specialized proprietary firms in which craft labor was a prime source of competitive advantage populated each industrial activity, and many entrepreneurs had previously been craft workers.

There were, however, two important differences between the British industrial districts that Marshall had observed in the late nineteenth century and those that experienced rapid growth in the Third Italy more recently. The first difference was the extent to which in Italy collective institutions supported the innovative activities of small firms. Sebastiano Brusco (1992) has emphasized the importance of the "red" local governments in Emilia-Romagna in promoting policies to support the activities of small enterprises, and in particular in facilitating cooperatives that provided these firms with "real services" related to business administration, marketing, and training. While consumer cooperatives sprung up in the British industrial districts of the late nineteenth century, producer cooperatives were rare. The second difference, which became more evident in the 1990s, was the extent to which, in some districts and in some industries, "leading" firms could emerge, drawing on the resources of the industrial districts while, through their own internal growth, transforming the innovative capability of the districts (see, for example, Belussi 1999). In contrast, when in the first half of the twentieth century competitive challenges confronted the British industrial districts, dominant firms failed to emerge to lead a restructuring process.

2.4 The US Managerial Corporation

Marshall located the limits to the growth of the firm in the problem of succeeding the original owner-entrepreneur. In *The Theory of Economic Development*, Schumpeter (1934: 156) concurred using the same aphorism as Marshall, literally clothed in different garb and specifically identified as a US phenomenon: "An American adage expresses it: three generations from overalls to overalls." Critical to this perspective were two assumptions: first, that the entrepreneur was the essence of the innovative firm, and second, that the integration of ownership and control was a necessary condition for entrepreneurship. Notwithstanding his own important study of comparative trends in industrial organization published in *Industry and Trade*, Marshall (1919) declined to recognize, as ultimately Schumpeter did, that the problem of innovative succession could be resolved by the separation of ownership and control.

Taking place during the same decades in which Marshall wrote his influential books, the separation of share ownership from strategic control was the essence of what Chandler (among others) would call "the managerial revolution" in American business. During this period Germany and Japan also experienced managerial revolutions (Chandler 1990; Chandler et al. 1997; Morikawa and Kobayashi 1986; Morikawa 1997). Many British firms, especially in the science-based chemical and electrical industries also made investments in managerial organization, but in such a constrained manner that it can hardly be said that a managerial revolution occurred in Britain during the first half of the twentieth century (Hannah 1983; Lazonick 1986; Chandler 1990; Owen 2000).

In the United States, the managerial revolution began in the 1890s in industries such as steel, oil refining, meatpacking, tobacco, agricultural equipment, telecommunications, and electric power that owner-entrepreneurs had built up over the previous decades. Wall Street (and especially the firm of J. P. Morgan) organized the merger of the leading companies, and in the process did what would later become known as "initial public offerings" (IPOs) in order to allow the owner-entrepreneurs to cash in on their ownership stakes. Many of them then retired from active management of the company. Taking their places in strategic decision-making positions were salaried managers, most of whom had themselves been recruited years or even decades earlier to help build the innovative firms that they now controlled. Hence, Marshall's "entrepreneurial" limit to the growth of the firm was overcome. By the turn of the century, the separation of ownership and control in many of the most successful industrial corporations served as a powerful inducement for bright young, and typically White, Anglo-Saxon, Protestant, men to consider careers as corporate executives (Lazonick 1986; O'Sullivan 2000*a*: ch. 3).

Also from the beginning of the twentieth century, a four-year undergraduate college degree became important for entry into managerial careers, and in 1908

Harvard University launched the first graduate school in business administration. In 1900 about 2 per cent of 18–24 year olds were enrolled in institutions of higher education; in 1930 over 7 per cent; and in 1950 over 14 per cent. By the 1920s the top managers of many large industrial corporations had college degrees. As employers of university graduates as well as beneficiaries of university research, big business took an active role in shaping the form and content of higher education to meet its needs for "knowledge assets" (Noble 1977; Lazonick 1986).

As they expanded, US industrial corporations tended to diversify into new lines of business. Capabilities developed for generating goods for one product market could be used as a basis for gaining entry to new product markets. Moreover, as companies were successful, they could use internally generated revenues to finance these new investments. Profitable US corporations generally paid ample dividends to shareholders, but they still generated enough revenues to invest for the future, including growing expenditures on R&D (Mowery and Rosenberg 1989: ch. 4).

Besides transforming technology, a critical role of the managerial organization was to gain access to product markets. Without high levels of sales, the high fixed costs of developing technology and investing in production facilities would have simply resulted in high levels of losses. The building of national transportation and communications infrastructures—themselves largely put in place by managerial enterprises—created the possibility for manufacturing enterprises to sell on mass markets. To take advantage of this opportunity, however, the industrial corporations had to make complementary investments in distribution capabilities, including sales personnel, sales offices, advertising, and in some cases even customized transportation facilities. As Chandler (1990) has shown, from the late nineteenth century, a "three-pronged" investment in production, distribution, and management was a necessary condition for the growth of the industrial enterprise.

If the social condition for the growth of the US industrial corporation was an integrated managerial organization, a distinguishing feature of the same corporation was a sharp organizational segmentation between salaried managers and what became known as "hourly" workers. This segmentation had its roots in the first half of the nineteenth century when industrial managers faced a skilled labor force that was highly mobile not only from one firm to another but also from one occupation and one locality to another. In contrast, in Britain the local pools of specialized craft labor generated by apprenticeship systems meant that employers had access to ample supplies of skilled labor, even in booms. As a result, there was much less pressure in Britain than in the United States for managers to invest in the development of skill-displacing technologies. In the United States, but not Britain, firms integrated technical specialists into their managerial organizations for precisely that purpose. Hence the emergence by the mid-nineteenth century of the distinctive "American system of manufactures" (Hounshell 1984: chs. 1–2).

The key to this system was the mass production of standardized, precision-engineered parts that could be used interchangeably in a product without the intervention of a skilled worker to make the parts fit together. As David Hounshell (1984) has shown, it took a century of investment in productive capabilities by many companies in many sectors of US industry before, during the boom of the 1920s, mass production, so defined, became a reality. The productivity of the mass-production enterprise, nevertheless, still relied upon the stable employment of "semi-skilled" production workers who tended high-throughput, and very expensive, machinery (Lazonick 1990: chs. 7–8).

During the Great Depression of the 1930s, such stable employment disappeared, leading semi-skilled workers at the major mass producers to turn to industrial unionism (Brody 1980: ch. 3). The major achievement of mass-production unionism in the United States was long-term employment security for so-called "hourly" workers, with seniority as the governing principle for internal promotion to higher pay grades and continued employment during company layoffs. In return, these unionized employees accepted unilateral managerial control over the organization of work and technological change. During the post-World War II decades, production workers enjoyed employment security and rising wages but they were not in general integrated with managerial personnel into the company's organizational learning processes.

The result was that going into the second half of the twentieth century US industrial corporations had powerful managerial organizations for developing new technology. These corporations also had devised arrangements with their unionized labor forces to ensure the high level of utilization of these technologies. In employing thousands and in some cases tens of thousands of production workers who were not integrated into the company's organizational learning processes, however, this US model of the innovative firm had a fundamental weakness that, in the 1970s and 1980s, would be exposed in international competition. The Japanese in particular would demonstrate the innovative capability that could be created by not only building highly integrated managerial organizations, as the Americans had done, but also, as a complement, developing the skills of shop-floor workers and integrating their efforts into the firm's collective learning processes.

Even the most insightful of the theories of the US managerial corporation could not, without elaboration, account for the Japanese challenge (Lazonick 2002*c*). Both Penrose (1995) and Chandler (1962 and 1977) focused exclusively on the managerial organization, as did the influential perspective of John Kenneth Galbraith (1967) with its notion of the "technostructure" as the essence of the modern firm. Penrose did not see that, once confronted by the Japanese challenge, the US managerial corporation would have to develop the capabilities of the shop-floor worker to make use of unused managerial resources. Chandler focused on speed or throughput as a basis for achieving economies of scale and scope, but ignored the role of the shop-floor worker in the process of transforming high fixed costs into low unit costs, and hence did not perceive an important limitation of the US managerial model (Lazonick 1990).

2.5 The Japanese Challenge

Within the new structure of cooperative industrial relations that emerged out the conflicts of the depression years, US industrial corporations were able to take advantage of the post-World War II boom to re-establish themselves as the world's pre-eminent producers of consumer durables such as automobiles and electrical appliances and related capital goods such as steel and machine tools. With the help of US government research support and contracts, US companies also became the leaders in the computer and semiconductor industries.

In the 1970s and 1980s, however, Japanese companies challenged the US industrial corporations in the very mass-production industries—steel, memory chips, machine tools, electrical machinery, consumer electronics, and automobiles—in which even as late as the 1960s US corporations seemed to have attained an insurmountable competitive advantage. During the 1950s and 1960s many Japanese companies had developed innovative manufacturing capabilities, often on the basis of technologies borrowed from abroad to produce mainly for the home market. As Japanese exports to the United States increased rapidly in the last half of the 1970s, many observers attributed the challenge to the lower wages and longer working hours that prevailed in Japan. By the early 1980s, however, with real wages in Japan continuing to rise, it became clear that Japanese advantage was based on superior capabilities for generating higher quality, lower cost products.

The three social institutions that, in combination, formed the foundation for Japan's remarkable success were cross-shareholding, the main bank system, and lifetime employment. Cross-shareholding provided the managers of Japanese industrial corporations with the strategic control to allocate resources to investments that could generate higher quality, lower cost products. The main bank system provided these companies with levels of financial commitment that permitted them to sustain the innovation processes until they could generate returns, first on home and then on foreign product markets. Given this financial support for strategic industries, lifetime employment enabled the companies involved to put in place a new model of hierarchical and functional integration that enabled them to mobilize broader and deeper skills bases for collective and cumulative learning (Lazonick 2001). Let us look briefly at how these institutions became embedded in the functioning of the Japanese industrial enterprise in the post-World War II decades.

In 1948 the Supreme Commander for the Allied Powers (SCAP)—the occupation authority in Japan—began the dissolution of the zaibatsu, the giant holding companies that had dominated the Japanese economy from the Meiji era of the late nineteenth century to World War II. The dissolution process not only dispossessed the families that owned the zaibatsu but also removed from office the top management layers of the zaibatsu holding companies and major affiliated firms (Morikawa

1997). Taking control of strategic decision making were "third-rank executives," primarily engineers plucked from the ranks of middle management to take leadership positions of companies whose challenge was to find non-military markets for their companies' accumulated capabilities.

With the reopening of the stock market in 1949, these young and ambitious executives feared that the new public shareholders might join forces to demand their traditional rights as owners. To defend themselves against these outside interests, the community of corporate executives engaged in the practice of cross-shareholding. Commercial banks and industrial companies took equities off the market by holding each other's shares. Though not contractual, cross-shareholding was sustained by the willingness of the entire Japanese business community to accept that one company would not sell its shareholdings of another company.[2] By 1975, according to its broadest, and most relevant, definition as stock in the hands of such stable shareholders, cross-shareholding represented 60 per cent of outstanding stocks listed on the Tokyo Stock Exchange. It peaked at 67.4 per cent in 1988, but by 2000 had declined to 57.1 per cent, mainly because the beleaguered banking sector had been forced to reduce their shareholdings.

During the "era of high-speed growth" from the early 1950s to the early 1970s, most of the financial commitment of Japanese companies came from bank loans, with the companies' debt–equity ratios often at 6 : 1 or 7 : 1. Each major industrial company had a "main bank" whose job it was to convince other banks to join it in making loans to the company and to take the lead in restructuring its client company should it fall into financial distress. Some economists (e.g. Aoki and Patrick 1994) have accorded the main banks a major role in monitoring the behavior of Japan's corporate managers. In funding the growth of Japanese companies, however, the Japanese banks were relatively passive agents of government development policy, with "overloans" being made by the Bank of Japan to its member banks for providing highly leveraged finance to growing industrial companies. Japanese banks, that is, played a critical role in providing financial commitment, but no significant role in the exercise of strategic control.

Integrated organizations of managers and workers, not financial interests, monitored the behavior of the top executives of Japanese corporations (Lazonick 1999). The main mode of achieving this organizational integration was the lifetime employment system, which extended from top executives to male (but not female) shop-floor workers. The origins of the lifetime employment system can be found in the widespread employment in industry of university graduates as salaried technical and administrative personnel during the early twentieth century (Yonekawa 1984). Some companies extended the promise of lifetime employment to shop-floor workers as well when dire economic conditions and democratization initiatives of the late 1940s had given rise to a militant labor movement. The goal of the new industrial unions was to implement "production control": the takeover of idle factories so that workers could put them into operation and earn a living (Gordon

1985). Leading companies such as Toyota, Toshiba, and Hitachi fired militant workers and created enterprise unions of white-collar (technical and administrative) and blue-collar employees. Foremen and supervisors were members of the enterprise unions, as were all university-educated personnel, for at least the first ten years of employment before they made the official transition into "management."

The most important achievement of enterprise unionism was the institutionalization of lifetime employment, a system that, while not contractually guaranteed, gave white-collar and blue-collar workers employment security, at first to the retirement age of 55, then from the 1980s to the age of 60, and currently (in transition) to the age of 65 (Sako and Sato 1997). This employment security both won the commitment of the worker to the company and gave the company the incentive to develop the productive capabilities of the worker. The system did not differ in principle from the organizational integration of technical and administrative employees that was at the heart of the US managerial revolution, except in one extremely important respect. In the United States there was a sharp segmentation between salaried managers and shop-floor workers, whereas the Japanese companies of the post-World War II decades integrated shop-floor workers into a company-wide process of organizational learning.

Through their engagement in processes of cost reduction, Japanese shop-floor workers were continuously involved in a more general process of improvement of products and processes that, by the 1970s, enabled Japanese companies to emerge as world leaders in factory automation (Jaikumar 1989). By the early 1990s the stock of robots in Japanese factories was over seven times that of the United States. Also of great importance was the ability of Japanese manufacturers to eliminate waste in production; by the late 1970s, for example, Japan's competitive advantage in television sets was not in labor costs or even scale economies but in a savings of materials costs (Owen 2000: 278; Fagerberg and Godinho in this volume). This productive transformation became particularly important in international competition in the 1980s as Japanese wages approached the levels of those in North America and Western Europe and, especially from 1985, as the value of the Japanese yen dramatically strengthened. During the 1980s and 1990s, influenced by not only Japan's export performance but also the impact of Japanese direct investment in North America and Western Europe, many Western companies sought, with varying degrees of success, to implement Japanese high-quality, low-cost mass-production methods.

During the 1980s most Western analyses of the sources of Japanese competitive advantage focused on the hierarchical integration of the shop-floor worker into the organizational learning process. By the early 1990s, however, as Japanese companies captured higher value-added segments of the products markets in which they competed, the emphasis shifted to the role of "cross-functional management," "company-wide quality control," or "concurrent engineering" in generating not only lower cost but also higher quality products within highly accelerated product development cycles. Much of the discussion of functional integration focused on its role in "new product development" in international comparative perspective, with, as Clark and Fujimoto (1991) showed for the automobile industry, the US managerial corporation performing quite poorly.

Given that the innovative power of the US industrial corporation resided in its integrated managerial organization, why should it have suffered from functional segmentation in competition with the Japanese? One reason was that, given the hierarchical segmentation of shop-floor activities from organizational learning processes in US companies, US engineers were not forced to communicate across their disciplines to solve "real-world" manufacturing problems. Another had to do with the increasing interfirm mobility of US engineers from the 1960s—mobility that, as we shall see, was related to the rise of the "New Economy" high-tech firm. The prospects for interfirm mobility gave scientists and engineers an interest in developing their reputations among their peers within their particular area of specialization, even if it detracted from integrating their specialist knowledge across functional areas within the particular firm for which they were working. By contrast, in the Japanese firm both the hierarchical integration of managers and workers and low levels of interfirm mobility of engineering personnel fostered functional integration.

The evolution of the semiconductor industry provides a vivid example of the competitive power, but also the limits, of Japanese organizational integration. From the late 1970s the Japanese mounted a formidable competitive challenge to US producers in dynamic random access memory (DRAM) chips, forcing most US companies, including Intel, to withdraw from the market after 1985. Already a powerhouse in semiconductors before the Japanese challenge, Intel reemerged even stronger in the 1990s as the leader in microprocessors, a product in which it was the pioneer in the early 1970s and for which during the 1980s it secured the franchise for the IBM PC and the subsequent IBM clones (Burgelman 1994).

Organizational integration was critical to the Japanese challenge in DRAMs. As Daniel Okimoto and Yoshio Nishi (1994) have shown, the most critical interactions in product and process development in Japanese semiconductor companies were between personnel in divisional R&D labs and factory engineering labs, with engineering capability being concentrated in the factory labs. They argue that in Japan "hands-on manufacturing experience . . . is almost a requirement for upward career and post-career mobility [whereas] [i]n the United States, by contrast, manufacturing engineers carry the stigma of being second-class citizens" (Okimoto and Nishi 1994: 195).

Value added in microprocessors is in the design that determines the use of the product, an activity for which US skill bases in semiconductors were more suited. Value added in memory chips is in process engineering that reduces defects and increases chip yields, an activity for which Japanese skill bases in semiconductors were more suited. By the 1980s Japanese companies such as Fujitsu, Hitachi, and

NEC were able to achieve yields in the production of DRAMs that were 40 per cent higher than the best US companies.

In the 1990s the Japanese economy as a whole has stagnated, to the point where many Western observers now blame its unique institutional framework, still largely intact, for its lack of innovation. Yet, in industries such as electronics and automobiles, Japanese companies such as Sony and Toyota, among many others, remain leading innovators in those types of products in which, as during the previous decades, their integrated skill bases gave them international competitive advantage. The main microeconomic problems in the Japanese economy are to be found in the financial system and, relatedly, institutions for creation of new innovative firms.

During the boom of the 1980s the leading Japanese manufacturing companies were able to reduce their reliance on bank debt, just as the banks were awash with cash to lend. The banks then channeled funds into speculative investments in land and stocks, thus fuelling the "bubble economy" of the late 1980s. When the bubble burst in 1990, the banks were saddled with mountains of bad debt. Although most of this bad debt has now been written off, the banks remain in fragile condition because most of their loans are being made to smaller companies that do not have anything close to the growth potential that was realized by many Japanese companies in the previous eras of high-speed growth and export expansion (Lazonick 1999). "Growth potential," however, is not exogenous to the "social conditions of innovative enterprise," as illustrated by the emergence of more powerful modes of strategy, finance and organization in the rise of the "New Economy" model of the innovative firm in the United States.

2.6 The New Economy Model

During the 1970s and 1980s while Japanese enterprises were challenging established US managerial corporations in many industries in which they had been dominant, there was a resurgence of the US information and communications technology (ICT) industries, providing the foundation for what by the last half of the 1990s became known as the "New Economy." Historically, underlying the emergence of the New Economy were massive post-World War II investments by the US government, in collaboration with research universities and industrial corporations, in developing computer and communications technologies.

By the end of the 1950s, this combined business–government investment effort had resulted in not only the first generation of computers, with IBM as the leading firm, but also the capability of imbedding integrated electronic circuits on a silicon chip, with Fairchild Semiconductor and Texas Instruments in the forefront of creating the technology that would become the standard of the semiconductor industry. Through the early 1960s the US government provided virtually all of the demand for semiconductors. From the second half of the 1960s, however, a growing array of commercial opportunities for electronic chips induced the creation of semiconductor startups. A new breed of venture capitalist, many with prior managerial or technical experience in the semiconductor industry, backed so many semiconductor startups clustered in the region around Stanford University that by the early 1970s the district was dubbed "Silicon Valley." Innovation in semiconductors, and especially the development of the microprocessor—in effect a computer on a chip—created the basis for the emergence of the microcomputer industry from the late 1970s, which in turn resulted in the enormous growth of an installed base of powerful "hosts" in homes and offices that made possible the Internet revolution of the 1990s.

As AnnaLee Saxenian (1994) has shown, intense, and often informal, learning networks that transcended the boundaries of firms contributed to the success of Silicon Valley. Like the Marshallian industrial districts of a century earlier, there is no doubt that, in Silicon Valley, "the mysteries of the trade . . . were in the air." But in its strategy, finance, and organization, the New Economy business model that emerged in Silicon Valley differed significantly from the Marshallian industrial district. Of particular importance was the extent to which in Silicon Valley organizational learning occurred within the firm, enabling some particularly innovative firms that grew to employ tens of thousands of employees to drive the development of the region. In its early stages this organizational learning tended to be backed by venture capital, a mode of finance that through its success in Silicon Valley from the 1960s evolved into an industry in its own right. Also of great importance in supporting the development of technology and the education of personnel available to firms in this high-tech industrial district were state funding and universities, institutions that for a century had been central to the US managerial model.

The founders of new ICT firms were typically engineers who had gained specialized experience in existing ICT firms, although in some cases they were university faculty members intent on commercializing their academic knowledge. While some of these entrepreneurs came from existing Old Economy companies, where it was often difficult for their new ideas to get internal backing, New Economy companies themselves became increasingly important as a source of new entrepreneurs who left their current employers to start a new firm (Gompers et al. 2003). Typically the founding entrepreneurs of a New Economy startup sought committed finance from venture capitalists with whom they shared not only ownership of the company but also strategic control. Besides sitting on the board of directors of the new company, the venture capitalists would generally recruit professional managers, who would be given company stock along with stock options, to lead the transformation of the firm from a new venture to a going concern. This stock-based compensation gave these managers a powerful financial incentive to develop the innovative capabilities of the company to the point where it could do an IPO or private sale to an established company. But, both before and after making this transition, their tenure with, and value to, the company depended on their managerial capabilities, not their fractional ownership stakes.

Key to making this transition from new venture to going concern was the organizational integration of an expanding body of technical and managerial "talent." Stock options became an important mode of compensation, usually as a partial substitute for cash salaries, for attracting these highly mobile people to the startup and retaining their services. The underlying stock would become valuable if and when they took the form of publicly traded shares. Shortening the expected period between the launch of a company and its IPO was the practice of most venture-backed high-tech startups of going public on the NASDAQ exchange (founded in 1971), with its much less stringent listing requirements than the Old Economy New York Stock Exchange. If and when the firm did an IPO or was acquired by another publicly listed company, the venture capitalists could sell their shareholdings on the stock market, thereby exiting from their investments in the firm, while entrepreneurs could also transform some or all of their ownership stakes into cash. With the company's stock being publicly traded, employees who exercised their stock options could easily turn their shares into cash.

During the 1980s and 1990s the liberal use of stock as a compensation currency, not only for top executives as had been the case in Old Economy companies since the 1950s, but also for a broad base of non-executive personnel became a distinctive feature of New Economy firms. For example, Cisco Systems, which grew from about 200 employees at the time of its IPO in 1990 to 38,000 employees in 2001, awarded stock options to all of its employees, so that by 2001 stock options outstanding accounted for over 14 per cent of the company's total stock outstanding. Since Cisco did hardly any of its own manufacturing—another distinctive characteristic of many New Economy "systems integrators"—the people in the skill base to whom these options were awarded were almost all highly educated employees who were potentially highly mobile on the labor market.

Besides using their own stock as a compensation currency, during the 1990s some New Economy companies grew large by using their stock, instead of cash, to acquire other, smaller and typically younger, New Economy firms in order to gain access to new technologies and markets. Cisco mastered this growth-through-acquisition strategy; from 1993 through 2002 Cisco made seventy-eight acquisitions (forty-one of which were during 1999–2000, the peak years of the New Economy boom), with stock providing the currency for over 98 per cent of the total value of these acquisitions.

At the same time Cisco conserved cash by paying no dividends, a mode of financial commitment that also distinguished New Economy from Old Economy companies. As a result, Cisco's astonishing growth in the 1990s occurred without the company taking on any long-term debt. Nevertheless, with the bursting of the New Economy bubble from mid-2000, Cisco spent billions of dollars repurchasing its own stock to support its sagging stock price (Carpenter et al. 2003). Even during the boom, when stock prices were rising, the extent to which New Economy companies issued stock to make acquisitions and compensate employees meant that some of them spent billions of dollars on stock repurchases; during 1997–2000, for example, Intel's stock repurchases totalled $18.8 billion and Microsoft's $13.4 billion. By way of comparison, over these years Intel's total expenditures on R&D were $14.2 billion, while Microsoft's were $11.2 billion.

As in the cases of Intel, Microsoft, and Cisco, by the end of the twentieth century a number of New Economy companies had grown to be formidable growing concerns (Lazonick 2004). In 2002 the top 500 US-based companies by sales included twenty ICT firms founded no earlier than 1965 that had been neither spun-off from nor merged with an Old Economy firm. These twenty companies had revenues ranging from $35.4 billion for Dell Computer to $3.0 billion for Computer Associates International, with an average of $10.4 billion. Their headcounts ranged from 78,700 for Intel to 8,100 for Qualcomm, with an average of 30,084, up from an average for the same twenty companies of 6,347 in 1993. Nine of these twenty companies (and seven of the top ten) were based in Silicon Valley, another two in Southern California, and the other nine in eight states around the country. Compaq Computer, the forty-sixth largest US company in 2001 with $33.6 billion in sales and 70,950 employees, would have been high up on this list in 2002 had it not been acquired by Hewlett-Packard.

Many of these large New Economy companies have become important contributors to the patenting activity of US-based corporations. Samuel Kortum and Josh Lerner (2000) have shown that in the first half of the 1980s a sharp decline in patenting by US corporations was counterbalanced by a massive increase in early-stage venture-capital disbursements. But from the last half of the 1980s patenting picked up again, in part because it became important to the competitive strategy of high-growth New Economy firms. In 2001 Intel was eighteenth in the number of US patents issued to all companies, and seventh among US-based companies. Ahead of Intel were not only Old Economy companies such as IBM, Lucent Technologies, General Electric, and Hewlett-Packard but also two much smaller, but still sizeable, New Economy semiconductor companies, Micron Technology, founded in 1978 in Idaho, in fourth place, and Advanced Micro Devices (AMD), founded in Silicon Valley in 1969, in fourteenth place. In 2002 AMD was the 535th largest US company by sales and had 12,146 employees, while Micron was 554th and employed 18,700.

Innovative New Economy companies have tended to grow large by upgrading and expanding their product offerings within their main lines of business, and thus far at least have not engaged in the indiscriminate diversification into unrelated technologies and markets that characterized, and ultimately undermined the performance of, many leading Old Economy companies in the 1960s and 1970s. At the same time, New Economy companies have become less vertically integrated than Old Economy companies because equipment manufacturers such as Cisco, Dell, and Sun Microsystems have focused their investment strategies on activities that require organizational learning in their core competencies, while outsourcing activities that, as is the case with semiconductor fabrication, are too expensive and complex to be done in-house, or, alternatively, as is the case with printed circuit board assembly, have become routine. Some of the largest ICT companies in the United States are upstream electronics components suppliers, most of which are New Economy firms. Among the top 1000 US companies by sales in 2002 were eleven semiconductor companies, with a total employment of 212,354, ranging from Intel with its 78,700 employees to Nvidia (a specialist producer of graphics processors founded in 1993) with 1,513 employees. The world's five largest contract manufacturers—Flextronics, Solectron, Sanmina-SCI, Celestica, and Jabil Circuit—to whom equipment manufacturers outsource the mass production of printed circuit boards and other components, employed a total of 260,000–270,000 people at the beginning of 2003.

The severe downturn in the ICT industries in 2001 and 2002 raised questions about the sustainability of the New Economy model. A major weakness of the New Economy model lay in the huge personal gains, often amounting to tens of millions and even hundreds of millions of dollars, that top executives could reap from stock-based rewards in a volatile stock market. When stock prices were rising, executives had strong personal incentives to allocate resources (or give the appearance of doing so) in ways that encouraged the speculative market. Many of these allocative decisions undermined the innovative capabilities of the firms over which these executives exercised control (Carpenter et al. 2003). When stock prices began falling, the same executives had strong personal incentives to cash in quickly by selling stock, so that they made immense fortunes (in most instances without breaking the law) even as their companies lost money and, in many cases, struggled to survive (Gimein et al. 2002).

A major problem for some of these companies was the way in which the use of stock as a combination and compensation currency in the New Economy boom affected the role of the stock market as a source of cash (O'Sullivan 2003). Seventy years earlier, in the stock market boom of the late 1920s, US corporations had sold stock at speculative prices to pay down debt or bolster their treasuries, thus making them less financially vulnerable when the boom turned to bust. In the boom of the late 1990s corporations did not take advantage of the speculative market by selling stock; if anything, these companies purchased stock to support their already inflated stock prices. While employees, and particularly high-level executives, benefited from these stock price increases, their companies were weakened financially, as became painfully evident for many ICT companies from mid-2000 when the stock market turned down.