

Innovation: A Guide to the Literature

By Jan Fagerberg¹,
Centre for Technology, Innovation and Culture,
University of Oslo

October 12, 2003

Abstract

Innovation is not a new phenomenon. Arguably, it is as old as mankind itself. However, in spite of its obvious importance, innovation has not always got the scholarly attention it deserves. This is now rapidly changing, however. As shown in the paper, research on the role of innovation economic and social change has proliferated in recent years, particularly within the social sciences, and often with a bent towards cross-disciplinarity. It is argued that this reflects the fact that no single discipline deals with all aspects of innovation, and that in order to get a comprehensive overview of the role played by innovation in social and economic change, a cross-disciplinary perspective is a must. The purpose of the paper is to provide the reader with a guide to this rapidly expanding literature. In doing so it draws on larger collective effort financed by the European Commission (the TEARI project, see <http://tikpc51.uio.no/teari/teari.htm>), one of the outputs of which will emerge as *Oxford Handbook of Innovation*, edited by Jan Fagerberg, David Mowery and Richard R. Nelson.²

Paper to be presented at the Workshop “The Many Guises of Innovation: What we have learnt and where we are heading”, Ottawa, October 23-24.2003, organized by Statistics Canada.

¹ I wish to thank my fellow editors and contributors to the TEARI project for helpful comments and suggestions. Thanks also to Ovar Andreas Johansson, who has assisted in the research and to Sandro Mendonca for his many creative inputs (which I unfortunately not have been able to follow to the extent that he deserves). The responsibility for remaining errors and omissions is mine. Financial support from the European Commission (HPSE-CT-2002-60052) and the Norwegian Research Council (projects 131468/510 and 139867/510) is gratefully acknowledged.

² References to publications “in this volume” refers to draft reports for the TEARI project, that eventually will be published in the new Oxford Handbook of Innovation.

Introduction

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 try them out in practice. Without it the world in which we live would have looked very, very different. Try for a moment to think of a world without airplanes, automobiles, telecommunications and refrigerators, just to mention a few important innovations from the not too distant past. Or – in an even longer perspective – where would we be without fundamental innovations such as agriculture, the wheel, the alphabet, printing etc.?

In spite of its obvious importance, innovation has not always got the scholarly attention it deserves. For instance, students of long-run economic change used to focus on other factors, such as capital accumulation or the working of markets, rather than innovation. This is now rapidly changing, however. Research on the role of innovation 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, in recent years the number of social-science publications focusing on innovation has increased much faster than total number of such publications. As a result our knowledge about innovation processes, their determinants and social and economic impact is greatly enhanced. The purpose of this paper is to provide the reader with a guide to this rapidly expanding literature

(FIGURE 1 APPR. HERE)

(BOX 1 APPR. HERE)

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). The name of the centre illustrates the tendency for innovation studies to develop under 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 last decade(s) a number of new research centres and departments have been founded focusing on the role of innovation in 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. Economics, for instance, has traditionally primarily dealt 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, firm and networks, the working of which is studied within disciplines such as sociology, organizational science, management and business studies. The way innovation is organized also undergoes important changes through time, as underscored by a

lot of work within 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.

The next section addresses some conceptual issues related to innovation and its role in social and economic life, followed, in section three, by a closer focus 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. The fourth section outlines this “systems perspective” on innovation studies and discusses the role of institutions, organizations and actors in this process at the national and regional level. Section five explores the diversity in how such systems work over time and across different sectors or industries. Finally, the sixth section examines the broader social and economic consequences of innovation and the associated policy issues, followed by a discussion of the state of the art in this area and the future research agenda.

What is innovation?

An important distinction is normally made between invention and innovation.³ Invention is the first occurrence of an idea for a new product or process. Innovation is the first commercialization of the idea. 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 carrying them out in practice. First of all, while inventions may be carried out anywhere such as, for instance, in universities, innovations occur mostly in firms in the commercial sphere. 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,⁴ e.g., the person or organizational unit responsible for combining the factors necessary (what the innovation-theorist Joseph Schumpeter (see Box 2) called the “entrepreneur”), may be quite different from that of the inventor.

(BOX 2 APPR. HERE)

Long lags between invention and innovation may also 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

³ 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 each other. 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 across the globe has progressed.

⁴ 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, and to use both definitions simultaneously may easily lead to confusion. It might therefore be preferable to use terms such “imitator” or “adopter” for such cases.

vital inputs or complementary factors are not (yet!) available. For instance, although Leonardo da Vinci is reported have had some quite advanced ideas for an airplane, these were impossible to carry out in practice due to 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.⁵ 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 its first commercialization, through 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, p.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 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 be classified according to “type”. Schumpeter (see Box 2) distinguished between five different types; new products, new methods of production, new sources of supply, 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, p. 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, respectively.⁶ The argument for focusing particularly on the distinction between product and process innovation often rests on the assumption that the 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 more 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

⁵ 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).

⁶ 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 refer to different types of knowledge (and, hence, challenges for the firm).

more 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.⁷

The focus on product- and process innovations, while useful for the analysis of some issues, should not lead us to ignore other important aspects of innovation. For instance, many of the innovations that, during the first half of the twentieth century, 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, 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,⁸ also included arrangements across firms such as 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 there took place 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 the existing setup (Freeman and Soete 1997). From this perspective continuous improvements of the type referred to above are often characterized as “incremental” or “marginal” innovations,⁹ 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 would lead to a biased view on long run economic and social change (Lundvall et al. 1992). 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 does exactly the same 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. However, 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. 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, or what is sometimes called “technology transfer”, and may be best classified as such (imitation). 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 3), many economically significant innovations occur while a product or process is diffusing (see also Hall in this volume).

⁷ 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 in this volume.

⁸ Schumpeter 1934, p. 66.

⁹ 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).

Introducing something in a new context often implies considerable adaptation (and, hence, marginal 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 3 APPR. HERE)

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 why 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 it 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 reaped the potential economic reward). In practice, Schumpeter argued, these two aspects meant that the standard behavioural rules economists used to assume, e.g., surveying all information, assessing it and finding the “optimal” choice, wouldn’t work. Other, quicker ways had to be found. This did in his view involve leadership and vision, two qualities he associated with entrepreneurship. The third 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 innovation 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, p. 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 account 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 is seen as (partly) endogenous. However, in reality, most innovations involve teamwork and take place within larger organizations (Lam in this volume). Thus, Schumpeter, especially in his early works (what is sometimes called “Schumpeter Mark I”), failed to take the organizational dimension properly into account. In later work he acknowledged this weakness, and emphasized the importance of “co-operative” entrepreneurship in big firms (so-called “Schumpeter Mark II”), without analysing the phenomenon in 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 agrees with Schumpeter’s emphasis on uncertainty (Nelson and Winter 1982, Nonaka and Takeuchi 1995 and Van de Ven et al. 1999). In particular for potentially

¹⁰ Kim and Nelson (2000) suggest the term “active imitation” for producers, who – by imitating already existing products – modify and improve these.

¹¹ For instance, in one 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 personell” (Schumpeter 1949/1989, p. 328)

rewarding innovations, it is argued, one may simply not know what the most relevant sources or the best options to pursue are (not to say how great the chance is to succeed).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 path. 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, it has been argued, 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

Hence, “openness” to new ideas, solutions, etc. is considered essential for innovation projects, especially in its early phases. The principle 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 in these factors within a given system, the greater the scope for new combinations of these factors, that is, new innovations, and the more complex (and sophisticated) these innovations will be. This evolutionary logic has, for instance 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 on 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 closely monitor 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 other firms 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 Pavitt, Powell and Grodal, Narula and Zanfei, all in this volume).

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 for instance 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, p.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, p. 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.

Thus, 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. These problems arguably reflect 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 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 commercially exploit these innovations, primarily because they did not seem to be of much value in 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 allows the firm to mobilize its entire knowledge base when confronting new challenges (Nonaka and Takeuchi 1995, Lam in this volume). Such organizing does not stop at the gate of the firm, however, 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 “weak ties” (Granovetter 1973). Partners linked together with strong ties, either directly, or indirectly via a common partner, may self-organize into (relatively stable) networks (see Powell and Grodal in this volume). 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).

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, p.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 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 in this volume) but, to a varying degree, 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 (labour force). To explore the technological dynamics, its various phases, and how this influences and is influenced by the wider social, institutional and economic framework has been the main focus of this type of analysis. Another important approach in the innovation-systems literature has focused at the spatial level, and used national or regional borders to distinguish between different systems. For example, Lundvall (1992) and Nelson et al (1993) have both 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 coined the notion “regional innovation systems” (see Asheim and Gertler 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 have proven to be influential among policy makers in this area, especially in Europe (see Lundvall in this volume).

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.¹⁵ Is the potential for communication and interaction through existing linkages sufficiently exploited? Are there potential linkages within the system that profitably might be established? Such questions apply of course for 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 gears 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 towards ignoring 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 is for 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 that innovation activities become 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, 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 often is 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 also have to do with lack of proper infrastructure, finance, skills etc. For instance, some of the most important innovations of this century, such as electricity and automobiles (Mowery and Rosenberg 1998, Bruland and Mowery in this volume), were dependent on very extensive infra-structural investments (wiring and

¹⁵ This is essentially what was suggested by Porter (1990).

roads/distribution-system for fuel, respectively). Moreover, to fulfil the potential of the new innovation, such investments often need to be accompanied by radical changes in the organisation of production and distribution (and, more generally, attitudes, see Perez 1983, 1985 and Freeman and Louca 2001). There are important lessons from this 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 is that it may require extensive infra-structural investments and/or organisational and social change to succeed. If so, the firm needs to think through how 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.

How innovation differs

One of the striking facts about innovation is its variability over time and space. It seems, as Schumpeter (see Box 2) used to point out, to “cluster”, not only in certain sectors but also in certain areas and time periods. Over time the centres of innovation have shifted from one sector, region and country to another. For instance, for a long period the worldwide centre of innovation was in the UK, and the productivity and income of its population increased relative to its neighbouring countries, so that by the mid nineteenth century it was fifty percent higher than elsewhere. Around the turn of the century the centre of innovation, at least in modern chemical and electrical technologies of the day, shifted to Germany. For a long time now the worldwide centre of innovation has been in the USA, which during most of the last century has 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 exploitation of economies of scale and scope (Chandler 1962, 1990) and mass production and distribution

How is this dynamics to be explained? Schumpeter, extending an earlier line of argument dating back to Karl Marx,¹⁶ 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 - that “swarm” the industry or sector with the hope of sharing the benefits (with the result that the initial innovator’s first mover advantages becomes quickly eroded). This “swarming” of imitators implies that the growth of the sector or industry in which the innovation occurs for a while will be quite high. Sooner or later, however, the effects on growth (created by an innovation) will be depleted and growth slow down.

To this essentially Marxian story Schumpeter added an important modification. Imitators, it was argued, are much more likely to succeed in their aims if they improve on the original innovation, e.g., become innovators themselves. This is all the more natural, Schumpeter argued, 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 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, pp. 100-101). Schumpeter, as is well

¹⁶ See Fagerberg 2002, 2003 for a discussion of this “Marx-Schumpeter” model.

known, looked at this dynamics as possible explanatory factor behind business cycles of various lengths (Freeman and Louca 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,¹⁷ 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 by stages, characterized by changing conditions of composition (and location of production).¹⁸ 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).

BOX 4. APPR. HERE

BOX 5. APPR. HERE

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 had 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,¹⁹ with considerable differences across industrial sectors in the way this dynamics is shaped. As exemplified by the taxonomy suggested by Pavitt (see Box 4), exploration of such differences (“industrial dynamics”) has evolved into one of the main areas of research within innovation studies (see the chapters by Malerba, VonTunzelmann/Acha and Miles in this volume). Inspired, to a large extent, by the seminal work by Nelson and Winter (see Box 5), research in this area has explored how industries and sectors differ in terms 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 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) won’t work equally well everywhere

¹⁷ See Fagerberg (1996), Wakelin (1997) and Cantwell in this volume for overviews of some of this literature.

¹⁸ For a more recent analysis in this spirit, with a lot of empirical case-studies, see Utterback (1994).

¹⁹ 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 2002, ch. 14).

The Marx-Schumpeter model was not, however, primarily intended as a model of industrial dynamics (and differences in such across industries, sectors and time). 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 would fail), and (2) that innovations, e.g., “new combinations” of existing knowledge and resources, open up possibilities for new business opportunities, and innovations, in the future, 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, may be because it did not lead itself easily to formal, mathematical modelling of the type that had become increasingly popular in that field. More recently, however, economists (Romer 1990), drawing on new tools for mathematical modelling, have attempted to introduce some of the above ideas in formal growth models (so-called “new growth theory” or “endogenous growth theory”).²⁰

In applying this perspective, Schumpeter (1939) was, as noted, particularly concerned with the tendency of innovation 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 world-wide during the 1970s led to renewed attention, and several contributions emerged, viewing long run economic and social change from this perspective. For instance, both Mensch (1979) and Perez (1983, 1985) 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 its 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 (Freeman and Louca 2001), the relationship between technological, organisational and institutional change continues to be an important research issue (Freeman and Louca 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 Borrás 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 have 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 labelled “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, p. 262).

A weakness of much of this work was that it was based on a very stylised representation of the global distribution of innovation, in which innovation was assumed to be concentrated in the developed world, mainly in the USA. However, as shown by Fagerberg

²⁰ For an overview, see Aghion and Howitt (1998). See also the discussion in Fagerberg (2002, 2003) and Verspagen in this volume.

and Godinho in this volume, 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 “why growth-rates differ”; innovation, imitation and other efforts related to the commercial exploitation of technology, as driving forces of growth. The inclusion of innovation in the explanatory framework, alongside the more conventional variables, significantly increased the model’s explanatory power. For instance, the analysis presented in Fagerberg (1988) 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 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.

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:

- Innovation introduces novelty (variety) into the economic sphere. Should the stream of novelty (innovation) dry up, the economy will settle down in a “stationary state” with little or no growth (Metcalf 1998). Hence, innovation is crucial for long-run economic growth.
- Innovation tends to cluster in certain industries/sectors, which consequently grow more rapidly, leading to structural changes in production and demand and, eventually, organisational and institutional change. The capacity to undertake the latter is important for the ability 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 activities towards leader-levels (see Godinho and Fagerberg in this volume).

Because of these desirable consequences, policy-makers and business-leaders alike are concerned with how 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.²¹ 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 design and evaluation of policy. However, 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 problem making it difficult to improve our understanding is that innovation has been studied by different communities of researchers with different backgrounds. 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. This can only be improved by bringing these different communities together in a constructive dialogue. Different, and to some extent competing, perspectives should not always be seen as a problem, however. Many social phenomena are too complex to be analyzed properly from a single disciplinary perspective. Arguably, innovation is a prime example of this.

References

- Aghion, Philippe and P. Howitt 1998. *Endogenous Growth Theory*, Cambridge, Mass.: The MIT Press
- Ancori, B., A Bureth and P. Cohendet (2000) The Economics of Knowledge: The Debate about Codification and Tacit Knowledge, *Industrial Dynamics and Corporate Change* 9: 255-287
- Arthur, W. B. (1994) *Increasing Returns and Path Dependency in the Economy*, Ann Arbor: The University of Michigan Press
- Braczyk, H.J. et al. (1998) *Regional Innovation Systems*, London: UCL Press
- Carlsson, B, and R. Stankiewicz (1991) On the Nature, Function and Composition of Technological Systems, *Journal of Evolutionary Economics* 1: 93-118
- Chandler, A.D. (1962) *Strategy and Structure: Chapters in the History of the American Industrial Enterprise*. Cambridge, M.A.: MIT Press.
- Chandler, A.D. (1990) *Scale and Scope: The Dynamics of Industrial Capitalism*, Harvard University Press.
- Cohen, W. (1995) Empirical Studies of Innovative Activity, in P. Stoneman (ed), *Handbook of the Economics of Innovation and Technological Change*, Oxford: Blackwell, pp. 182-264
- Cohen, W. and Levinthal, D. (1990) Absorptive Capacity: A New Perspective on Learning and Innovation, *Administrative Science Quarterly*, 35:123-13
- Cowan, R., P. A. David and D. Foray (2000) The Explicit Economics of Knowledge Codification and Tacitness, *Industrial Dynamics and Corporate Change* 9: 211-253
- Diamond, J. (1998) *Guns, Germs and Steel: A Short History of Everybody for the Last 13000 Years*, London: Vintage
- Dosi, G. (1988) Sources, Procedures and Microeconomic Effects of Innovation, *Journal of Economic Literature* 26: 1120-71

²¹ 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).

- Dosi, G., Freeman, C., Nelson, R., Silverberg, G. and Soete, L. G. (eds.) (1988) *Technical Change and Economic Theory*, London: Pinter
- Edquist, C., L. Hommen, and M. McKelvey (2001) *Innovation and Employment, Process versus Product Innovation*, Cheltenham: Elgar
- Fagerberg, J. (1987) A Technology Gap Approach to Why Growth Rates Differ, *Research Policy* 16: 87-99
- Fagerberg, J. (1988) "Why Growth Rates Differ," in Dosi, Giovanni et al. (eds.), *Technical Change and Economic Theory*, London: Pinter, pp. 432-457
- Fagerberg, J. (1996) Technology and Competitiveness, *Oxford Review of Economic Policy* 12: 39-51
- Fagerberg, J. (2000) "Vision and Fact: A Critical Essay on the Growth Literature", in Madrick, J. (ed.), *Unconventional Wisdom, Alternative Perspectives on the New Economy*, The Century Foundation, New York pp. 299-320
- Fagerberg, J. (2002) *Technology, Growth and Competitiveness: Selected Essays*, Cheltenham: Edward Elgar
- Fagerberg, J. (2003) Schumpeter and the revival of evolutionary economics: An appraisal of the literature, *Journal of Evolutionary Economics*, forthcoming
- Fagerberg, J., and B. Verspagen (2002), Technology-Gaps, Innovation-Diffusion and Transformation: An Evolutionary Interpretation, *Research Policy*, 31: 1291-1304
- Freeman, C. (1987) *Technology policy and economic performance: Lessons from Japan*, London: Pinter
- Freeman, C., J. Clark and L. G. Soete (1982) *Unemployment and Technical Innovation: a Study of Long Waves and Economic Development*, London: Pinter
- Freeman, C. and L. Soete (1997) *The Economics of Industrial Innovation*, Third Ed., London: Pinter
- Freeman, C. and F. Louca (2001) *As Time Goes By. From the Industrial Revolutions to the Information Revolution*, Oxford: Oxford University Press
- Granovetter, M. (1973) The Strength of Weak Ties, *American Journal of Sociology*, 78: 1360-1380
- Granstrand, O., Patel, P. and Pavitt, K. (1997) Multi-technology Corporations: Why They Have 'Distributed' rather than 'Distinctive Core' Competencies, *California Management Review*, 39: 8-25.
- Henderson, R.M. and Clark, R.B. (1990). 'Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms'. *Administrative Science Quarterly*, 29: 26-42.
- Hobday, M. (2000) East versus Southeast Asian Innovation Systems : Comparing OEM- and TNC-led Growth in Electronics, in L. Kim and R.R. Nelson: *Technology, Learning & Innovation: Experiences of Newly Industrializing Economies*, Cambridge: Cambridge University Press, pp. 129-169
- Hughes, T.P. (1983) *Networks of Power, Electrification in Western Society 1880-1930*, Baltimore: The Johns Hopkins University Press
- Kim, L. and R.R. Nelson (2000) *Technology, Learning & Innovation: Experiences of Newly Industrializing Economies*, Cambridge: Cambridge University Press, pp. 13-68
- Kline, S.J. and N. Rosenberg (1986) "An Overview of Innovation", in R. Landau and N. Rosenberg (eds) *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, Washington D.C.: National Academy Press, pp. 275-304
- Krugman, P. (1979) A model of innovation, technology transfer and the world distribution of income, *Journal of Political Economy* 87: 253-266
- Lundvall, B. Å. (1988) Innovation as an Interactive Process: from User-Producer Interaction to the National System of Innovation, in Dosi, G. et al. (eds.), *Technical Change and Economic Theory*, London: Pinter, pp. 349-369
- Lundvall, B. Å. (1992) *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Pinter
- Malerba, F. and L. Orsenigo 1997. Technological Regimes and Sectoral Patterns of Innovative Activities, *Industrial and Corporate Change* 6: 83-117
- Malerba, F., R.R. Nelson, L. Orsenigo and S. G. Winter (1999) "History-friendly" Models of Industry Evolution: The Computer Industry, *Industrial Dynamics and Corporate Change* 8: 1-36
- Mensch, G. (1979) *Stalemate in Technology*, Cambridge, Mass: Ballinger Publishing Company
- Metcalf, J. S. (1998) *Evolutionary Economics and Creative Destruction*, London: Routledge

- Mowery D. and N. Rosenberg (1998) *Paths of Innovation, Technological Change in 20th-Century America*, Cambridge, UK: Cambridge University Press
- Nelson, R.R. and S.G. Winter (1982) *An Evolutionary Theory of Economic Change*, Cambridge, Mass: Harvard University Press
- Nelson, R.R. (ed.) (1993) *National Systems of Innovation: A Comparative Study*, Oxford: Oxford University Press
- Nonaka, I. and H. Takeuchi (1995) *The Knowledge Creating Company*, Oxford: Oxford University Press
- Pavitt, K. 1984. Patterns of Technical Change: Towards a Taxonomy and a Theory, *Research Policy*, 13, 343–74.
- Porter, M. E. (1990) The Competitive Advantage of Nations, *Harvard Business Review* 68: 73-93
- Perez, C. (1983) Structural Change and the Assimilation of New Technologies in the Economic and Social system, *Futures* 15: 357-375
- Perez, C. (1985) Micro-electronics, Long Waves and World Structural Change, *World Development* 13: 441-463
- Posner, M. V. (1961) International Trade and Technical Change, *Oxford Economic Papers* 13: 323-341
- Rogers, E. (1995) *Diffusion of Innovations 4th.ed.*, New York: The Free Press
- Romer, P.M. (1990) Endogenous Technological Change, *Journal of Political Economy* 98: S71-S102
- Rosenberg, N. (1976) *Perspectives on Technology*, New York: Cambridge University Press
- Rosenberg, N. (1982) *Inside the Black Box: Technology and Economics*, New York: Cambridge University Press
- Schmookler, J. (1966) *Invention and Economic Growth*, Cambridge, Mass: Harvard University Press
- Schumpeter, J. (1934) *The Theory of Economic Development*, Cambridge, Mass: Harvard University Press
- Schumpeter, J. (1939) *Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process* (2vol), New York: McGraw-Hill
- Schumpeter, J. (1943) *Capitalism, Socialism and Democracy*, New York: Harper
- Schumpeter, J. (1949) Economic Theory and Entrepreneurial History, Change and the Entrepreneur, pp. 63-84, reprinted in Schumpeter, J. (1989) *Essays on Entrepreneurs, Innovations, Business Cycles and the Evolution of Capitalism*, edited by Richard V. Clemence, New Brunswick, N.J.: Transaction Publishers, pp. 253- 231
- Schumpeter, J. (1954) *History of Economic Analysis*, New York: Allen & Unwin
- Shionoya, Y. (1997) *Schumpeter and the Idea of Social Science*, Cambridge, UK: Cambridge University Press
- Soete, L. (1987) The Impact of Technological Innovation on International Trade Patterns: the Evidence Reconsidered, *Research Policy* 16: 101-130
- Swedberg, R. (1991) *Joseph Schumpeter: his Life and Work*, Cambridge, UK: Polity Press
- Tidd, J. J. Bessant and K. Pavitt (1997) *Managing Innovation: Integrating Technological, Market and Organizational Change*, Chichester: John Wiley & Sons
- Tushman, M.L. and Anderson, P. (1986). 'Technological Discontinuities and Organizational Environments'. *Administrative Science Quarterly*, 31/3: 439-465
- Utterback, J.M. (1994) *Mastering the Dynamics of Innovation*, Boston: Harvard Business School Press
- Van de Ven, A., D.E.Polley, R. Garud and S. Venkataraman (1999) *The Innovation Journey*, New York: Oxford University Press
- Vernon, R. (1966) International Investment and International Trade in the Product Cycle, *Quarterly Journal of Economics* 80: 190-207
- Von Hippel, E. (1988) *The Sources of Innovation*, New York: Oxford University Press
- Wakelin, K. (1997) *Trade and Innovation: Theory and Evidence*, Cheltenham: Edward Elgar
- Walker, W.B. (1979) *Industrial Innovation and International Trading Performance*, Greenwich: JAI Press

BOX 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 background from subjects as different as economics, sociology, psychology and engineering. SPRU developed its own cross-disciplinary master and PhD 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 system-approach to the role of innovation in long run economic and social change. Freeman later followed this up through 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 PhD graduates).

In many ways SPRU came to serve as a role model for the many centres/institutes that were established, mostly from the mid 1980s onwards, combining cross-disciplinary graduate and PhD teaching with extensive externally funded research. Most of these, as SPRU itself, were located to 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.

BOX 2. THE INNOVATION THEORIST JOSEPH SCHUMPETER

Joseph Schumpeter (1883-1950) is one of the most original social scientists of the 20th century. He grew up in Vienna around the turn of the century and studied law and economics there. 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-first-war (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 on until his death. He published several books and papers in German early on, among these the “Theory of Economic Development”, published in German 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” (1942) 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, exploitation of new markets and new ways to organize business. He defined innovation as “new combinations” of existing resources. This combinatory activity he labelled “the entrepreneurial function” (to be fulfilled by “entrepreneurs”) to which he attached a lot of importance. One main reason for this was the prevalence of inertia, or “resistance to new ways” as he phrased it, at all levels of society that entrepreneurs had to fight to succeed in their aims. In his early work, what is sometimes called “Schumpeter Mark I”, Schumpeter focused mostly at 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 forwards 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. Not 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) and Fagerberg (2003)

BOX 3 WHAT INNOVATION IS NOT: THE LINEAR MODEL

Sometimes it is 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 erroneous view on 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 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 reconsideration of earlier steps, and this may eventually lead to totally new innovations.

BOX 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 to classify 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 high, medium and low R&D intensity in production (or value added), either directly (in the industry itself) or also including R&D embodied in machinery and other types of input. 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, metal products and so on (Fagerberg, 2002).

However, while organized R&D activity is an important source of innovation in contemporary capitalism, it is not the only one. A sole focus on R&D 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 also took these other factors into account. Based a very extensive data-set on innovation in the UK, 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 labelled “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), it too 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 a lot across industries/ sectors. This obviously called into question technology or innovation policies that only focused on one mechanism, such as, for instance, subsidies to R&D.

BOX 5. INDUSTRIAL DYNAMICS – AN EVOLUTIONARY INTERPRETATION

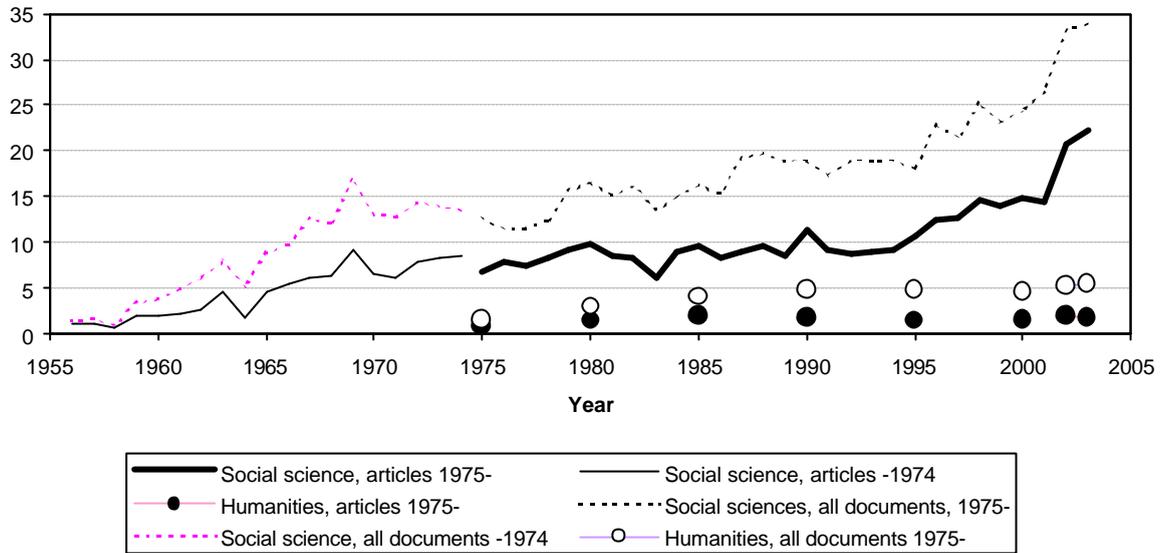
The book “An Evolutionary Theory of Economic Change” (1982) by Richard Nelson and Sidney Winter is one of the most important contributions to the study of innovation and long run economic and social change. Nelson and Winter share the Schumpeterian focus on “capitalism as an engine of change”. However, 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, firm’s actions are guided by routines, which are reproduced through practise, as parts of the firm’s “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 search for a new one, which - if it satisfies the criteria set by the firm – will eventually be adopted (so-called “satisficing” behaviour).

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 look at 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 behaviour etc.). For instance, they distinguish between an “innovation regime”, in which the technological frontier is assumed to progress independently of firm’s 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.

Figure 1. "Innovation" in Title

Articles/ all documents, share in 10 000 (Social Sciences Citation Index, SSCI and Arts & Humanities Citation Index, A&HCI)



Note: The source is the ISI Web of Knowledge. Both Social Sciences Citation Index (SSCI) from 1956 to present and Arts & Humanities Citation Index (A&HCI) from 1975 to present were included. For each database, a search has been done, for the number of (i) articles and (ii) all documents (including articles) in English, and the total number of publications in each database, from the year 1975 to present. The results are presented as shares of total articles/documents. Before 1975, also non-English articles/documents were included in the calculations, so the numbers from that period are not strictly comparable to those for later years.