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Innovation – a New Guide

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Abstract

There is no shortage of syntheses or overviews on specific topics within innovation studies. Much more rare are attempts to synthesize the syntheses, i.e., cover the entire area of innovation studies, emphasize the achievements that have been made, discuss the implications for policy and point to developments that require further research. The introductory chapter "Innovation: A Guide to the literature" in The Oxford Handbook of Innovation (2004) was an attempt to do just that. However, as a guide it is by now a bit out of date. This paper is an attempt to update and extend it, taking into account lessons from new research on the development of innovation studies - and the knowledge base underpinning it - as well important additions to this knowledgebase from the last decade. A more elaborate discussion of innovation policy, including its theoretical underpinnings and what it may achieve, has also been added.

Acknowledgments

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Contents

1. 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 to 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 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, printing, etc.?

However, in spite of its obvious importance, innovation has not always received the scholarly attention it deserves. Indeed, until the early 1960s scholarly publications on innovation were few and far between. The main exception to this rule was the work of the Austrian-American social scientist Joseph Schumpeter. Working in the early days of social science, he combined insights from economics, sociology and history into a highly original approach to the study of long run economic and social change, focusing in particular on the crucial role played by innovation and the factors influencing it. Nevertheless, Schumpeter's life-long advocacy for seeing innovation as the driving force behind economic and social change seemed almost a lost cause at the time of his death in 1950. Instead, the economics literature increasingly came to be dominated by highly mathematized, static, equilibrium exercises of the type that Schumpeter admired but held to carry little promise for improving our understanding of long run technological, economic and social change.

"Innovation studies" may be defined as the study of how innovations emerge and diffuse, what factors influence these processes (including the role of policy) and what the social and economic consequences are. The origins of the field date back to the early post Second World War period, when researchers, mainly in the US and the UK, started to address questions concerning the roles played by innovation and diffusion for economic and social change.[1] Actors outside academia, public as well as private, were often instrumental in making this happen (see e.g. Clausen et al. 2012). An important event in the field's development was the formation in 1966 of the Science Policy Research Unit (SPRU) at the newly founded University of Sussex in the UK, which under the leadership of its first director, Christopher Freeman, developed into a global hub for the emerging field (see Box 1). The name of the centre illustrates the tendency for innovation studies to develop under other 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, but also the notions used to characterize the area, changed. During the decades that followed, a number of new research centres and departments were founded, focusing on the role of innovation in economic and social change and associated policy matters. As SPRU, many of these had a multi and inter-disciplinary orientation.

[1] An important contribution from the early years of the field's existence was the collective volume "The Rate and Direction of Inventive Activity" published by NBER and edited by Richard Nelson (Nelson 1962, ed.). See Fagerberg and Verspagen (2009) and Fagerberg et al. (2011) for more information on the origins of the field.

BOX 1. SPRU, FREEMAN AND INNOVATION STUDIES

SPRU – Science Policy Research Unit – at the University of Sussex, UK was founded in 1966 with Christopher Freeman (1921-2010) as its first director. Freeman had previously worked for the OECD on research and development (he was the author of the OECD's "Frascati Manual" which set the standards for R&D statistics). An economist by training, Freeman realized that the study of science, technology and innovation in the economy required a stronger theoretical foundation, and this he increasingly found in Schumpeter's work. Freeman was an ardent believer in multi-and interdisciplinarity, and from the very beginning SPRU had a multi-disciplinary research staff with backgrounds in subjects as diverse as economics, sociology, psychology, and engineering. SPRU developed its own interdisciplinary master's and PhD programs and carried out externally funded research, much of which focused on the role of innovation in economic and social change. It attracted a large number of young scholars from other countries, and SPRU served as a role model for the many centres/institutes within Europe and Asia that were established, mostly from the mid 1980s onwards, combining multi- and inter-disciplinary graduate and PhD teaching with extensive externally funded research.

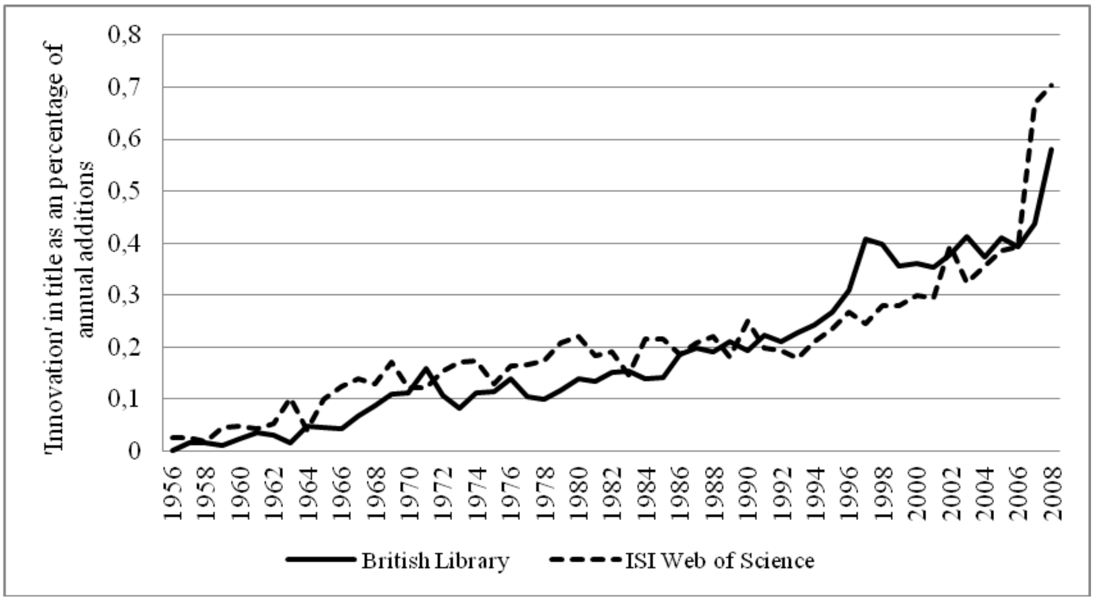
The research initiated at SPRU led to a large number of projects, conferences, and publications. "Research Policy", which became the central academic journal in the field of innovation studies, was established in 1972, with Freeman as the first editor (he was later succeeded by Keith Pavitt, also from SPRU). An important initiative in the early phase was the SAPPHO project, focusing on factors explaining success or failure in innovation (Rothwell et al. 1974). Freeman's influential book "The economics of industrial innovation", drawing to a large extent on the lessons from the SAPPHO project, was published in the same year. In 1982, after he had stepped down as director, the book "Unemployment and Technical Innovation", written by Freeman, Clark, and Soete, appeared, introducing a systems approach to the analysis of the role of innovation in long run economic and social change. Freeman later followed this up with an analysis of the "national innovation system" in Japan (Freeman 1987), the first published work to use that term. Freeman's last major book, focusing on how to understand and study long-run growth (Freeman and Louçã, 2001), appeared in 2001, the year he turned 80.

Further reading:

Fagerberg, J., Fosaas, M., Bell, M., Martin, B.R., 2011. Christopher Freeman: Social science entrepreneur. Research Policy 40, 897-916.

Figure 1 reports the number of publications with innovation in the title as a share of total annual additions to the catalogue of the British Library (mostly books) and the ISI Web of Science (mostly journal articles) from 1956 onwards. As shown in the figure, in the beginning there were very few publications on the subject, at least as far as indicated by their titles. However, since that time the number of publications with innovation in the title has increased steadily as a share of the annual additions, with a particularly sharp rise in recent years.

Figure 1. Growth of the literature on innovation



Source: Fagerberg, Fosaas and Sapprasert (2012)

The growth of the community associated with research in this area also led to the creation of several new journals, conferences and professional associations. “Research Policy” was as mentioned established in 1972. More recent additions to the publication outlets in this area include for example Technovation (1981), Industrial and Corporate Change (1992) and Industry and Innovation (1993). A professional association honouring Schumpeter’s name, The International Schumpeter Society (ISS), founded in 1986, hosts an international conference every two years for scholars working in the Schumpeterian tradition. The Technology and Innovation Management Division (TIM) of the (American) Academy of Management, which meets annually, was formed in 1987. The Danish Research Unit for Industrial Dynamics (DRUID), initially a relatively local Danish affair, has since 1995 hosted an annual conference with broad international participation. A more recent initiative is the GLOBELICS network, which since 2003 has organized annual conferences on issues related to innovation and development. Hence, towards the turn of the millennium, the field of innovation studies was relatively well established, with a substantial core literature (see section 5) and a set of journals and professional associations.

A few 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. However, as indicated by Figure 1, since then the literature on innovation has grown much larger and it has become more difficult to get a good overview and understanding of the accumulated knowledge in this area. The demand for good syntheses and up to date overviews has from the early 1990s onwards has led to the publication of several so-called handbooks on innovation or aspects thereof, consisting of overviews of specific subfields of innovation research. Thus, there is no shortage of syntheses or overviews on specific topics within innovation studies. But attempts to “synthesize the syntheses", i.e., cover the entire area of innovation studies, emphasize the achievements that have been made, discuss the implications for policy and point to developments that require further research, are rare. The present author is only aware of a few such attempts, the most recent of which is the introductory chapter "Innovation: A Guide to the literature" in The Oxford Handbook of Innovation from 2004. However, so much has happened in this field since the paper was written that as a guide it is out of date. This paper is an attempt to update and extend that guide based on new research on the development of innovation studies as a scientific field - and the knowledge base underpinning it - as well as additions to this knowledge base during the last decade.

The structure of the paper is as follows. The next section, entitled "What is innovation," presents some basic concepts and discusses their interrelationships. This is followed, in section 3, by a discussion of three main topics in innovation research, at the micro, meso and macro level, respectively: innovation in firms; innovation systems; and consequences of innovation for social and economic change. Section 4 focuses on innovation policy, broadly defined, and the extent to which it can help in dealing with contemporary challenges. The most important contributions to innovation literature are presented in section 5. The final section considers the implications for the future agenda of the field.

Finally a word of caution: As every experienced traveller should know, a guide is just a (hopefully helpful) tool when entering a new territory, not a substitute for the actual travel. The same caution applies to reading - this guide is by no means a substitute for the original works surveyed. Moreover, although a broad range of topics is covered, some issues (or contributions) that other scholars perhaps would attach great importance too, may only be dealt with very briefly if at all. The reader is therefore well advised also to consult other sources. [2]

2. What is Innovation?

An important distinction, attributed to the innovation-theorist Joseph Schumpeter, is between invention and innovation. Invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out in practice. To be able to turn an invention into an innovation, the innovator normally needs to combine several different types of knowledge, capabilities, skills and resources. For instance, production knowledge, skills, facilities, market knowledge, a well-functioning distribution system, sufficient financial resources, and so on may be required. It follows that the role of the innovator, i.e., the person or organizational unit responsible for combining these required factors (what Schumpeter called the "entrepreneur"), may be quite different from that of the inventor.

[2] The handbooks mentioned above would be a good start. For a list see http://www.innoresource.org/handbooks/.

BOX 2 THE INNOVATION THEORIST JOSEPH SCHUMPETER

Joseph Schumpeter (1883-1950) was one of the most original social scientists of the 20th 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 a politician, serving briefly as finance minister in the first post-First-World-War (socialist) government of Austria, 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 remained until his death.

Very early in his scholarly writings, he developed an original approach, focusing in particular on the crucial role of innovation for economic and social change. In so doing he distanced himself from the (then) emerging neoclassical strand of economics, because it in Schumpeter's own words assumed that "economic life is essentially passive … so that the theory of a stationary process constitutes really the whole of theoretical economics … I felt very strongly that this was wrong, and that there was a source of energy within the economic system which would of itself disrupt any equilibrium that might be attained" (Schumpeter 1937/1989, p. 166). It was this 'source of energy', innovation, that he wanted to explain.

In Schumpeter's early writings, what is sometimes called "Schumpeter Mark I", he focused mostly at individual entrepreneurs as the driving force for innovation, while in later works he also emphasized the importance of innovation in large firms (so-called "Schumpeter Mark II"). He published several books and papers in German early on, among these the "Theory of Economic Development", published in 1912 and in a revised edition in English in 1934, which presents the main aspects of his theory. Among his most well-known later works are "Business Cycles" in two volumes (from 1939), focusing on the tendency for innovations to "cluster" in certain industries and time periods (and the derived effects on growth, e.g., so-called "long waves" in the world economy), and "Capitalism, Socialism and Democracy" (1942) which among other things discusses the extent to which the capitalist system and its institutions can survive in the longer run. The way we analyse innovation today, including its causes and impacts, and the terms that are used in such analyses, are significantly influenced by Schumpeter's works.

Further reading:

There is a large literature on Schumpeter. The first of the two references below focuses on Schumpeter's life and the second on his works:

McCraw, T.K., 2007. Prophet of Innovation: Joseph Schumpeter and Creative Destruction. Belknap Press of Harvard University Press, Cambridge, Mass.

Andersen, E.S. 2011. Joseph A. Schumpeter: A Theory of Social and Economic Evolution, Palgrave Macmillan, Basingstoke and New York

For a short introduction to Schumpeter's works (and those of his followers) see Fagerberg (2003).

History is replete with cases in which the inventor of major technological advances fails to reap the profits from his or her breakthroughs. Although invention and innovation occasionally are closely linked, to the extent that it is hard to distinguish one from another (biotechnology for instance), in many cases there is a considerable time lag between the two. In fact, a lag of several decades or more is not uncommon. Such lags reflect the different requirements for working out ideas and implementing them. Long lags between invention and innovation may also have to do with the fact that some or all of the conditions for commercialization may be lacking. There may not be a sufficient demand (yet!) or it may be impossible to produce and/or market because some vital inputs or complementary factors are not (yet!) available. For instance, 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 suitable 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. As this example shows, many inventions require complementary inventions and innovations to succeed at the innovation stage.

Thus, what we think of as a single innovation is often the result of a lengthy process involving many interrelated innovations. 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, p.283)

Innovations are commonly classified according to "type". Schumpeter 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. In economics, most of the focus has been on the two first of these. 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. However, 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, many of the innovations that, during the first half of the twentieth century, made it possible to for the United States to "forge ahead" of other capitalist economies, were of the organizational kind (Bruland and Mowery 2004). Many of these affected the distribution of manufactured products, with great consequences for a whole range of industries.

Another approach, also based on Schumpeter's work, has been to classify innovations according to how radical they are (see Freeman and Soete 1997). From this perspective, continuous improvements are often characterized as "incremental" or "marginal" innovations, as opposed to "radical" innovations (such as the introduction of a totally new type of machinery in a specific industry) or "technological revolutions" (consisting of a cluster of innovations that together may have a very far-reaching impact in a whole range of industries or the economy as a whole). In recent writings on the subject the latter type is often called "general purpose technologies" (GPTs, see e.g., Lipsey et al. 2005). Schumpeter focused in particular on the latter two categories, e.g., radical innovation and technological revolutions, which he believed to be of greater importance. It is a widely held view, however, that the cumulative impact of incremental or marginal innovations may be just as great (if not greater), and that to ignore these would lead to a flawed understanding of long run economic and social change. In fact, the realization of the economic benefits from "radical" innovations in many if not most cases (including those of the airplane and the automobile) required a series of incremental improvements.

Innovation may strengthen - or threaten - existing business models or markets for existing products. Schumpeter used the notion "creative destruction" to characterize the process through which innovation, especially when of the market creating and/or organizational type, "revolutionizes the structure from within, incessantly destroying the old one, incessantly creating the new one." (Schumpeter 1942, p. 83). More recently, Christensen (1997, 2003) has suggested the term "disruptive innovation" for innovations that through the exploitation of new markets or market niches gradually undermine the position of existing business models. The fate of firms such as Eastman Kodak, Nokia, or Digital Equipment suggests that innovation retains considerable potential to upend existing industries or markets.

A further distinction is between innovation and imitation. The latter is the replication of an innovation and is of great social and economic significance. Without imitation the social and economic impact of innovation would matter much less (if at all). However, the distinction between innovation and imitation, although clear enough in theory, is often difficult to draw in practice. This partly has to do with the fact that something that is well known in one context may be new in another context. For example, 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? A common practice, to some extent based on Schumpeter's work, is to reserve the term innovator for A and characterize B as an imitator. But one might also argue that it would be correct 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 definition adopted by the European Union's Community Innovation Survey (CIS, see Smith 2004). Moreover, 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. Therefore, innovation studies focus not only on how innovations occur, but also on how innovations spread (or diffuse), through imitation or by other means, and the feedback from this process on innovation activity.

BOX 3. ZVI GRILICHES: A PIONEER IN THE STUDY OF DIFFUSION OF INNOVATIONS

Zvi Griliches (1930-1999) was born in Lithuania, sent to the Dachau concentration camp during the 2nd World War and afterwards lived briefly in Palestine before coming to the USA as a graduate student in agricultural economics. He finished his education with a PhD in economics at the University of Chicago in 1957 which was the basis for his most famous work, "Hybrid Corn: an Exploration in the Economics of Technological Change", published as an article in Econometrica in the same year. This article, which pioneered the use of logistic diffusion curves to analyse of the spread of new technology, was later to be followed by many others on a variety of topics. However, Griliches continued to place emphasis on issues related to innovation and diffusion of technology and its role for economic growth. Among the topics he focused his attention on were the analysis of patent and R&D data, social versus private returns to R&D, spillovers, the effects of investments in education and the sources of economic growth (see, e.g., Griliches 1979, 1990, 1992). As a young man Griliches was a strong believer in the explanatory power of traditional neoclassical economics and among other things believed that the famous "residual" in growth accounting – which had been attributed by Robert Solow (1956, 1957) and others to technological progress – could be eliminated altogether if only proper methods were used. Later in life he retreated from that position - characterizing it as "youthful recklessness" (Griliches 2000, p. 23) - and emphasized the need to better take into account phenomena such as "increasing returns to scale, R&D spillovers and other externalities and disequilibria" (ibid). He also pointed out that "if we want to understand better what we are talking about, where technical change is actually coming from, we will need to study history." (ibid, pp. 89-90).

Further reading:

Diamond A. (2004) Zvi Griliches's contributions to the economics of technology and growth, Economics of Innovation and New Technology 13: 365-397

Griliches, Z. (2000) R&D, Education and Productivity: A Retrospective, Harvard University Press, Cambridge (Mass)

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3. Innovation Research: Micro, Meso and Macro

The preceding section provided some basic building blocks for the development of an understanding of innovation and its role in society. This section goes a bit more into depth on three important issues on the micro, meso and macro level, respectively, that are central to contemporary innovation studies. These are:

- the making of innovations (in firms and organizations),

- innovation systems (relations between firms, customers, suppliers, the public R&D infrastructure etc.), and

- the impact of innovation on social and economic change (the consequences for growth, competitiveness, employment etc.)

It should be noted that the discussion necessarily is very brief and cannot do full justice to the existing scholarly literature. Moreover, although much work in this area may fall within these three areas, not everything will. Readers are therefore encouraged to also consult other relevant sources, such as the handbooks mentioned earlier. The implications for policy will be discussed in more detail in the next section.

3.1. The making of innovations

"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).

A fundamental question for innovation research is to explain how innovations occur. Arguably, 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 thereby reap the potential economic reward). In practice, Schumpeter argued, these two aspects meant that the standard behavioural rules commonly assumed by economists, 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.

In Schumpeter's early work (what is sometimes called "Schumpeter Mark I") innovation is the outcome of continuous struggle between individual entrepreneurs, advocating novel solutions to particular problems, and social inertia. Although this may, to some extent, have been an adequate interpretation of events in Europe around the turn of the century, during the first decades of the twentieth century it became clear to observers that innovations increasingly involve teamwork and take place within larger organizations. In later work, Schumpeter acknowledged this and emphasized the need for systematic study of "co-operative" entrepreneurship in big firms (so-called "Schumpeter Mark II"). However, he did not analyse the phenomenon in much detail, although he strongly advised others to (Schumpeter 1949/1989, p. 271). Systematic theoretical and empirical work on innovation-projects in firms (and the management of such projects) was slow to evolve, with the possible exception of the work of the US business historian Alfred Chandler (Box 4). But especially during the last few decades a quite substantial literature has emerged.

BOX 4. INNOVATION IN LARGE FIRMS: THE PERSPECTIVE OF ALFRED CHANDLER

Alfred Chandler (1918-2007) was a leading American business historian who took up the challenge left by Schumpeter with respect to understanding innovation activities in large firms. Chandler did extensive research on a number of large US, Japanese, and European companies. His main thesis, set out in his two main books (Chandler 1962, 1977), was that the potential for higher productivity made possible by the advent of the scale-intensive technologies of the "Second Industrial Revolution" required extensive organizational innovation and investment to be realized. Only companies –and countries (Chandler 1990) – that managed to do this were in his view able to reap the full benefits of the new technologies. Chandler's work arguably foreshadowed (and inspired) much of the later work on (firm level) "capabilities", and became highly influential in business history, management, organizational studies and innovation studies.

Further reading:

David J. Teece (2010) Alfred Chandler and «capabilities» theories of strategy and management, Industrial and Corporate Change 19(2): 297-316

From "routines" to "dynamic capabilities"

A very important theoretical contribution to the literature on innovation in firms is the book "An Evolutionary Theory of Economic Change" from 1982. The authors, the American economists Richard Nelson and Sidney Winter (see Box 5), agree with Schumpeter that the fundamental uncertainty and complexity involved in innovation mean that the standard "rational man" approach to decision making will not work. Rather, what firms do, according to Nelson and Winter, is to base their decision-making on "routines" for dealing with problems. These routines help to define what the firm is capable of doing, i.e., its "capabilities", a much used term in the subsequent literature. For example the Korean development scholar Lin-su Kim uses the term "technological capability" to analyse of the rise of Korean firms such as Samsung. He defines it as "the ability to make effective use of technological knowledge in efforts to assimilate, use, adapt and change existing technologies. It also enables one to create new technologies and to develop new products and processes…" (Kim 1997, p. 4).[3] Three layers of technological capability are identified; the ability to organize production efficiently and deliver products of sufficient quality (production capability), the capacity to venture into new areas (investment capability) and – finally – the ability to create new products and processes (innovation capability). Another much used term - initially suggested by David Teece and co-authors (1997) – is "dynamic capabilities", defined as "the skills, procedures, organizational structures and decision rules that firms utilize to create and capture value" (Teece 2010a, p. 680).

[3] It may be noted that the definition of "technological capability" by Kim is quite similar to that of "absorptive capacity" by Cohen and Levinthal (1990), to be discussed later.

BOX 5. RICHARD NELSON AND THE REVIVAL OF EVOLUTIONARY ECONOMICS

Richard Nelson (b. 1930) is perhaps the most influential theorist on innovation in the world today. An economist by education he worked for the RAND Corporation in the 1950s and 1960s. During this period he published a series of articles on the economics of R&D (Nelson 1959), economic growth and other topics in American (mainstream) economics journals. Nelson became a professor at Yale University in 1968 and stayed there for twenty years before he moved on to Columbia University. It was during his time at Yale that Nelson together with his colleague Sidney Winter developed a new "Evolutionary Theory of Economic Change" which led to a series of articles and a book with the same name published in 1982. In this book Nelson and Winter criticize traditional economic theory for basing itself on an unrealistic view on what humans are able to do. Humans, they argue, are simply not able to calculate the consequences of all possible actions and choose between them in the way economists usually assume: the world is too complex, the volume of information too large and the cognitive abilities of humans - and the organizations in which they take part - too limited to allow for this type decision-making. What organizations -including firms - actually do, according to Nelson and Winter, is to practice a simpler and less demanding type of decision-making called "bounded" or "procedural" rationality, based on "routines" that are reproduced (and modified) through practice and stored in the firm's "organizational memory" or "knowledge" (as guidelines for its activities). This new theory, based on a combination of Schumpeter's work and the behavioural theories of Herbert Simon and others (Simon 1947, Cyert and March 1963), explains how firms' "organizational knowledge" evolves, influences and is influenced by economic dynamics at the level of the industry and the entire economy. The book – and the theory - has been hugely influential, but less so in economics than in management, organizational studies and, of course, in innovation studies. Nelson has also played an important role as a network builder (and leader) within the emerging field of innovation studies among other things through his long-time collaboration with other central scholars in this area, such as Christopher Freeman and Nathan Rosenberg, and through a series of international research projects (often leading to edited volumes or special issues). It was a project of this kind that led to the second of his most well known publications, "National Innovation Systems" from 1993, the first book to systematically compare national innovation systems in different countries.

Uncertainty, path-dependency and "lock in"

Another central topic in the literature has to do with the 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 a superior path exists, which some other firm equipped with more patience (or luck) happened to find, the early mover may be in big trouble because it may simply be too costly or too late to switch paths. Therefore, it has been suggested 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 (Nonaka and Takeuchi 1995 ,Van de Ven et al. 1999).

Openness

Hence, "openness" to new ideas, solutions, etc. is essential for innovation and many firms have learnt, by necessity, to search widely for new ideas, inputs and sources of inspiration. It is sometimes argued that 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. Arguably, cultivating the capacity for absorbing (outside) knowledge, so-called "absorptive capacity" (Cohen and Levinthal 1990), is a must for innovative firms, large or small. The importance of "open innovation" is also emphasized by Chesbrough (2003) and, with a particular focus on the role of users, by von Hippel (2005). 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 may hold even for results from development projects ordered and financed by the firm itself. Xerox, for instance, financed research on both the PC and the mouse, but failed to exploit commercially these inventions, primarily because they did not seem to be of much value to the firm's existing photo-copier business (Rogers 1995).

3.2. Innovation systems

"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)

Innovation does not occur in a vacuum. To succeed innovation processes require participation from many different actors and inputs from a multitude of different sources. Some of these are private, others are public. When such patterns of interactions (or networks) take on a certain element of stability, it is common to use the term "innovation system" (see Edquist 2004 for an overview).

A central question is how to define the output of the system. Is it innovation in a narrow sense, e.g. new products, processes and so on, or does it also include the diffusion and use of innovations? The most common choice is the latter, i.e., a broad perspective. The reasons for this choice are twofold. First, what matters economically is not innovation as such but the changes in production and consumption it gives rise to. Second, as pointed out earlier, innovation, diffusion and use are interrelated phenomena, with feedbacks back and forth between the different phases. Employing a narrow perspective, i.e., not including diffusion and use, would not only exclude what matters most economically but also make it more difficult to understand the innovation dynamics.

A related issue is how the boundaries of a system are to be decided. How do we know what should be included in the system in contrast to being part of, say, its environment (or other systems)? Edquist (2004) argues for a holistic perspective, including everything that influences the output of the system. Markard and Truffer (2008) criticize this for failing to distinguish between factors that influence each other, and therefore should be considered as part of the system, and other factors that may have an impact on the system but are not affected by it, which they see as external parameters. However, social systems are generally full of feedback effects, and totally excluding the possibility of such feedback may be difficult (if not impossible) in most cases. Arguably, the most relevant question may not be whether a feedback effect exists or not, but how important it is (i.e., its strength) and how much time it takes for the effect to run its course. Therefore it is advisable (at least initially) to follow Edquist's suggestion and try to map all relevant factors. Without it one may easily end up making biased inferences about the working of various factors (including policies).

Different types of innovation-systems

The innovation systems approach may be applied at different levels of aggregation. One approach has been to delineate systems on the basis of technological, industrial, or sectoral characteristics (Hughes 1983; Carlsson and Stankiewicz 1991; Malerba 2004) 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), and so on. To explore the technological dynamics, 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 work. In recent years this approach has among other things been exploited in studies of the prerequisites for the transition from a carbon-based to more sustainable economic system (Jacobsson and Bergek 2004, Bergek et al. 2008).

Another 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 (1993) have used the term "national system of innovation" to characterize the systemic interdependencies within a given country, while Braczyk et al. (1997) similarly have offered the notion of "regional innovation systems" (see Asheim and Gertler 2004). 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 Borras 2004).

Nations (and regions) have a number of different sectors (and technological systems) within their borders. Innovation systems at different levels of aggregation therefore coevolve and influence each other (see Box 6.)

BOX 6. A COEVOLUTIONARY TALE: THE EMERGENCE OF A NORWEGIAN NATIONAL INNOVATION SYSTEM

A national system of innovation consists of firms in many different sectors operating within a common (national) framework. The sectoral composition of a given national economy therefore influences the operation and structure of its national innovation system, even as the national innovation system affects the performance of its constituent sectoral systems. Hence, the relationship between sectoral and national innovation systems is a co-evolutionary one.

Norway is a good example of this. Historically, the country's economy has been based on exploitation of natural resources, and this is still the situation today. Traditionally, Norway relied extensively on technologies from foreign sources, which were adapted to local conditions by technically trained individuals, many of whom had been educated abroad. Nevertheless, a national public research infrastructure evolved slowly in response to the needs of Norwegian firms and industries, particularly the established (and politically influential) industries of the 19th century, such as mining, fisheries and agriculture. A mining college had been founded already under Danish rule during the 18th century, and by the turn of the 20th century, Norway's primary industries lobbied successfully for the formation of public research institutes in agriculture and fisheries. However, only with the emergence of the large-scale, capital-intensive industries of the early twentieth century, based on the exploitation of Norway's cheap and abundant hydro-electrical energy, was Norway's first technical university (NTNU) established in 1910, nearly a century after neighbouring Sweden. Once established, NTNU became an important source of qualified personnel for industry. Norwegian university scientists and engineers became active in industrial consultancy in the first half of the 20th century, and during the following decades Norway's research institutes, many of which are public (or semi-public), expanded their operations.

By the mid-twentieth century, Norway's national innovation system had acquired many of its current features. Although Norwegian firms were innovative in many respects and demanded highly educated labour, they invested little in internal R&D. Instead they utilized "localized search" (Nelson and Winter 1982) in problem-solving, seeking technical knowledge from other firms, research institutes, public sources, academia etc. Thus, the dominant approach to innovation relied on interaction with other actors in the system, in combination with modest levels of investment in intra-firm R&D. When a new natural resource based sector - the oil and gas industry - emerged in the 1970s, it followed the same trajectory. Even today the strong tendency for Norwegian firms to engage with other partners in innovation, e.g., to pursue collaborative innovation strategies, combined with little "own R&D," distinguishes Norway's innovation system from that of many other developed economies. For example, 30-40% of the firms in several important Norwegian manufacturing industries report that they collaborate with public research institutes, which is high by international standards. Business R&D as a share of value added is one of the lowest in the developed world, however, less than one half of the level in the other Nordic countries.

Source: Fagerberg, J., D. C. Mowery and B. Verspagen (eds.) (2009) Innovation, Path Dependency and Policy: the Norwegian Case, Oxford: Oxford University Press.

System analysis

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. Is the potential for communication and interaction through existing linkages sufficiently exploited? Are there potential linkages within the system that might profitably be established?

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 (and that are costly or difficult to alter). 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 towards ignoring potentially fruitful avenues of exploration.

An important feature of systems that has come into focus is the strong complementarities that commonly exist between the parts of a system. If, in a dynamic system, one critical, complementary factor 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 often is a very considerable time lag between invention and innovation. However, such constraints need not be of a purely technical character (such as, for instance, the failure to invent a decent battery, which severely constrained the diffusion of electric cars for more than century), but may have to do with lack of demand, a proper infrastructure, finance, skills, etc. A central topic in applied work based on the innovation system approach, therefore, is the identification of factors (or processes) that hamper the dynamics of the system, and how such problems can be dealt with (Bergek et al. 2008). This is discussed in more detail in Section 4.

3.3. Innovation and social and economic change

"Like Alice and the Red Queen, the developed region has to keep running to stay in the same place" (Krugman, 1979, p. 262).

One of the striking facts about innovation is its variability over time and space. 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 its productivity (and income) level was fifty per cent 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 (2004), 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 1990).

Technological competition

How is this dynamic to be explained? Schumpeter, extending an earlier line of argument dating back to Karl Marx, held technological competition (competition through innovation) to be the driving force in economic development (see Fagerberg 2003). If one firm 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, if entry conditions allow, will "swarm" the industry or sector with the hope of sharing the benefits (with the result being that the initial innovator's first mover advantages may be quickly eroded). Imitators, Schumpeter argued, are much more likely to succeed in their aims if they improve on the original innovation, e.g., become innovators themselves. This simple scheme has been remarkably successful in inspiring applications in different areas (e.g., technology gap theory (Posner 1961); product cycle theory (Vernon 1966)). In spite of this, it had little influence on the economics discipline at the time of its publication, perhaps because it did not lend itself easily to formal, mathematical modelling of the type that had become popular in that field. More recently, economists (Romer 1990, Aghion and Howitt 1992), drawing on new tools for mathematical modelling, have attempted to introduce some of the above ideas into formal growth models (so-called "new growth theory" or "endogenous growth theory", see Verspagen (2004) for an overview).

Long waves

According to Schumpeter one (important) innovation tends to facilitate (induce) other innovations in the same or related fields. These systemic interdependencies between the initial and the induced innovations also imply, he argued, that innovations (and growth) "tend to concentrate in certain sectors and their surroundings" or "clusters" (Schumpeter 1939, pp. 100-101). Schumpeter saw this as a possible cause of business cycles of various lengths including so-called "long waves" in economic activity (with a duration of half a century or so). Although these ideas were not well received by the community of economists at the time, the big slump in economic activity world-wide during the 1970s led a to renewed attention, and several contributions emerged viewing long run economic and social change from this perspective. For example, both Mensch (1979) and Perez (1983, 1985) argued that major technological changes, such as, for instance, the ICT revolution (or electricity a century ago), require extensive organizational and institutional change to run their course (see also Freeman and Perez 1988). 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 in 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 Louca 2001), not the least with respect to discussions about how to achieve a transition from a carbon-based to a more sustainable economy (see, e.g., Geels 2002).

Technology gaps

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 (see Fagerberg 1994 for an overview). 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. However, 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 verified by several recent surveys of innovation in the developing part of the world, successful catch-up in technology and income is normally not based only on imitation, but also involves innovation to a significant extent (see Fagerberg, Srholec and Verspagen 2010).

Innovation and economic growth

Innovation is pervasive phenomenon that affects growth in all parts of the world. For example Fagerberg (1987) identified three factors affecting differential growth rates across countries: 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. The analysis suggested that superior innovative activity was the prime factor behind the huge difference in performance between Asian and Latin-American 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 (see Fagerberg et al. 2007 for more recent evidence). The research also indicated 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.

Technological and Social Capabilities

The capacity to develop and exploit knowledge commercially is as mentioned above often called "absorptive capacity" (Cohen and Levinthal 1990) or "technological capability" (Kim 1997). Successful catch up, however, does not only depend on technological achievements but also on broader social, institutional and political factors pertaining to the society in which a company operates, so called "social capability" (Abramovitz 1986) or "social capital " (Putnam 1993, Woolcock and Narayan 2000), which may be challenging to measure and hence include in empirical analysis. Nevertheless, in recent years several new sources of data, mostly based on surveys carried out by NGOs or intergovernmental organizations, have become available that in a better way reflect such factors, e.g., the extent of "red tape" for new businesses, the degree of corruption, the prevalence values conducive to innovation and diffusion (trust and tolerance for example), etc. This has led to new research confirming the importance of both technological and social capabilities for successful catch up and growth (Fagerberg and Srholec 2008, 2009; Fagerberg, Feldman and Srholec 2013).

4. Innovation, Policy and Societal Challenges

While innovation may be a fascinating topic in its own right, this is not the reason why most people - including policymakers - are interested in it. Rather what they are interested in is the beneficial effects that innovation is commonly believed to have, not only for the innovator and/or her immediate environment, but for the society as whole. Given that such societal benefits can indeed be assumed to exist, the natural question for policy-makers is how they can influence innovation through the creation, use and development of various policy "instruments" (Smits and Kuhlman 2004). However, it is important to note that the focus of policy, the terms used and the theories underpinning design and implementation of policy have changed considerably over time. For example, as pointed out in the introduction, while initially the focus was on science (and hence the term "science policy" was popular), later it shifted to technology (and "technology policy") and more recently innovation (with the associated term "innovation policy"), see Lundvall and Borras (2004) and Boekholt (2010) for more detailed treatments. As discussed below these shifts in focus also reflect changes in the way the workings of the society and the economy are understood.

4.1. Rectifying "market failure"

As pointed out earlier the interest for science, technology and innovation policy started in earnest in the aftermath of World War Two. In the early days the main focus was on progress in science and the role it might play in the economy. The dominating perspective was what has later been termed "the linear model" (see Box 7), which sees scientific progress as the main causal factor behind economic progress. The main challenge, according to this approach, is to achieve fast scientific progress, from which economic benefits can be assumed to follow more or less automatically. Problems associated with transforming scientific knowledge, mainly created in universities and research institutes, into innovation and economic value in the business sector are if not ignored assumed to be of relatively minor importance.

However, if science is the main factor behind creation of economic value, why do private firms not undertake the necessary investments themselves? This question was of course of concern to economists who were brought up to believe that self-regulating markets would create the best result for everybody. The explanation offered by them was that knowledge had "public good" properties that markets were not designed to take into account. For example, one actor's use of a body of knowledge would not preclude other actors from doing the same. However, from the economists' perspective the fact that other firms may benefit just as much or more, also implies that it may be difficult for a firm investing in the creation of new knowledge to recoup its investment, not to say earn a profit from it. Rational firms would therefore according to this reasoning tend to stay away from such investments, even if the potential benefits for society as a whole might be very large. Thus, in this case, a self-regulating market would fail to secure a socially optimal allocation of resources in the economy. For economists such "market failure" provides a justification for market interventions - or policy instruments - aiming at increasing investments in science in the economy towards the socially "optimal" level (Nelson 1959, Arrow 1962). Such interventions can take different forms, such as financing organizations dedicated to doing science (e.g., universities and research institutes), subsidizing research activities in private firms (with the hope that they will do more of it that they otherwise would) and attempts to change the rules of the game by, say, strengthening intellectual property rights (thereby forcing copycats to pay for the knowledge they use).

BOX 7. 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 in an influential paper (1986) that used the concept "the linear model" to characterize a widespread - but in their view 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 of 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 holds for only 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. Shortcoming and failures that occur at various stages may lead to reconsideration of earlier steps, and this may eventually lead to totally new innovations.

The "market failure" argument continues to be invoked as a rationale for public investments in science in modern capitalist societies. As commonly advanced, however, it does not provide much guidance on how much governments should spend on science (for example what the amount of public investment necessary for arriving at the "optimal" allocation of resources would be), nor does it provide a very accurate template for understanding the structure and priorities of government R&D spending (see Mowery, 2009). A more serious problem may be that it is not obvious that the argument holds much beyond basic science (and perhaps not always there either). It is particularly problematic in the case of private firms, because it is quite evident that the underlying premises of the theory: (1) that knowledge is very fluid (i.e., non-appropriable) and (2) that firms are omnipotent entities, endowed with full knowledge ("perfect information") about all potentially relevant factors related to its activities and capable of instantly processing all this information to arrive at the optimal choice, do not hold in practice. For example, it is well established that much economically useful knowledge is contextual in character, hard to identify, difficult to get access to and demanding and costly to absorb. Hence, high "fluidity"/ non-appropriability of knowledge may not be such a big hurdle for firms in most cases. In fact, the exact opposite, that knowledge is very "sticky" (von Hippel 1994), may be a much harder problem for firms. Moreover, far from being omnipotent, firms are as Nelson and Winter (1982) pointed out generally rather constrained in their abilities, and this holds in particular when trying to prepare for future developments, which tend to be clouded by genuine (or radical) uncertainty.[4] Such uncertainty may well prevent firms from investing in innovation, but this is again something the traditional theory would lead the analyst to not give much attention to (since it conflicts with the underlying premises).

4.2. Some "stylized facts"

Theoretical work, if it wants to be relevant for policy, has to be based on assumptions that are broadly consistent with the empirical facts. Therefore, from the 1960s onwards, the search for such "stylized facts" has been the "leitmotif" for a series of investigations into how firms perceive the conditions affecting their innovative activities (which policy may influence). An early attempt to do this, which came to have a lasting influence on how we look at innovation processes in firms, was as mentioned earlier the SAPPHO project at SPRU (Rothwell et al. 1974). Another important exercise of this kind, this time in the US, was the Yale survey (Levin et al. 1987). From 1991 onwards the European Union has carried surveys of firms' innovation activities and the factors that influence these (Community Innovation Survey,[5] CIS, see Smith 2004 for details). The empirical results generated by this empirical work are very consistent across different surveys and over time. In the following we are going to use some empirical results from the CIS survey to illustrate some of the "stylized facts" associated with innovation at the firm level that are relevant for discussions of innovation policy.

Figure 2 reports the answers from European firms about what the important sources of information for innovation are. The most important source is to be found within the firm itself. Among the external sources, the by far most important are customers and suppliers, followed by other firms in the same industry or sector. Public sources, such as conferences and journals, are also deemed to be of relevance. Universities and public research institutes figure towards the bottom of the list. Hence, there is not much support for the "linear model" in these data.

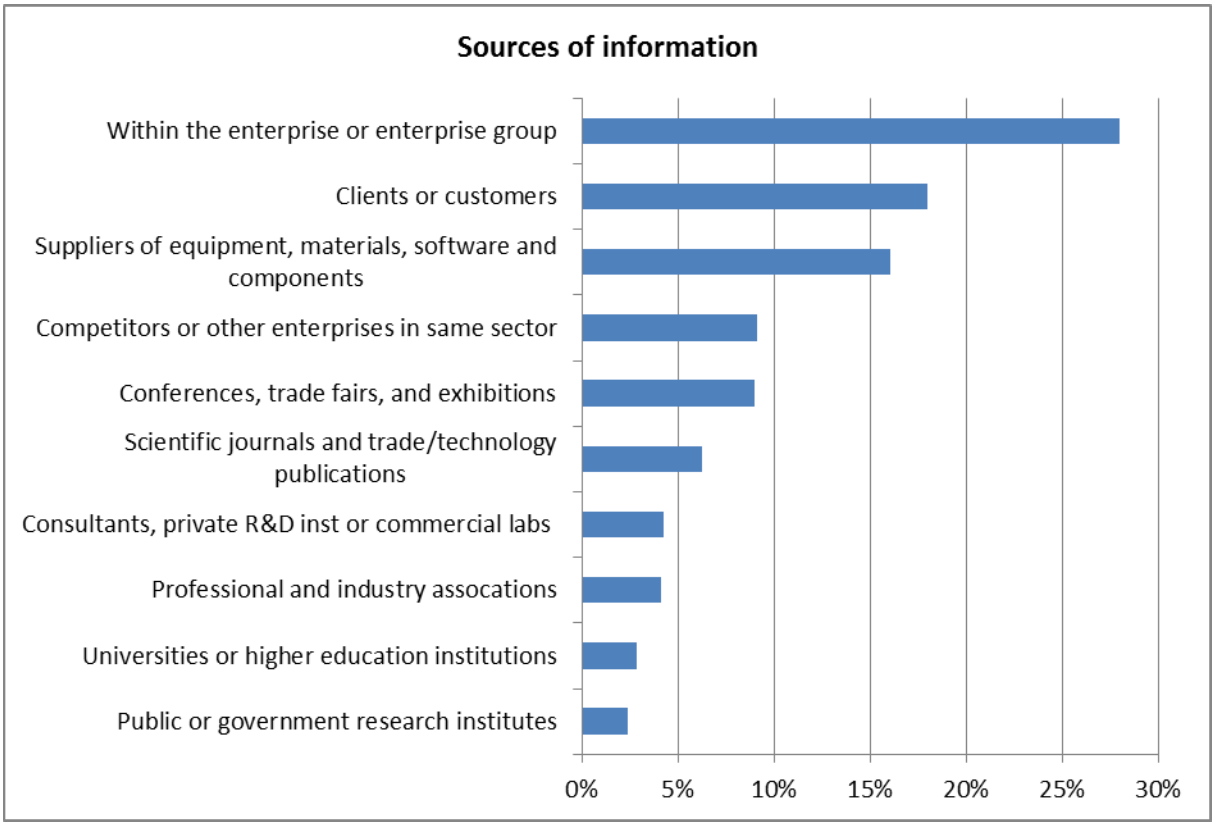
In figure 3 we move from sources of information to innovation cooperation. The picture is very much the same; the most important external partners for firms in innovation are, as for information, customers and suppliers (in reverse order though). Then follow other firms in the same enterprise group and consultants/private R&D labs. Albeit less frequent they do also cooperate with universities and public research institutes.

Figure 4 reports the answer to the question about which factors hamper innovation. The most frequent answer is that innovation costs are too high, followed by lack of qualified personnel, problems related to entering new markets and uncertainty with respect to demand. Lack of information on technologies and markets is deemed to be of less importance.

[4] Genuine or radical uncertainty has to be distinguished from risk. With risk there is probability for a certain outcome. In the case of genuine or radical uncertainty you simply don't know.

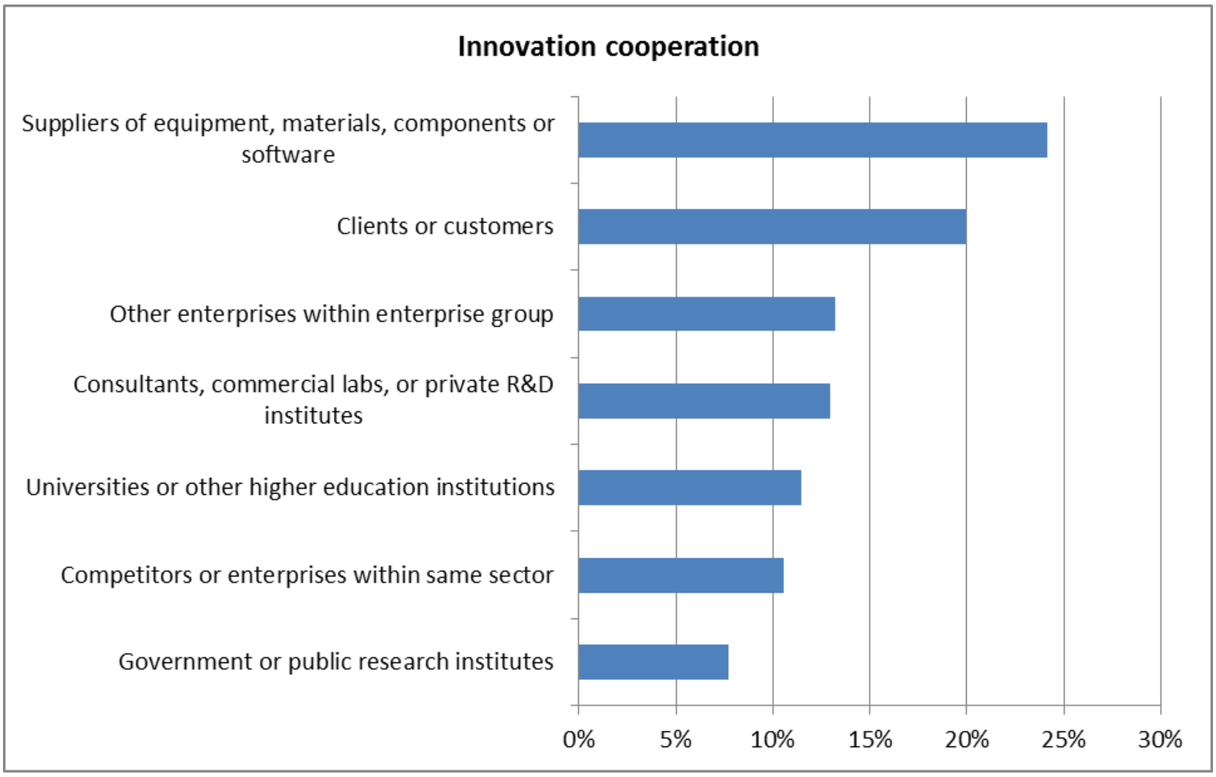
[5] The more recent versions of the European Union's Community Innovation Survey (CIS) typically include information from several hundred thousand firms in 20-30 European countries. However, the coverage may differ from one question to another and across different waves of the survey. For more information see http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Innovation_statistics

Figure 2. Important sources of information for innovation



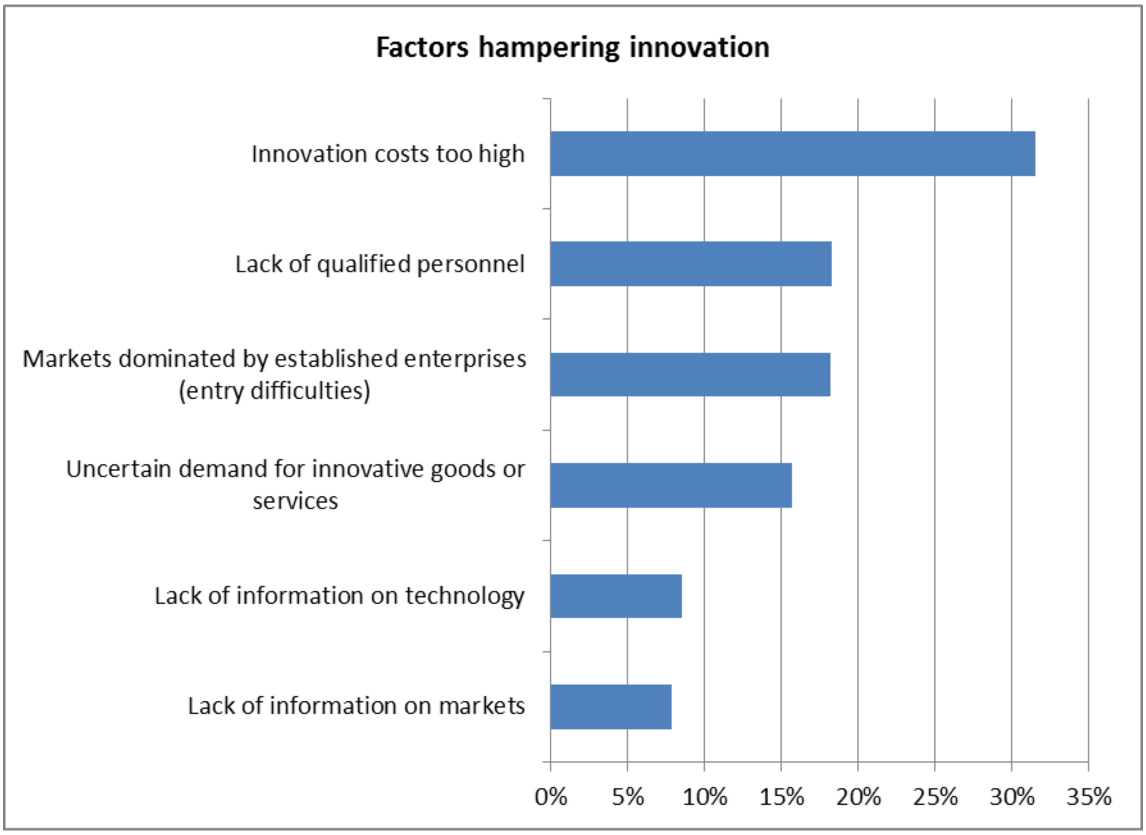
Source: Own calculations based on information from CIS 5 (2006)

Figure 3. Innovation Cooperation.



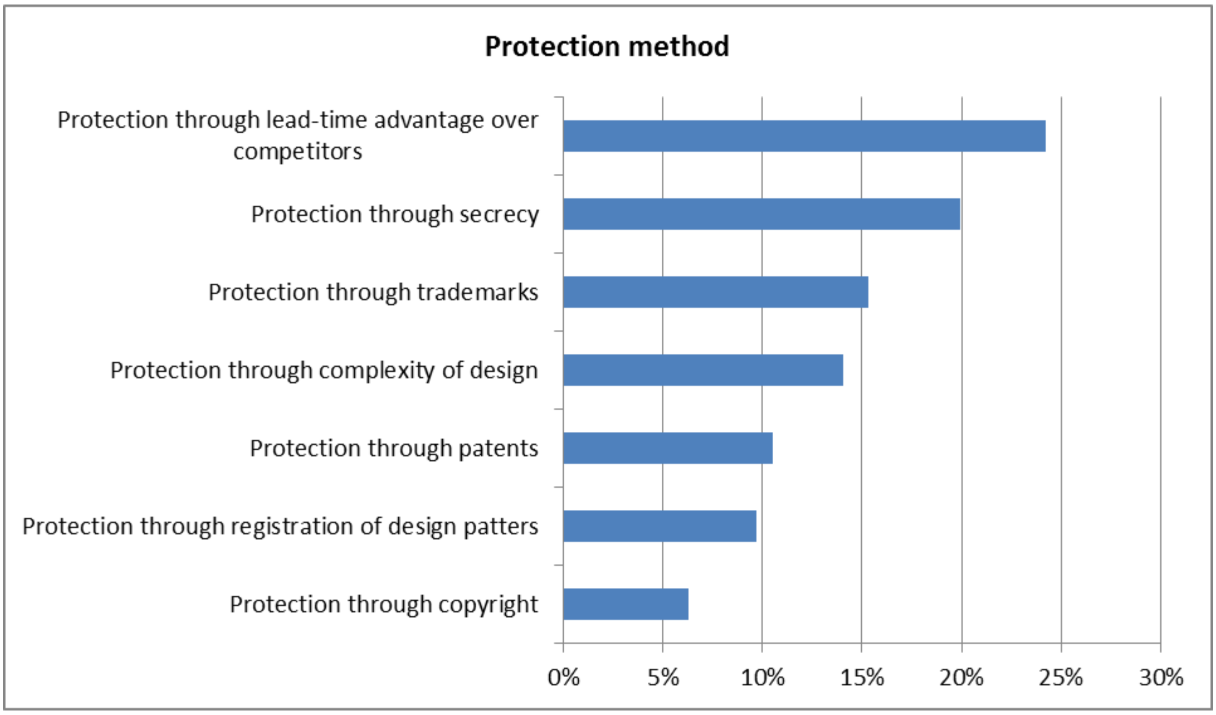
Source: Own calculations based on information from CIS 5 (2006)

Figure 4. Factors hampering innovation



Source: Own calculations based on information from CIS 5 (2006)

Figure 5. How to appropriate the benefits from innovation?



Source: Own calculations based on information from CIS 3 (2000)

Information about how firms go about to appropriate the benefits from their innovative activities is provided in Figure 5. The by far most used appropriation methods are lead-time and secrecy. Complexity of design is also listed as an important factor. Among the formal protection methods, trademarks are assessed to be the most important. Patent protection figures relatively low on the list, indicating that firms on average do not regard patents to be very important means for benefitting from innovation, something that is consistent with other research (Cohen 1995). However, it should be noted that the use of appropriation methods differs a lot across industries (patenting is for instance much more important in pharmaceuticals than the above average pattern would suggest).

These observations are consistent with the view that in most cases innovative firms do not regard fluidity of knowledge as a big hurdle, probably because many aspects of the technological capabilities they draw on are not so easily copied. To be first in the market with their new innovative solutions - keeping their competitive edge - is what matters most to them. The data also show that firms do not try to insulate themselves from their environments, jealously guarding their secrets, but on the contrary interact closely with external partners, among which customers and suppliers tend to be the most important. Hence, the central role of users for innovation, emphasized by several authors (Lundvall 1985, von Hippel 1988), is also confirmed by the CIS. There are good reasons for this state of affairs. For example, users are an important part of the selection environment for innovations. If they continue to be dissatisfied, the innovation will probably be selected against, as happen with many if not most attempted innovations. Moreover, users have intimate knowledge about the requirements that an innovation need to satisfy, and sharing the user's experiences may be of great value to the innovating firm.

BOX 8. MEASURING INNOVATION

Many are interested in measuring innovation in, say, a firm, industry, region or country and compare the resulting numbers with those of similar entities elsewhere. Such “benchmarking” may be useful for many purposes. However, innovations are inherently difficult to measure with precision.

One widely used approach has been to measure something else which is alleged to reflect innovation, the most common choice being patents (applications or grants). Although widespread this practice is problematic. First, patents are awarded for inventions, not innovations. Most inventions never make it to the innovation stage. Second, many important innovations are not patented or even patentable. This holds, for example, for organizational innovations, much innovation in so-called “low-tech” sectors and in the developing part of the world. Third, patenting is much more common in some industries, such as pharmaceuticals and biotechnology, than in other industries. Hence, in many cases, using a patent-based measure of innovation is likely to lead to a biased picture.

An alternative is to approach firms and ask questions about their innovation activities. This is basically the methodology applied in the Community Innovation Survey (CIS), which has been carried out in Europe since 1991. More recently this methodology has also been adopted by a number of non-European countries, some of which are developing (see Fagerberg, Srholec and Verspagen 2010). Although more relevant than counting patents, this approach also has its pitfalls. For example, there may be differences in sampling techniques, which can make comparisons across countries and over time problematic. Moreover, even if the question is intended to be the same, differences in language, culture, context etc., may lead firms that objectively are relatively similar to answer differently, further complicating comparisons. The interpretation of the results also depends on how innovation is defined in the survey (and whether or not the firms understand what is meant). The most common definition is something “new to the firm” rather than to the sector/industry or the world at large, which at least to some would sound more like imitation than innovation.

Hence, for these and other reasons, finding a good, reliable innovation “metric” that can be used to compare, say, countries and regions and over time remains a challenge. This does not mean that nothing valuable comes out of the innovation surveys. They contain a wealth of interesting information on how firms assess various factors affecting their innovation activity, which can enrich our understanding of it, as figures 2-5 illustrate.

Literature: Smith (2004), Fagerberg, Srholec and Verspagen (2010).

4.3. Dynamizing national innovation systems

It is clear from the preceding discussion that innovation is an interactive phenomenon, and for a theory to be helpful in shaping policy, it needs to take this into account. From the very beginning the contributors to the literature on national innovation systems,[6] e.g., Freeman (1987), Lundvall (1988, 1992), Nelson (1988, 1993) and others, made such interaction the hallmark of their approach.[7] Basing itself on Schumpeterian and evolutionary perspectives, the approach left little room for the idea of an "optimal" state towards which the system should be assumed to converge if only appropriate policies were applied. Rather the national innovation system is seen as the result of a long historical process characterized by coevolution between a country's industrial structure and its political system (Smits and Kuhlman 2004, Fagerberg et al. 2009, see also Box 6). As a result national systems of innovation may differ greatly, and a policy mix that works in one context may be totally inadequate in another. Adopting an innovation system approach, therefore, leads to a sceptical attitude towards policy advice that advocates the same solution everywhere independent of contextual differences (for example, the European Union's stated goal of raising R&D investments as a percentage of EU GDP to 3%).

The first empirical analyses of national innovation systems were descriptive in nature and focused on what the authors of the studies considered to be the main actors and their interrelationships (Nelson 1993). However, the authors of these national studies often approached the issue differently with the consequence that the studies were not directly comparable (Edquist 1997). Moreover, these studies often had a static perspective, focusing on the structure of the system at a particular point of time, rather than on its dynamics.

After the turn of the century the scholarly work on national innovation system took a new twist, with a sharper focus on the relationship between the output of the innovation system (its technological dynamics) and the factors influencing it (Liu and White 2001, Edquist 2004, Bergek et al. 2008). These factors have invariably been called (fundamental) activities, processes, functions and sub-functions but in this paper the more generic term processes will be preferred. Although the number and definitions of these processes differ somewhat across the various studies, these differences may arguably be seen as minor (and may to some extent be explained by differences in focus rather than theoretical considerations).[8]

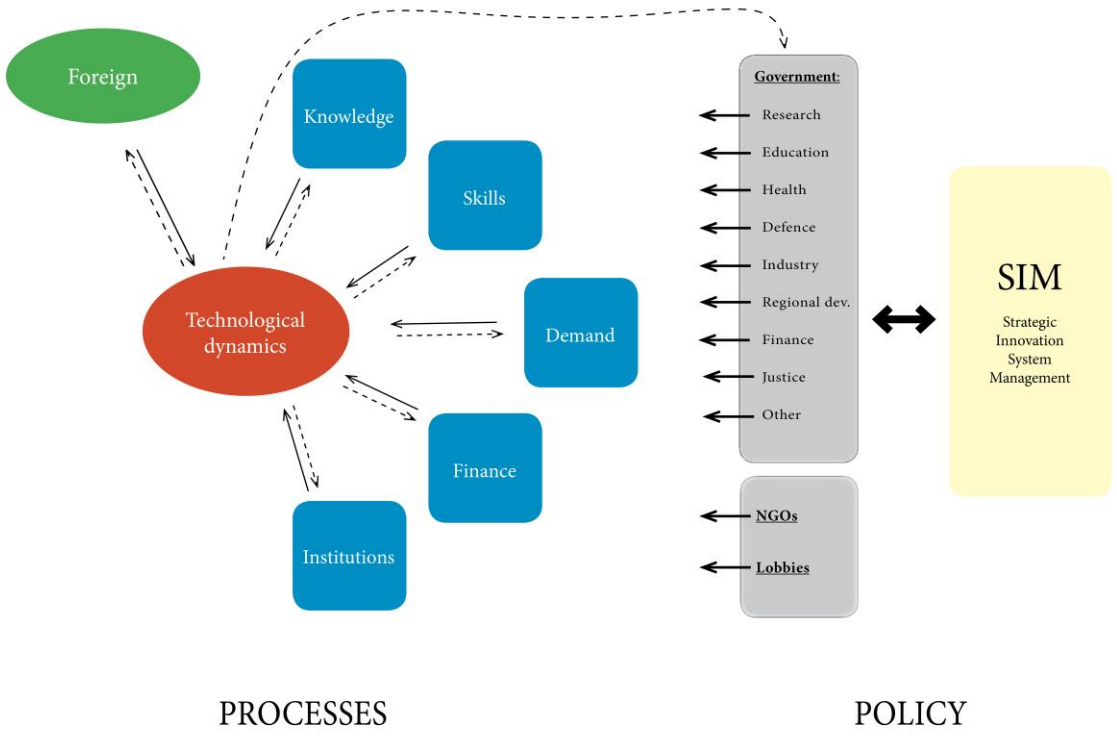
[6] Although innovation systems, as noted above, may be delineated in different ways depending on the purpose of the analysis, we will in the following mainly focus on the national level, since it is primarily at this level that policies are shaped. This holds at least for most developed economies. However, in some large countries with a federal structure it might have been just as relevant to do the analysis at the level of regions, such as US states or German "länder".

[7] Sharif (2006) and Fagerberg and Sapprasert (2011) trace the emergence of the innovation system approach.

[8] For example, Bergek et al. (2008) focus on emerging technological systems, the support of which requires "legitimation" in the broader society surrounding it; hence they include "legitimation" as one of the "functions" in such systems. While very relevant for the analysis of competing technologies, it is arguably less relevant for the study of the national system of innovation as a whole, which is why we have not included it in Figure 6.

Hence, in recent versions the innovation system approach is best characterized as a process perspective that can be used to analyse the dynamics – or lack of such - of a system. If these dynamics are deemed unsatisfactory[9] by e.g., policymakers, the approach may then be used to identify the mechanisms – or "problems" - behind the result and discuss what can be done about it. In Figure 6 below we illustrate of the dynamics of a national innovation system. The output of the system, i.e., innovation, diffusion and use of technology, is labelled "technological dynamics". Technological dynamics is a result of activities within the private business sector, influences from abroad ("foreign") and interaction between the business sector and actors in other parts of society. Without denying the importance of the two former, we will in this section concentrate on the latter, because policy - the topic under scrutiny here – is more influential in that area.

Figure 6. The National Innovation System: Dynamics, processes and policy



In the figure technological dynamics is depicted as influenced by five generic processes in the national innovation system, labelled knowledge, skills, demand, finance and institutions. The influences on the technological dynamics from these processes are indicated with solid arrows, while the possible feedbacks from technological dynamics on the generic processes are represented by

[9] The term "system failure" is sometimes used in the literature for such cases. It is an ambiguous term, however, because it is not clear what "failure" refers to, and it is therefore advisable to avoid using it. Literally, a failing system would be a system that fails to fulfil its function. Such a system would most likely disappear in the course of events.

dotted arrows. Policy makers may influence the technological dynamics by helping to shape the processes that impact the dynamics. To do so they need to have access to an adequate supporting knowledge base, and they may need to coordinate policies across different domains (see below). Their actions will also be motivated by goals they themselves set, i.e., strategic choices that they make and their "visions" for the development of society. Therefore we have labelled this process "strategic innovation system management". Their incentives to do so may also be affected by how vibrant (or lacklustre) the technological dynamics are conceived to be, giving rise to a feedback from performance on policy.

The five generic processes included in the figure may be described as follows:

- **Knowledge**: Knowledge may for example be provided by public R&D organizations (universities, R&D institutes etc.) that complement firms' own capabilities and through schemes that promote interaction between firms and other actors (such as technology platforms or cooperative R&D). Such processes receive financial support from, and are influenced by, various layers within Government, particularly the Ministry for Research, but also other ministries, such as ministries for industry, regional development, health, defence, etc.

- **Skills**: Skills, both specialized and more general, are essential for firms' abilities to generate technological dynamics, and the provision of these is normally the responsibility of the Ministry of Education but other ministries may also influence aspects of this process (such as supporting vocational training for example, which may fall under the Ministry of Industry).

- **Demand**: Without demand for new, innovative solutions, innovative firms get nowhere. The government can help to relieve such constraints by supporting the creation of markets for innovative solutions (subsidizing use for example), by changing standards and regulations so that demand for new, innovative solutions is strengthened and by using public procurement proactively to foster innovation (Edler and Georghiou 2007, Edquist and Zabala 2012). Such policies often fall under the Ministry of Industry and organizations for which it is responsible, but other ministries, such as the Ministry of Defence, the Ministry of Energy, the Ministry of the Environment and the Ministry of Health, may also have say.

- **Finance**: Finance is necessary for innovation to persevere, and access to well developed capital markets is therefore essential. Some innovative initiatives, particularly from small firms, entrepreneurs, etc., or in cases characterized by high uncertainty, technologically or otherwise, may have difficulties in raising the necessary finance in ordinary financial markets, and in such cases the public sector may play an important role. This would normally fall under the responsibility the Ministry of Industry or the Ministry of Regional Development. However, the design of the tax system, which is the responsibility of the Ministry of Finance, may also be a matter of importance.

- **Institutions**: Institutions refer to the "rules of the game" that influence entrepreneurial actions. They range from law and regulations, the responsibility of the Ministry of Justice, to informal norms and rules (on which the influence of policy actors may be more indirect). Examples of relevant institutions include IPRs, requirements for setting up or close down businesses, regulations regarding hiring or firing personnel, the prevalence of corruption (or lack of such) and attitudes conducive to innovation, for example with respect to trust, cooperation, etc. Institutions are often considered to be relatively stable. But laws and regulations of relevance for business activities do sometimes change, often related to "voice" on the part of the business community. In fact, even attitudes and values change in response to technological and economic changes, albeit very slowly, from one generation to the next (Inglehart 1977, 2008).

As Figure 6 illustrates there is a broad range of processes that influence the technological dynamics of a nation, and these processes are influenced by a large number of policies and actors.[10] Most of these policies are not dubbed "innovation policies" and have traditionally not been regarded as such either. Nevertheless, their effects on innovation may be much more important than those of more narrowly defined "innovation policies" (specifically designed to influence innovation). What matters from an innovation system perspective is not the name of a policy, but its impact, and this has important implications for how the analysis of the relationship between policy and technological dynamics should be conducted. In general, the innovation system perspective leads to a much broader perspective on policy (e.g., number and type of policies to take into account) than what has been common. Moreover, since the processes that these policies influence are seen as interdependent (complementary), it follows that the effect of a specific policy cannot be assessed in isolation, i.e., independent of other relevant policies (Flanagan et al. 2011). The innovation system perspective therefore leads to a holistic perspective on policy (which has given rise to the term "holistic innovation policy", see, e.g., Boekholt 2010).

This "holism" follows logical from the underlying theory but is arguably challenging for policy makers. First, calculating the total effects of a broad set of interacting policies (processes) requires a larger (and more sophisticated) analytical capacity in public administration than what has been common. In some countries deliberate steps have been taken to generate such capacities, for example the creation of the "Swedish Governmental Agency for Innovation Systems" in 2005 (Carlsson et al. 2010), but in most countries such capacity building is probably still in its infancy. A further complicating factor is that applying the innovation system perspective to policy would mean that policy makers from different domains (ministries, sectors, administrative levels etc.) have to work together and coordinate their activities (policies). This need is not something that only exists in the case of innovation policy, it applies also to other policy areas (environmental policy for instance), but it is something that is known to be difficult to achieve, as it tends to conflict with the established structures, practices and routines in public administration (Flanagan et al. 2011). Successfully applying the innovation system approach to policy may therefore require the development of new "systemic instruments" (Smits and Kuhlman 2004) facilitating the creation, adaptation and

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[10] The Ministry of Health, to take just one example, is a very influential actor in many national innovation systems, not the least in the US, and this influence works through several channels, e.g., public R&D, skills, demand etc. Similarly for the Ministry of Defence, some of the most important innovations during the last century (and the US is again the prime example) evolved with the help of defence contracts/support. Moreover, as shown in the figure, the range of relevant actors does not only include parts of government but may extend to non-governmental organizations of various kinds.

coordination of policy (so that policies support rather than counteract each other). It is this we in Figure 6 have called "strategic innovation systems management".

4.4. Coping with societal challenges

Up to now we have mainly concentrated on the general effects of innovation for society, related to phenomena such as welfare, standards of living, productivity, etc., and the role of policy in this context. However, innovation policy may also have more specific aims, such as developing a solution to a particular societal challenge. In fact, this is something governments have been engaged in long before the term innovation policy was invented (the Manhattan project during the Second World War comes to mind).

Reflecting the fact that much has happened in innovation research since that time, we now have a much more elaborate understanding of how new technologies develop and diffuse. Attempts to use innovation policy to cope with particular challenges may build on this understanding. For example we now know that there are many hurdles during the early phase of the development of a new technology, such as uncertainties with respect to a technology's potential, market, costs, etc., that may easily kill the embryonic project. Moreover, although there is a possibility that the new technology will yield substantial benefits, it may also fail to do so for reasons that were not (and in many cases could not) be properly understood ex ante. To learn more about the technology's potential, real life experiments are often necessary, and failures will occur (and need to be tolerated). The challenges for policy makers in this context may for example be (1) to help mobilize the necessary support so that the experiment can get going, (2) avoid that it is aborted too early (for reasons that policy makers can influence) and (3) not to draw premature conclusions about the superiority/potential of the new technology before a sufficient knowledge base about the focal technology and alternatives has been accumulated.

To assist policy makers in mobilizing innovation in the solution of specific challenges, process perspectives of the type discussed above have been applied and further developed, sometimes in interaction with the policy makers themselves. An example of the latter is the "technological system" approach, mentioned earlier, which was developed and improved through interaction between researchers and policy makers in Sweden (see Carlson et al. 2010). This approach consists of studying the processes that influence the development, diffusion and use of a specific new technology, with particular emphasis on identifying so called "blocking mechanisms" that hamper the development of one or more of these processes (or their interaction) and hence the dynamics of the system as a whole (see Bergek et al. 2008 for an overview). The implication is that policy makers' attention may fruitfully be directed towards removal of the "blocking mechanisms".

A related approach, particularly (but not exclusively) motivated by the climate-crisis and the need for a transition to a more sustainable economic system, has been developed in the Netherlands under the label "multi-level perspective" (MLP). Multi-level perspectives are well known from evolutionary theorizing, which has been a source of inspiration for the MLP approach as well as other types of innovation research (e.g., Nelson and Winter 1982) on which the MLP approach also draws (see Rip and Kemp 1998). In the case of the MLP approach, three levels are highlighted in the analysis: the macro-level (labelled "landscape") which is assumed to change slowly and for reasons that may be seen as "exogenous"; the meso-level, which following Nelson and Winter (1982) is dubbed the “technological regime” and the micro-level, which is termed “niche”. The niches are where the development of radical new technologies - the experimentation - is assumed to occur. However, such experimentation is fraught with difficulties of various sorts, and may require political support to persist long enough so that reliable conclusions can be reached. Moreover, a new, radical technology, even if successful in a narrow technological sense, also needs to be accepted by the broader technological regime[11] structuring the relevant part of the economy, which is seen as challenging since such regimes are perceived as rooted in the past and resistant to change (Rip and Kemp 1998). Much work in this area has therefore focused on the role of policy in nurturing technological experimentation and identifying areas in which the new, radical technologies can be applied so that they can develop further and eventually be more broadly accepted, so-called “strategic niche management” or “transition management” (Kemp et al. 1998, Rotmans et al. 2001).

In the MLP approach much of the focus has been on the interaction between the meso and micro levels, or between regimes and niches. However, more recently attention has turned to the interaction between the regime and the landscape levels, e.g., how differences in the pressure for change at the macro level may influence regimes and, depending also on the underlying technological dynamics, open up for different “transition pathways” (Geels and Schot 2007). The integration of the macro (or “landscape”) dimension into the analysis appears as a fruitful avenue for future work in this area. Take the climate change (global warming) issue, for example, which underlies much contemporary research. In reality, climate change is not an exogenous phenomenon, but a result of economic and technological dynamics, past and present. What appears to be needed in order to avoid the detrimental consequences of global warming is a change in the very factors that underpin the current unsustainable trajectory. These factors may have as much to do with the policy choices of politicians at the national level as with experimentation with new solutions at the micro level, or inertia among incumbent firms, organizations or “regimes”. Moreover, as for other types of innovation policy, policies aiming at mobilizing innovation to combat the problems associated with global warming may be much more effective if better coordinated across different policy domains and levels (i.e., what we above called “strategic innovation system management”).

5. Innovation Studies: The Core Literature

What are the most important contributions to innovation studies? Different scholars may have different opinions about this. To arrive at a more objective answer Fagerberg et al. (2012) carried out a meta-study based on 277 different surveys of innovation studies (or parts of it) published between 1993 and 2010 in 11 different “handbooks”. Together these surveys referred to nearly 15000 different publications. However, the great majority were cited only once. The assumption used in the study was that important contributions to the field should be expected to be cited many times by different surveys. This led to the selection of a core literature on innovation of 130 publications ranked according to the preferences (citations) of the survey-authors[12]. A characteristic

[11] Rip and Kemp (1998, p. 338) provide the following definition of a technological regime: “A technological regime is the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems - all of them embedded in institutions and infrastructures”.

[12] See Fagerberg et al. (2012) for details on the criteria behind the ranking.

feature of the core literature is the important role played by books (as opposed to articles in journals). Whether this has to do with the emerging character of the field or is a more permanent feature remains to be seen. Another characteristic that strikes the eye is the dominance of academics (and research environments) from the US and the UK, a feature that arguably reflects the origins of the field. The top 10 contributions to the core literature on innovations are reproduced in table 1 below:

Table 1. Innovation Studies: Top 10 contributions

No	Author	Country	Title	Type	Year
1	Nelson RR & Winter S	USA	An Evolutionary Theory of Economic Change	Book	1982
2	Nelson RR	USA	National Innovation Systems	Book	1993
3	Porter ME	USA	The Competitive Advantage of Nations	Book	1990
4	Schumpeter JA	Austria/USA	The Theory of Economic Development	Book	1912 (1934)
5	Rogers EM	USA	Diffusion of Innovations	Book	1962
6	Lundvall B-Å	Denmark	National Innovation Systems – Towards a Theory of Innovation and Interactive Learning	Book	1992
7	Freeman C	UK	The Economics of Industrial Innovation	Book	1974
8	Cohen W & Levinthal D	USA	Absorptive Capacity	Article	1990
9	Pavitt K	UK	Sectoral Patterns of Technical Change	Article	1984
10	Arrow K	USA	Economic Welfare and Allocation of Resources for Invention	Book Chapter	1962

Source: Fagerberg, J., Fosaas, M. and Sapprasert (2012)

Some of the contributions to the core literature are **theoretical** in nature, such as Schumpeter's classic text "The Theory of Economic Development" (number 4 on the list), portraying innovation as a dynamic force that causes continuous transformation of social, institutional and economic structures (Andersen, 2011; McCraw, 2007). Many ideas that are central in the innovation literature today can be found here (Fagerberg 2003). However, in the view of the authors of the surveys, an even more important theoretical contribution is "An Evolutionary Theory of Economic Change" from 1982 by Nelson and Winter (number 1 on the list), which as previously mentioned combines Schumpeterian and evolutionary perspectives with insights obtained from theories on organizations and human behaviour to produce a theory of how firm-level knowledge, the strategies that firms pursue with respect to innovation and the outcomes of their actions are shaped (see Box 5). Nelson and Winter's work has been an important source of inspiration for subsequent work on "knowledge-based firms", "technological regimes" and "industrial dynamics", to mention some important topics. Cohen and

Levinthal (1990), number 8 on the list, also focus on the importance of firm-level knowledge, in particular so-called “absorptive capacity”, which they see as critical for the ability to identify and exploit external sources of knowledge in innovation.

Other top-ranked contributions focus on **new concepts or frameworks** of analysis and their application. For instance, this is true of the two books by Nelson and Lundvall on “National Systems of Innovation” that appeared around 1990 (numbers 2 and 6 on the list) and subsequently became very influential both inside and outside academia (among other things through the involvement of the OECD with which Lundvall was associated at the time, see Fagerberg and Sapprasert 2011). As pointed out above the innovation-systems framework emphasizes the need to study the interactions between the various factors that influence a country’s innovation and growth performance. Another widely diffused framework of analysis, especially among analysts and policy makers dealing with regional issues, which also focuses on the interaction between domestic factors in fostering innovation and growth, is Porter (1990), number 3 on the list (see Box 9). Like Nelson and Winter’s work, Porter’s book is very highly cited in the Web of Science, indicating the wide applicability of the approach. Still another example of a novel concept or framework that has inspired subsequent work is Pavitt’s (1984) empirically based “taxonomy” of innovation activities in different sectors and industries (see Box 10).

BOX 9. MICHAEL PORTER’S CONTRIBUTION TO INNOVATION STUDIES

Michael Porter (b. 1947), one of the most influential management scholars in the world, has a multi-disciplinary background. Initially educated in aerospace and mechanical engineering, he continued with an MBA before he concluded his education with a PhD in economics. Porter considers himself to work on the intersection between economics and management. He did research and published several articles within economics (“industrial organization”) before he turned to management where he among other things published a highly successful textbook. However, he has also contributed significantly to innovation studies, not the least through his book on the “Competitive Advantage of Nations” (Porter 1990). The book explains how a country’s productivity and income levels depend on its innovative performance, which, the book argues, should be seen as shaped by the interaction between demand conditions, related and supporting industries, factor conditions and competition. Porter also emphasizes the spatial dimension of this interaction (so-called “clusters”, see also Porter 1998). Porter’s work has influenced policy makers’ efforts to enhance such interaction in specific regions or countries.

Further reading:

Huggins, R. and H. Izushi, 2011. Competition, Competitive Advantage and Clusters: The Ideas of Michael Porter, Oxford University Press, Oxford

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Finally, a number of highly rated contributions consist of **synthetic overviews and interpretations** of the current knowledge of innovation or aspects of it. The prime example here is Freeman’s “The Economics of Industrial Innovation” originally published in 1974 (but with two later editions), which for a long time had a virtual monopoly in presenting the 'state of the art' of knowledge in the field (number 7). The latter comment also applies to Rogers' overview of work on the diffusion of innovations (Rogers 1962, no. 5 on the list), which – partly because of its exceptionally broad coverage of a large number of cases – has continued to attract interest in a wide range of disciplines and scientific fields. In contrast to most of the other contributions, it is written from a sociological perspective, focusing on the conditions that affect the adoption by users of products or technologies new to them.

BOX 10. PAVITT'S TAXONOMY

Keith Pavitt (1937-2002) was educated as a RAF pilot during his military service, went on to study engineering and industrial management at Cambridge University and finished his education with a Master's degree in economics and public policy at Harvard University in 1960-61. After working for the OECD, where he met Christopher Freeman, he joined the latter in SPRU in 1971. Pavitt had a strong empirical orientation in his research and made extensive use of data on innovations and patent statistics where he made pioneering contributions. His most influential work is his taxonomy of technological change (Pavitt 1984) which was based on a very extensive dataset on innovations in the UK. Pavitt 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 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, and hence that a "one size fits all" policy will not suffice. Together with colleagues at SPRU and elsewhere Pavitt also made important contributions to the study of international competitiveness and economic growth (Dosi et al. 1990) and, particularly in later years, the management of innovation (Tidd et al. 1997).

Further reading:

Meyer, M., T. Santos Pereira, O. Persson and O. Granstrand (2004), "The Scientometric World of Keith Pavitt: A Tribute to his contributions to Research Policy and Patent Analysis", Research Policy, 33 (9), pp. 1405-1417.

Verspagen, B. and C. Werker (2004) "Keith Pavitt and the Invisible College of the Economics of Technology and Innovation," Research Policy, 33, pp. 1419-1431.

Having identified the core literature on innovation and discussed its evolution to its current stance, Fagerberg et al. (2012) went on to explore the characteristics of the (academic) users of the innovation literature. Academic use leaves trails in the forms of citations and these were exploited to identify the disciplines and fields that used (i.e., cited) the innovation literature. The analysis showed that the innovation literature is used by scholars in a wide range of disciplines and fields extending far beyond social science proper, confirming the strong multi- and interdisciplinary appeal of this literature. However, the analysis also indicated that the role of "Management" scholars among the users has increased in recent years, and that it now is the largest single user group. This undoubtedly has much to do with the rapid growth of Business and Management Schools, and hence Management as a scientific field, in recent years. But it may also reflect that innovation has become a more central topic on Management scholars' agendas.

6. Innovation Studies: An Evolving Agenda

Schumpeter published his first theoretical works on innovation more than a century ago. Half a century has passed since Nelson published the edited volume on "The rate and direction of inventive activity", which in many ways was the starting point for the development of modern innovation studies. The first specialized academic units on the subject, such as SPRU, are also nearly fifty years old. Hence, the field may be seen as approaching "maturity" as Steinmueller (2013) puts it. It is high time to take stock of what has been achieved, critically reflect on the current knowledge and discuss what researchers in this area need to focus their attention to in the years to come. In fact, this discussion has already started (see e.g., Fagerberg, Martin and Andersen 2013). In the following we will briefly examine some relevant points.

A better understanding?

Although the Schumpeterian framework for how to think about innovation (and its effects) continues to be widely adhered to, it soon became clear to scholars in the field that there were big blank areas on the Schumpeterian map. For example, there was very little on innovation in large firms, although it was evident that many innovations occur in such settings (and to his credit Schumpeter acknowledged that). Nor was there any room for policy or policymakers. Much post-Schumpeterian theorizing about innovation can be seen as attempts to deal with these "problems". For example, both Chandler's work and Nelson and Winter's evolutionary theory may be seen as responding to the first problem (innovation in large firms), while the innovation systems literature mainly addresses the second problem (policy). As shown in this paper these seminal contributions have sparked new work, which is continuing to this very day.

Thus, theoretical work in this area has managed to address some of the most important problems in the older literature. Nevertheless, theoretical work in this area has also been criticized for lacking consistency (Hodgson 1993) and "micro-foundations" (Felin and Foss 2009). Arguably, these criticisms reflect the way theorizing in this area has developed. Rather than progressing according to an overall plan, or based on a commonly accepted set of axioms about human behaviour (such as in neoclassical economics for example), theorizing in this area has developed in a piecemeal fashion, in response to problems that arise. In doing so, researchers have drawn on the received theoretical framework, influenced by Schumpeter's work, but also theories, approaches and methods sought from other disciplines when these were found to be helpful for understanding the problem they were grappling with. Examples include evolutionary theory (from biology), behavioural theory (from organizational science and psychology), network theory (from sociology), etc., illustrating once more the strongly inter-disciplinary character of work in this area. The result has been a set theories (or approaches), developed for the analysis of particular phenomena at different levels of aggregation (micro, meso, macro), sharing important communalities (see Fagerberg 2003), but also differing in some respects.

The problem-oriented mode which characterizes much work within innovation studies is not unique. In fact, it is quite common in the social sciences (Becher and Trowler 2001), albeit less so in economics than in many other fields. Felin and Foss (2009), in a criticism of Nelson and Winter's work and the associated literature on capabilities, argue that an approach placing more emphasis on "micro-foundations" and so-called "methodological individualism"[13] is what is required for the field to progress. This is, of course, very close to the view that has been dominant in economics for a very long time. It is worth pointing out, however, that the narrow focus in economics on the actions of so-called "rational" individuals has in fact precluded the development of an understanding of a whole range of important social phenomena, including innovation. The jury is probably still out on the most promising future research strategy in this area. Arguably, this is likely to depend on the insights offered by researchers pursuing different trajectories (i.e., the proof of the pudding is in the eating).

Whatever the future will bring in this regard, the fact is that the received theoretical basis in this area includes a number of different - albeit related - theories or approaches, developed for the analysis of different phenomena, and this is unlikely to change anytime soon. However, this does of course not mean that these theories should be seen as immune to criticism or that attempts to relate – or bridge - these theories are pointless. On the contrary, work on the interfaces between theories developed for different levels of analysis may be a fruitful avenue for further research. For example, the received Schumpeterian theory of entrepreneurship is basically a theory about individual innovators trying to navigate through a largely inert social and economic environment. In contrast Nelson and Winter's theory - and the associated work on capabilities - is mainly about organizations, how they cope, influence - and are influenced by - the (also rather inert) environment in which they operate. The interface between these theories may have to do with how individual entrepreneurs engage with organizations and how such interaction influences both the entrepreneurs and the organizations that are involved. Similar issues may arise in other contexts (levels of analysis).

A broader focus?

Not so long ago, innovation was often seen through more narrow lenses than what is common today. The focus was mostly on tangible innovation of the product or process kind in manufacturing industry. Other types of innovations, for example of the organizational kind, or innovations in services, tended to be ignored. Add to this the common tendency, inherited from Schumpeter, of focusing mainly on large, spectacular innovations and overlooking the more frequent, smaller ones, and a very narrow perspective results. Innovation, in this sense, is something that only goes on in a small part of society, such as "high tech" firms and dedicated R&D establishments.

[13] Felin and Foss (2009) embrace "methodological individualism" but without referring to Schumpeter who to the best of our knowledge coined the concept (and was much closer to the individualist position they advocate than, say, Nelson and Winter).

However, these self-imposed limitations on the object of study were to a very limited extent the result of flaws in the conceptual framework (or theory) inherited from Schumpeter. In fact, his definition of innovation was much wider than what became common subsequently. Organizational innovation, for example, was explicitly included in Schumpeter's typology. As the field has evolved, innovation researchers have started to break out of the narrow fences put up by earlier generations of researchers (Martin 2013). Organizational innovation has become a flourishing research area (see Lam 2004 for a survey), and the same goes for innovation in services (Miles 2004, Gallouj and Savona 2009, Gallouj and Djellai 2010). In fact, organizational innovations have been found to be particularly relevant in services industries. Similarly, innovation is so-called "low tech" industries, which used to be ignored, has also received more attention (von Tunzelman et al. 2004) and the same goes for innovation in developing countries (Fagerberg et al. 2010).

As a consequence of these developments, innovation has become a more relevant phenomenon, not only for firms and for researchers, but also for policymakers. More research along these lines in the years ahead will undoubtedly increase our insights into the conditions for innovation in various settings, and is likely to lead to improvements in measurement, methods, theory and policy. An interesting question is what it would take to broaden the focus even further, to innovation outside the private business sector, in public sector services for example.[14] Innovation is usually understood as the attempt to try out new solutions in practice, and this definition appears relevant for public sector services as well. What mainly differs is the character of the selection environment. Policy makers, for example, would usually be strongly involved in deciding the fate of innovations in the public sector, and may therefore be potential objects for study. A broadening of the agenda in this direction may require more interaction with researchers with expertise on political processes, e.g., from fields such as public administration, political science etc.

Is innovation good for you?

This rhetorical question was raised by Luc Soete in a recent article (Soete 2013). As he points out innovation is almost always seen as "positive," and is so portrayed in media and advertisements. This claim, however, is far from obvious. For example, while innovation may solve a particular problem, it may also create new, often unforeseen ones. To some extent this may be seen as a natural consequence of the fundamental uncertainty associated with innovation as discussed above. Perhaps the best example of this, also mentioned by Soete, is so called "financial innovation," allegedly intended to make markets more efficient while in reality undermining their stability and playing a major role in the global financial crisis of 2008.

While this may seem rather obvious it is not something that innovation studies are particularly well equipped to handle. This is not because researchers in the field generally share the almost quasi-religious affection for innovation that is common in media and among consultancy firms. Rather, the problem is the opposite; the evolutionary thinking which underlies most theorizing in the field is almost void of normative concerns. According to the theory, new innovations occur all the time, but

[14] See e.g., the recent special issue of Research Policy special issue on mission-oriented R&D, which contains an extensive set of case studies on public-sector innovation for public-sector missions as well as for adoption within the civilian economy (Volume 41, Issue 10, December 2012, Pages 1697-1792)

only a few – those that survive the selection process – succeed, because they have a better "fit" with the relevant selection environment. This is something the researcher can study in detail (and hence "explain"). However, the fact that one innovation is better adapted to the selection environment than another innovation, does necessarily not make it superior in a normative sense. Arguably, to be able to judge whether an outcome is "good" or "bad", the researcher may need to go beyond evolutionary theory. How this might be done is not a question that can be resolved here. But it is arguably an issue that is likely to be higher on innovation researchers' agendas in the years to come than it has been in the past.

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