Innovation Systems: A Survey of the Literature from a Schumpeterian Perspective

Bo Carlsson
Weatherhead School of Management
Case Western Reserve University
Bo.Carlsson@cwru.edu

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Introduction

The concepts of innovation and entrepreneurship are probably Schumpeter’s most distinctive contributions to economics. One of the recurring themes in the writings of Schumpeter is the role of innovation (“new combinations”) and entrepreneurship in economic growth. But his views on this topic changed over time. In his earlier view (articulated in *The Theory of Economic Development*, originally published in 1912), Schumpeter emphasized the function of entrepreneurs as that of carrying out new combinations; he viewed the occurrence of discontinuous and ‘revolutionary’ change as the essence of ‘economic development’ which breaks the economy out of its static (‘circular flow’) mode and sets it on a dynamic path of fits and starts. Three decades later, in his *Capitalism, Socialism, and Democracy* (1942), Schumpeter took the view that dynamic capitalism was doomed to fail because the very efficiency of capitalist enterprise would lead to monopolistic structures and the disappearance of the entrepreneur.

Schumpeter distinguished clearly, particularly in his early work, between the circular flow view of ‘economic life’ - “the economic system’s tendency towards an equilibrium position”
(Schumpeter 1912, quoted in Schumpeter 1949, p. 62) - and the ‘economic development’ view in which “changes in economic life are not forced upon it from without but arise by its own initiative, from within” (op. cit., p. 63). Thus, the idea of studying innovation occurring within an economic system is certainly consistent with Schumpeter’s emphasis on the need to understand not only innovation as a source of growth but also how it arises within the economic system, how it is implemented, as well as what its effects are on the economy and society. Yet, as Freeman has pointed out, in spite of Schumpeter’s emphasis of the entrepreneurial function, his focus on the individual entrepreneur is the reason for the absence in his theory of “multiple sources of information inputs from within and from outside the innovating organization and the importance of a ‘national system of innovation’ – the supporting network of scientific and technical institutions, the infrastructure, and the social environment” (Freeman 1990, p. 26).

For reasons too complex to discuss here, most “Schumpeterian” analysis has come to be based on Capitalism, Socialism, and Democracy rather than on The Theory of Economic Development. This is certainly true of the innovation systems literature, as will become apparent below.

The purpose of this essay is to survey the literature on innovation systems that has emerged over the last two decades and to provide a broad overview of its contents: the types of innovation systems studied, the main questions analyzed, and the main lessons learned. The paper is organized as follows. We begin with a discussion of the theoretical motivation for the study of innovation systems. Next, an overview of the literature is provided, organized according to the types of systems studied: national, regional, sectoral, and technological innovation systems. This
is followed by a review of some of the important features and contributions of the literature.

The paper concludes with a discussion of lessons learned and future avenues of research.

**Why Study Innovation Systems?**

The basic motivation for the study of innovation was provided by Schumpeter: the need to understand the nature and sources of economic growth. “There is no disagreement with [Schumpeter’s] insistence that innovation incessantly revolutionizes the economic structure and that ‘this process of creative destruction is the essential fact about capitalism’ (Freeman, 1990, p. 22, quoting Schumpeter 1943, p. 83). In this regard the study of innovation systems is similar to endogenous (‘new’) growth theory. Indeed, it is interesting to note that the study of innovation systems began in the late 1980s, at about the same time as the first publications on endogenous growth theory appeared (Romer 1986, 1990; Lucas 1988). But it differs fundamentally from endogenous growth theory. Whereas the latter focuses on the role of knowledge in macroeconomic growth, it leaves ‘knowledge’ in a black box in the aggregate production function. Innovation systems, on the other hand, refer to the microeconomic contents of the black box. In particular, innovation systems emphasize and analyze the role of institutions; as a result, both the analysis itself and the policy discussion to which it gives rise are much richer empirically and more qualitatively oriented. Also, the analysis is much less formal in nature. However, as this survey will show, there is still a gap in our understanding of the mechanisms that link knowledge and knowledge formation to economic growth.

Thus, the importance of innovation for economic growth may be taken for granted. But why study innovation systems?
Innovation is closely related to knowledge: “new combinations” give rise to new knowledge. Given a vast opportunity set and bounded rationality, actors in the economy gain knowledge both through their own efforts and (if they have sufficient absorptive capacity) through spillovers from other actors. Thus, internal R&D is necessary but not sufficient for economic growth. The very term ‘spillover’ suggests the unintended nature of the knowledge flow from the point of view of the individual actor undertaking research. It also suggests that the transfer of knowledge frequently takes the form of non-market interaction. In fact, the more knowledge intensive an activity is, the more it depends on non-market interaction. As a result, clustering of activity, both geographically and in terms of inter-industry linkages, is common in many industries, particularly in high-tech sectors such as biotechnology, electronics and computers, and software. Clustering facilitates the sharing and transfer of knowledge, competence, and skills.

Innovation systems can be viewed as institutional arrangements to facilitate spillovers (provide connectivity) among economic actors. Put differently, the systems concept is necessary in analyzing the economic impact of innovation when non-market synergies are important.

A systems framework brings out three things.

1. It makes it necessary to specify the components (and therefore the boundaries) of the system. In some cases the boundaries of the system may be exogenous or easily defined by geography or administrative units, while in others the determination of boundaries is an inherent

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1 While knowledge may be transferred through market transactions (contracts), it seems inappropriate to refer to such knowledge transfers as spillovers.
part of the analysis. Similarly, the components to be included, e.g., the various actors (individuals and firms, buyers and sellers) that normally interact in markets, as well as academic units, research institutes, government agencies, trade associations, and other units making up the institutional infrastructure – are sometimes easily defined, sometimes not.

2. The relationships among the various components in the system need to be analyzed - especially, the non-market-mediated interaction in the form of knowledge spillovers. In the areas of economic activity that are the most dynamic in terms of innovative activity, such spillovers are often pervasive, not rare exceptions. Therefore, they need to be included in the analysis, i.e., they are part of the system.

3. The attributes or characteristics of the components need to be specified. These include the competencies and functions of the components that determine the system’s performance (Carlsson 1998, p. 158).

Statistical Survey of Innovation System Studies 1987-2002

The study of innovation systems began in the late 1980s, the first published reference being Freeman (1987). There were several precursors (Bowers et al. 1981, Krupp 1984, Saviotti 1986) based on the engineering concept of ‘technological systems’ referring to complex systems of physical artifacts such as large electrical systems (Hughes 1983; Bijker, Thomas and Pinch 1987; Mayntz and Hughes 1988). This literature is not included in this survey.2

The most common definitions of innovation system refer to national, regional, sectoral, and technological innovation systems. In addition, recently there has emerged literature on other

2 For a description of the methodology used in this study, see the Appendix.
innovation systems, particularly at the firm level. As suggested by their names, national and regional innovation systems refer to innovative activities within national and regional boundaries, respectively. Sectoral innovation systems refer to individual sectors or industries, while technological innovation systems are defined by a particular technology or set of technologies rather than by a geographic region or industry. To avoid confusion with the engineering concept of ‘technological system,’ the term ‘technological innovation system’ will be used here.

The notion of innovation systems has generated a lot of interest among economists and other social scientists, as well as engineers. As a result, a large literature now exists. By the end of 2002, more than a thousand studies of innovation systems had been published. Collecting all these into a database proved to be a daunting and time-consuming task. After eliminating newspaper articles, book reviews, double counting of entries, as well as references to ‘technological systems’ in the engineering sense, we are left with about 750 entries. Half of this literature refers to National Innovation Systems (NIS). The other half is equally distributed between studies of regional innovation systems (RIS) and studies of sectoral/technological systems. 309 (41 %) of these studies were published in journals, the rest in books (42 monographs, 37 edited volumes, and 364 chapters in books). The fact that most studies are published in books complicates the task of surveying and classifying this literature, since abstracts are available only for journal articles. Therefore, it has not been possible to review this whole literature in detail. Beyond the statistical summary and classification presented here, there are many topics to explore in further research; some of these are indicated in the analysis that
follows. But the analysis of the more specific content of the literature remains somewhat
impressionistic and superficial at this time; much more could be done.

*National Innovation Systems (NIS)*

Of the 381 publications classified as NIS studies, 147 (38 %) are focused on individual countries.
55 of these study European countries, 47 Asian countries, 22 Latin America, 14 North America,
and 9 the rest of the world. Japan is the most frequently studied country (17 studies), followed by
China (11), Finland and Germany (9 each). The most common orientation of these studies is
toward policy discussion (66), general description of national innovation systems (21), and focus
on a particular sector or industry (19). About one-third of these studies deal with developing or
transition economies.

51 NIS-studies are comparative in nature (comparing one country or set of countries with
another). 164 (43 % of NIS studies) are not focused on any particular country or group of
countries but discuss concepts/theory (56), policy (43), issues having to do with globalization
(42), or other issues without reference to country. These could also be classified as general
innovation system studies.

*Regional Innovation Systems (RIS)*

201 studies are focused on regional innovation systems (RIS). Slightly more than half (103
studies) are empirically oriented, focusing mostly on a particular region (62) or on multiple
regions (24). More than half of these studies deal with regions within Europe. The other
empirical studies are case studies of various sorts involving innovation surveys, patent analyses,
globalization issues, or innovation policy. Of the 93 non-empirical RIS studies, 70 are conceptual in nature and 11 are policy-oriented.

**Sectoral Innovation Systems (SIS)**

There are 49 published studies of sectoral innovation systems (SIS). 30 of these focus on individual sectors or industries (the service sectors and the biomedical/pharmaceutical industry being most heavily represented). 9 studies are conceptual, three are comparative, four are policy-oriented. The remaining three fall into a miscellaneous category.

**Technological Innovation Systems (TIS)**

The technological innovation system studies differ from others not only in that they are more narrowly focused (being defined by a particular technology or set of technologies rather than a geographic region or industry) but also in that they are more conceptual/theoretical in nature. This is largely a result of the need to establish both the core and the boundaries of the systems before the analysis can take place. These issues are much less problematic in other approaches. Also, technological innovation systems have three dimensions (cognitive, institutional/organizational, and economic – see Carlsson 2002), while other approaches focus primarily on institutions. Thus, of the 149 studies of technological innovation systems, more than one-third (57) are conceptual in nature. The remaining two-thirds are either case studies of various sorts or otherwise classified. The biotech/biomedical/pharmaceutical sector is the most frequently studied (17 studies), followed by agriculture (8), factory automation (6), and information technology (5).
**Other Innovation Systems**

The ‘Other innovation systems’ category contains 30 publications. 19 of these are conceptual in nature without specific reference to any of the types of innovation systems previously mentioned, or refer to innovation systems in general. 11 focus on corporate innovation systems and related management issues.

As shown in Figure 1, the number and focus of innovation studies have varied over time. After the first few studies on NIS (Freeman, Lundvall, Nelson et al.) and technological innovation systems (particularly focused on agriculture) in the late 1980s, the numbers increased dramatically in the early 1990s, peaking at 175 in 2000, and then declined sharply. Regional and sectoral innovation system studies began to appear in the late 1990s. The large number of studies published in 2000 appears to be a coincidental result of several books being published in the same year. The number of publications of RIS and SIS studies was particularly large that year compared with other years. Several books on RIS were published by Dunning, Holbrook, Boekema and others. Similarly, half of the SIS studies published in that year are chapters in books on the service sector (edited by Metcalfe & Miles, Boden & Miles, and Andersen et al., respectively).

**Overview of Topics and Themes**

206 (27 %) of all the innovation systems publications are conceptual/theoretical in nature. As indicated already, the definition of boundaries and core activities is more problematic in regional and technological innovation systems than in others. This is reflected in the fact that a larger share of the regional (36 %) and technological (34 %) innovation system studies are conceptual
than is the case for other systems. The corresponding numbers for SIS and NIS are 21 % and 16 %, respectively.

Of all the innovation system publications, 11 % have a sector focus. As one would expect, the SIS studies are the most sector-oriented: 58 %. (Other SIS studies are primarily conceptual in nature.) It is perhaps more surprising that as many as 9 % of both NIS and TIS studies and only 4 % of regional studies are focused on a particular sector or industry. To some extent this reflects difficulties of appropriate labeling. For example, studies of the role of particular sectors in a national innovation system are generally classified as both NIS and SIS. They are often parts of edited volumes focusing on a particular national innovation system and its components. In other cases the terminology used in the studies refers to national innovation systems, even though a sectoral designation would be more appropriate. Similarly, some TIS studies use the term ‘technological’ when ‘sectoral’ would be more appropriate. These difficulties are an unavoidable result of the procedure used to identify entries into the database. It is interesting to note, however, that the sector focus has shifted markedly over time. All innovation system studies have become much more sector-oriented (18 % in 2000-2002, compared with only 11 % in 1987-1999). The shift has been particularly dramatic in NIS studies: from 6 % in 1987-1999 to 16 % in 2000-2002. This suggests that as more has been learned about innovation systems at all levels (and especially at the national level), there is a greater need for more detailed, micro-based studies.

Only a small subset (about 60 studies) can be considered ‘dynamic’ in the sense that they focus on a historical process or development over time rather than on a snapshot of a system in a
particular time period. There are even fewer studies dealing with new system formation, leaving an as yet wide open area for future research. It is tempting to conclude that Schumpeter’s vision of the dynamics of what he called the “economic system” is not yet fully developed: most studies still adhere to a static view of the world.

Schumpeter distinguished sharply between invention (the original idea for a new product or process), innovation (its conversion into a commercializable product), and the diffusion of innovations. The innovation systems literature is heavily oriented to the earlier (invention) stage and to some extent diffusion, with relatively little emphasis on the innovative (entrepreneurial) stage. This is somewhat surprising, given the prominence of entrepreneurship in Schumpeter’s work, and the Schumpeterian origin of innovation system studies. Only about 20 studies address entrepreneurial issues. Thus, it appears that innovation systems are more deeply rooted in Schumpeter’s later work (Capitalism, Socialism, and Democracy) than in his earlier work (The Theory of Economic Development) that features the individual entrepreneur more prominently. It also appears that to the extent that entrepreneurial activity is necessary to convert innovation into economic growth, there is a missing link in the innovation systems literature.

This is reflected also in the discussion and analysis of public policy in the literature. 190 of all the publications (25 %) deal with policy issues. The NIS studies tend to be the most policy-oriented (34 %), while 24 % of RIS and 13 and 12 % of sectoral and technological innovation system studies, respectively, have a policy focus. Again, this state of affairs is no surprise. To a large extent it reflects the fact that it is easier to identify the relevant policy makers with respect
to nations and regions than in sectoral and technological systems. It is also easier to identify policy measures at the national level than at other levels.

As one would expect, the policy discussion in the NIS studies tends to focus on national policies with respect to the technology infrastructure: promotion of R&D, intellectual property rights (especially, patent laws), the role of public and private research and technology institutes (particularly university-industry collaboration, technology transfer, and the role of science parks), as well as trade policy and the role of foreign direct investment. This reflects the fact that public policies in all these areas form an important part of the infrastructure for all innovation systems within nations (including regional, sectoral, and technological innovation systems). The lower the level of aggregation, the more qualitative and specific the policy analysis becomes, focusing more on interaction among actors and on institution building. It is therefore difficult to summarize briefly. However, it can be safely said that throughout the innovation systems literature, the primary policy concern is to improve the technology infrastructure and therefore increase the supply (and to some extent improving the diffusion) of innovations rather than stimulating entrepreneurship.

Even though institutions are deeply imbedded in innovation systems and are the primary focus in many studies, it should be noted that the definition ‘institutions’ varies among studies and that, as a result, there is considerable confusion about what institutions are and what role they play. Some authors, (e.g., Freeman 1987 and Nelson & Rosenberg 1993) refer to institutions as networks or organizations supporting technical innovation, while Lundvall (1992) stresses the “institutional set-up” in the sense of rules or regimes that determine behavior. Carlsson &
Stankiewicz (1991) refer to the set of institutional arrangements in the form of both regimes and organizations. What is clear is that most innovation system studies use the notion of supporting organizations and that there is not much analysis or discussion of the specific mechanisms through which institutions work.

One consequence of this lack of in-depth analysis of institutional mechanisms is a relative neglect of the role of financial institutions, mechanisms, and arrangements. Only five studies have finance as their primary focus. This is in sharp contrast to Schumpeter’s thinking. As Freeman has observed, Schumpeter devoted far more attention to the financial side of business cycles (in his *Business Cycles*, published in 1939) than to inventions and innovations. “More important was his preoccupation with the individual entrepreneur and the individual innovation, and his reluctance to conceptualize invention, innovation, and technology accumulation as a social process. This is related to his theory of diffusion with its sharp distinction between truly original entrepreneurs and routine managers and imitators” (Freeman 1990, p. 24). Of course, another reason for the relative lack of emphasis on the finance of entrepreneurial enterprise is the limited attention given to entrepreneurial activities in innovation systems.

More or less in parallel with innovation system studies there has emerged another branch of economic analysis that has many similar features, namely the study of industry clusters. A lot of this work has been inspired by Porter (1990) and colleagues. What is the difference between a cluster and an innovation system? If a cluster is defined as a set of closely related business activities in a certain geographic region, the difference would be that an innovation system

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3 For further discussion of these definitions, see Edquist and Johnson (1997).
differs from a cluster in that it takes into consideration the whole set of factors (especially institutional ones) that are conducive to the formation of a cluster. Most cluster definitions in the literature thus far ignore institutions (Porter being a notable exception). Probably mostly for this reason there is surprisingly little overlap between “cluster-focused” and innovation system-focused publications: only 63 out of 752 innovation system publications reviewed here mention clusters. But the overlap between the two strands of literature has increased over time, most of it involving publications in 1996 and later.

As mentioned earlier, about 50 NIS studies are focused on individual developing or transition countries. Many of these are cross-referenced as SIS or TIS studies also. Beyond these, there is an additional handful (about 10) publications dealing with innovation systems in developing/transition economies but not focusing on any particular country. It seems fair to say that this is a relatively undeveloped part of the innovation systems literature. But there seems to be increasing interest in innovation systems in developing or transition economies; the vast majority of publications in this area have appeared in 1999 or later. Many of these studies deal with the problem of catching up with more advanced countries and importing technology, knowledge, and ideas, particularly via direct foreign investment and repatriation of nationals educated abroad.

Another area that has not received much attention in the innovation systems literature is the performance of various systems. Only about 20 studies are aimed at assessing the performance of innovation systems. There may be several reasons for this. One is certainly the difficulty of measuring performance: what indicators should be used? (Only 11 studies discuss measurement issues specifically.) What indicates high or low performance – i.e., what should be the standard?
Relative to a different time period? This requires historical data that are difficult to obtain.
Comparisons with other systems? Given the detailed and complex data requirements, such analyses are also extremely difficult.

One consequence of the lack of performance data and analyses is that there is still no connection between innovation and economic growth. Through the study of innovation systems we have learned a lot about the contents of the ‘black box’ that converts innovation into economic growth, but there are still missing links: As already indicated, the role of entrepreneurship connecting invention via innovation to successful commercial application and diffusion is poorly understood. While there has been a lot of recent work on entrepreneurship, it has not generally been integrated with innovation systems. Also, there has not been much theoretical work explicitly connecting innovation systems to economic growth. As a result, there is little formal modeling in the innovation systems literature. Only 10 studies involve modeling; six of these pertain to technological innovation systems. Beyond a few simulation studies there is no empirical testing of hypotheses. Thus, in spite of hundreds of innovation system studies we have not really advanced much (yet) beyond the endogenous growth model. We still lack understanding of how to measure success and what makes innovation systems successful. There is still much to be done.

**What Have We Learned, and What Difference Does Research on Innovation Systems Make?**

Perhaps the most important insight gained from the study of innovation systems is a better understanding of how complex innovation systems are – and how complex the growth process is.
There is much more to innovation – and to economic growth – than an aggregate production function captures. Even though there are still missing elements in our understanding of the links between innovation and economic growth, the study of innovation systems has already resulted in a deeper and more comprehensive view of economic growth. This is certainly consistent with Schumpeter’s ideas about growth originating within the system and about the role of history and institutions. The new insights are limited but they are still useful in that (1) they help economists better understand how to think about innovation and its role in economic growth, and (2) they put industrial/technology policy in a broader framework than was the case previously. The questions raised are different and more qualitatively oriented, with attention given not only to the end results but also to the mechanisms involved. Even though the policy recommendations may differ, there is certainly consensus that more attention than in the past needs to be given to institutions and institution building. Policy makers have responded at all levels, from international organizations such as the OECD and national governments (by re-organizing their technology policies and agencies to focus on innovation systems as distinct from more piecemeal policies) to regional and sectoral agencies. The various systems approaches are complements, not substitutes, each focusing on a particular domain with its own issues, problems and opportunities. The policy recommendations vary among the various systems approaches, but they are not necessarily inconsistent. They basically reflect the fact that different systems address different questions.

Though the study of innovation systems has charted a new course in economic analysis, it is not a smooth and easy one. There are many obstacles and bumps in the road ahead: how to formalize the theoretical insights that have already been gained, how to link microeconomic phenomena
with macroeconomic outcomes, and how to correctly measure both inputs and outputs are just a few. There seems to be no escaping building the micro foundations (i.e., micro dynamics) for understanding macroeconomic growth. Innovation system studies represent an important step in the right direction.
APPENDIX

Data Sources

Data for the present study have been obtained from a variety of sources, mostly on-line. The Social Science Citation Index as well as ABI Inform and EconLit were used to obtain references and abstracts for journal articles. In some cases data had to be entered separately for journals not covered in these indices. For books the main sources were EconLit and library catalogs, particularly OhioLink, a joint catalog of the university libraries in Ohio. In a few cases data were entered separately based on the author’s own research.

Methodology

The above-mentioned databases were searched for references using various combinations of the keywords Innovation System or Systems, National Innovation System(s), Regional Innovation System(s), Sectoral Innovation System(s), and Technological System(s). This search yielded over 600 references that were then entered into a database using the EndNote program. Each entry was given an initial classification depending on what keyword combination had been used to identify the publication. Multiple entries of the same publication were eliminated, but only after noting all the appropriate classifications. (Thus, for example, entries found under the keywords “National Innovation System” and also under “Regional System of Innovation” were classified with both an NIS and an RIS code.) Newspaper articles and book reviews were eliminated. Publications pertaining to the engineering definition of “Technological System” were also eliminated. Through this process, about 100 entries were removed.

A classification system for each type of innovation system was devised as follows:
NIS studies were classified according to the following categories:

- Individual country focus
- Comparative studies
- Non-country focus
- Conceptual
- Sector or industry focus
- Policy-oriented
- Performance assessment-oriented
- Developing/transition economy focus
- Concern with globalization (incl. multinational firms and direct foreign investment)
- General description of NIS
- Management/business behavior-oriented
- Miscellaneous

RIS studies were classified as follows:

- Empirical
  - Focus on a particular region
    - Europe
    - Outside Europe
      - Canada
      - Other
  - Multiple regions
    - Europe
    - Outside Europe

- Non-empirical
  - Conceptual
  - Other
    - Policy
    - Globalization
    - Miscellaneous

SIS studies were classified as follows:

- Conceptual
- Sector or industry focus
  - Service sector
  - Biomedical/pharmaceutical
  - Other sectors/industries
- Comparative
- Policy-oriented
- Miscellaneous

TIS studies were classified as follows:

- Case studies
  - Historical/evolutionary
    - Biotechnology/Biomedicine/Pharmaceutical
Each entry in the database was coded (manually) with the appropriate labels. Most entries were found to fit in several categories and thus received several labels. For journal articles, titles, abstracts, and keywords were used to classify items. For many books (including most edited volumes), a table of contents was available on-line, but no abstract or keyword. In some cases a table of contents was not available on-line but was entered separately from other sources. In the remaining cases (mostly monographs) only the title was available. For edited volumes with table of contents, each relevant chapter was entered separately under its author’s name. Thus, an edited volume with 12 chapters might be represented by 13 entries in the database (one entry for each chapter and one for the volume as a whole). In cases when only one or two chapters could be classified, only the chapters were entered into the database and the book entry removed.

Through this process several hundred entries were added to the database. After further checking, the final database for this study included 752 items.
REFERENCES


Leipzig, Duncker und Humblot.


