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National innovation systems: the emergence of a new approach

Jan Fagerberg and Koson Sapprasert

The term 'national innovation systems' surfaced for the first time in print during the late 1980s and, in the years that followed, several important contributions on this topic appeared. This paper investigates the role that this new literature plays within innovation studies and the world of science more generally and discusses the sources for its emergence. With the help of expert assessments, the three most important contributions to the 'national innovation systems' literature are identified. Then the citations to these works in scholarly journals in the Web of Science are presented and the characteristics of the 'national innovation systems' literature, as compared with other areas of research, are analyzed.

INNOVATION IS NOT a new topic. Arguably it is as old as humankind itself. But scholarly attention to it is of much more recent origin. Figure 1, which depicts scholarly publications with innovation in the title as a share of all annual additions to the Web of Science, gives an illustration of this fact. As Figure 1 indicates, in the early 1960s scholarly publications with innovation in the title were few and far between. But from then on scholarly interest in the subject gradually increased. Moreover, there is evidence of a trend break in the early 1990s, after which scholarly works on innovation increased at an even faster pace than before.

This trend break was associated with a bifurcation in the literature on innovation. Until that time the major focus in the literature was on innovation at the level of the firm and/or industry. Although firms and industries continued to be important levels of analysis in the innovation literature, the late 1980s and early 1990s saw the arrival of a new branch of scholarly work that was more holistic in its approach, had a stronger emphasis on the interdependencies between the actors, organizations and institutions that influence the innovation and — above all — was much more focused on policy.

This new branch of the literature — which emerged under the brand name 'national innovation systems' (NIS) — was mainly developed by three scholars; Christopher Freeman (1987), Bengt-Åke Lundvall (1992) and Richard Nelson (1993). However, as we shall see, the contributions by Lundvall were in several ways particularly important in this respect. Not necessarily because he was the first to use the term (which he may have been, see later) but because his work was embedded in a broader theory of the relationship between various social factors, such as shared culture, values and institutions, on the one hand, and learning, innovation and competitiveness on the other hand.

The central focus of this approach, which became very influential, was on interactive learning, not only in a few selected industries but economy-wide, as a driving force of long run economic development. This approach has also inspired similar work on innovation systems at the regional level (Braczyk *et al*., 1998, Asheim and Gertler, 2004).

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To illustrate the change of focus in the scholarly literature, a search for publications containing combinations of 'innovation' and 'system' in the title — a characteristic of the new branch — was undertaken in the ISI Web of Science, and the result was compared with similar information for publications having 'innovation' and 'industry' or 'firm', respectively, in the title. Figure 2 reports the number of new articles added to the ISI Web of Science each year between 1996 and 2008 for 'innovation and system', 'innovation and industry' and 'innovation and firm', respectively, when the average number of articles in each group over the years 1993–1995 was set to 100. The results clearly confirm that the 'system' literature has grown much faster than the innovation literature at large.

The next section of this paper analyses the core literature on innovation with a focus on the role of the 'national innovation systems' literature. Then, in section 3, some of the sources for this new approach are discussed with particular emphasis on the role of the IKE group in Aalborg and the work by Lundvall. In section 4, the focus is shifted from the literature (and the scholars who produced it) to the users of that literature as reflected through citations in scholarly journals. The journals citing this literature are identified and, based on the orientations of these journals towards various disciplines and fields, a 'disciplinary' profile of the users of the NIS literature is constructed. The final section discusses the lessons from the analysis.

2. The role of 'national innovation systems' in the scholarly literature on innovation

What are the most important scholarly publications on innovation and how does the 'national innovation systems' literature fit into this? These are not easy questions to deal with as opinions about what the most important contributions are may differ from one scholar to another. Taking the most cited articles with innovation in the title in the ISI Web of Science (or a similar database) would not solve the problem. First, such databases contain only journal articles, not books, that may be equally or more important in many fields. Second, citations in the database come from all areas of science, and it is not at all obvious that what is most appreciated by the scientific world at large coincides with the preferences of those active in the field of innovation studies. Unfortunately, those preferences are difficult to identify, since 'innovation studies' is not among the many 'subject areas' recognized in the database. One way to circumvent this identification problem might be to narrow the number of citing journals included in the search based on some prior information about which journals that can be considered to be the most

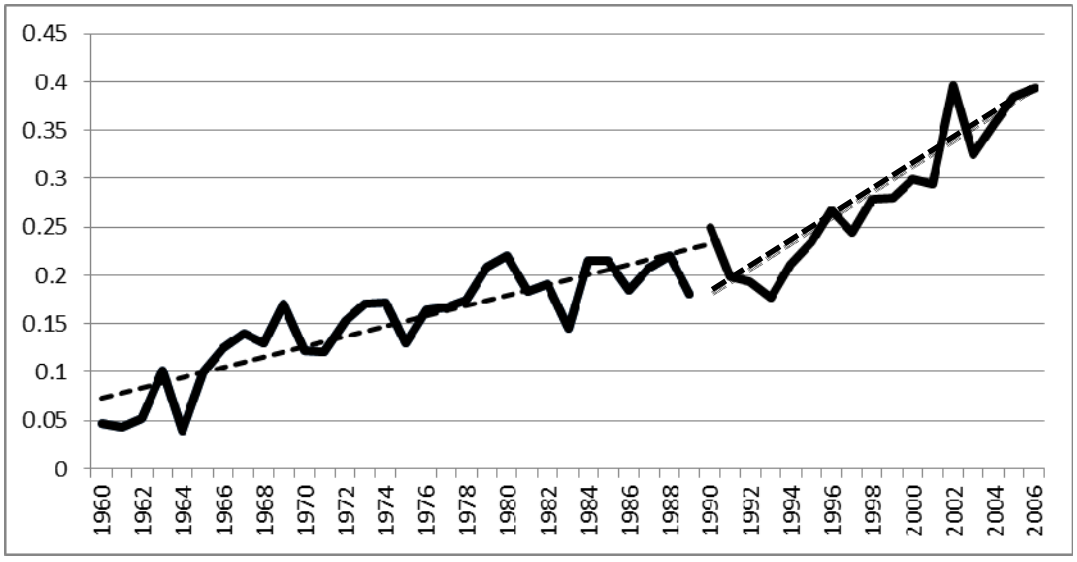

Figure 1. Innovation in title, 1960–2006, percentage of all publications
Source: Own calculations based on data from ISI Web of Science

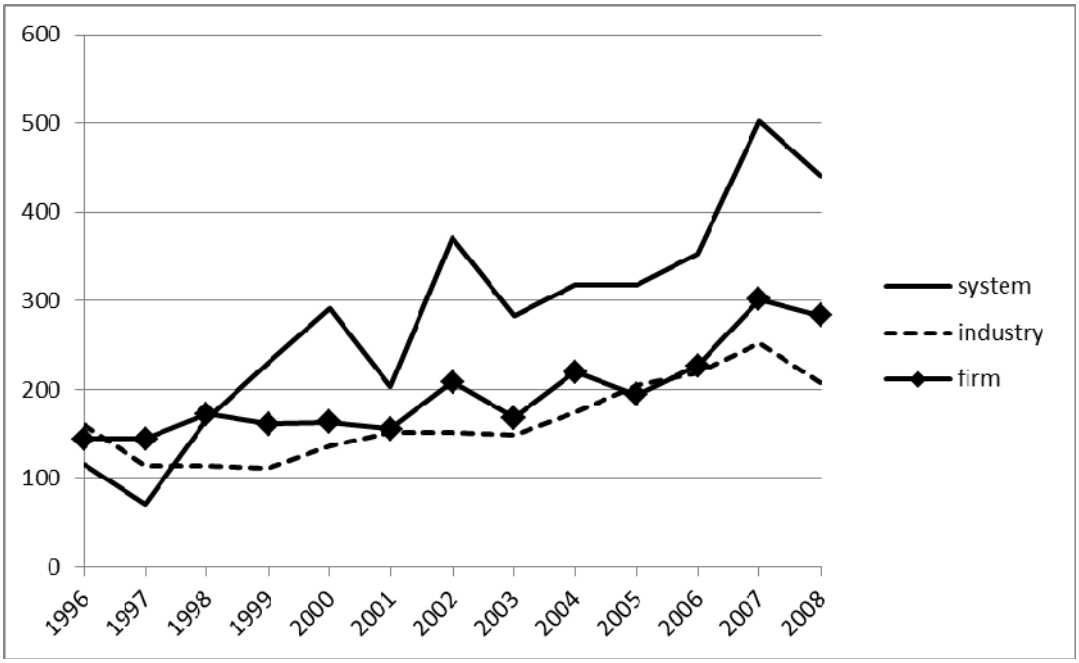

Figure 2. Recent trends in innovation research
Source: Own calculations based on data from ISI Web of Science
Note: System, industry, firm, 1993–95 = 100

relevant. This is, however, quite problematic since important work in innovation studies may occur in many different settings. Arguably, limiting the pool of relevant citations to one or a few selected journals may easily lead to a biased picture.

Therefore, the approach adopted in this paper is to identify the most important contributions through expert assessments. The analysis exploits the fact that there already exist a large number of papers published in so-called 'handbooks' with the explicit purpose of surveying the field or parts of it. It seems reasonable to assume that as experts in their fields the authors of these surveys will refer to the most important literature of relevance for their topic(s). Since these topics may differ — as may the preferences of these authors — the composition of the references should be expected to vary. However, some references may be referred to many times by different authors because these are considered to be of high importance to the field as a whole (and not only a particular aspect of it).

Since the NIS literature did not start to emerge before the second half of the 1980s, with several important contributions from the early 1990s, it seemed appropriate to base the analysis on surveys published after that period. Hence, the first of the eight handbooks in our sample is from 1994 and the last from 2010 (see Appendix 1 for a complete listing).[1] Together these eight innovation handbooks include 209 surveys of various aspects of innovation with altogether 17,403 references to 12,212 different works. Most of these were only referred to once or twice but some were mentioned many times. These are the ones that are of primary interest in the present context. Since scholarly contributions published relatively recently had a smaller chance of being cited than the older literature (simply because the number of surveys published later than the contribution then will be smaller), a measure of citations that adjusts for these differences was preferred (the J-index).[2] To make the analysis more robust we imposed the requirements that to merit consideration here a publication should have at least 60 chances to be cited (this excluded publications from 2004 or later) and the citations it received should come from several handbooks, not just one.[3]

For the reasons pointed out above, when reporting the results of this exercise, it was deemed useful to distinguish between contributions published before the NIS literature emerged (1985 was chosen as the dividing year) and the more recent literature (Tables 1 and 2). In each case, the most important contributions, following the assessments of the experts (as reflected by the J-index), are listed first.[4]

The older literature (Table 1) is dominated by theoretical and/or conceptual contributions with an evolutionary leaning, focusing on the role of firms in long-run economic change (Schumpeter, 1911; Nelson and Winter, 1982; Rosenberg, 1982). Interpretative surveys reflecting the accumulated knowledge at the time about innovation and/or diffusion (Freeman, 1974; Rogers, 1962) also have high ranks. In contrast several of the more recent top-ranked contributions focus almost entirely on the national level, the role of innovation for economic performance and what policy might contribute. Arguably, this reflects a clear shift in orientation. The two top contributions published after 1985 (Lundvall, 1992 and Nelson, 1993) both explicitly deal with NIS. This also goes for Freeman (1987). Porter's (1990) *The Competitive Advantage of Nations*, although not sharing the conceptual framework of the three others, deals with similar issues, for example, the role of innovation for long-run growth and competitiveness, and the implications of this for policy.

Table 1. Ten most important publications published 1985 or earlier

No.	Author	Title	Year	J-index
1	Nelson, R and S Winter	*An Evolutionary Theory of Economic Change*	1982	18.66
2	Rogers, E M	*Diffusion of Innovations*	1962	17.22
3	Freeman, C	*The Economics of Industrial Innovation*	1974	16.27
4	Schumpeter, J A	*The Theory of Economic Development*	1934	14.83
5	Pavitt, K	*Sectoral Patterns of Technical Change: Towards Taxonomy and a Theory*	1984	11.96
6=	Arrow, K	*Economic Welfare and the Allocation of Resources for Invention*	1962	11.00
6=	Rosenberg, N	*Inside the Black Box*	1982	11.00
8	Schumpeter, J A	*Capitalism, Socialism, and Democracy*	1942	8.61
9	Nelson, R R	*The Simple Economics of Basic Scientific Research*	1959	8.13
10=	Solow, R M	*Technical Change and the Aggregate Production Function*	1957	7.66
10=	Burns, T and G M Stalker	*The Management of Innovation*	1961	7.66

Source: References in handbooks (see Appendix 1)

Table 2. Ten most important publications published after 1985

No.	Author	Title	Year	J-index
1	Nelson, R	*National Innovation Systems: a Comparative Study*	1993	20.1
2	Lundvall, B-Å	*National Systems of Innovation - Toward a Theory of Innovation and Interactive Learning*	1992	15.97
3	Christensen, C	*The Innovator's Dilemma*	1997	13.04
4=	Von Hippel, E	*The Sources of Innovation*	1988	12.92
4=	Porter, M	*The Competitive Advantage of Nations*	1990	12.92
6	Cohen, W and D Levinthal	*Absorptive Capacity: a New Perspective on Learning and Innovation*	1990	12.44
7	Freeman, C	*Technology Policy and Economic Performance, Lessons from Japan*	1987	11.96
8=	Kline, S J and N Rosenberg	*An Overview of Innovation*	1986	11.00
8=	Henderson, R and K Clark	*Architectural Innovation: the Reconfiguration of Existing Product Technologies and the Failure of Established Firms*	1990	11.00
10	Teece, D J	*Profiting from Technological Innovation: Implications for Integration, Collaboration Licensing and Public Policy*	1986	10.05

Source: References in handbooks (see Appendix 1)

In the following we are going to focus in more detail on how these three central contributions to the literature on NIS have been received by the scientific world. However, before doing so it seems pertinent to delve briefly into the processes that led to the emergence of this new strand.

Christopher Freeman (1987) *Technology Policy and Economic Performance: Lessons from Japan*, Pinter: London
Single-authored book on the factors behind Japan's rapid economic growth. Focus is as the title indicates on governmental technology policies and the role of MITI. Although this is the first publication to use the NIS term, there is not much discussion of it.

Bengt Åke Lundvall (1992) *National Systems of Innovation – Toward a Theory of Innovation and Interactive Learning*, Pinter: London
Collective work by members of the IKE group in Aalborg introduced and edited by Lundvall. Several theoretical and thematic chapters focusing on national systems of innovation and aspects thereof. Mostly but not exclusively referring to Danish evidence. Freeman is among the contributors.

Richard R Nelson (1993) *National Innovation Systems: A Comparative Study*, Oxford University Press: New York
Collective work by an international team of authors edited and introduced by Nelson. The book contains an introduction and summary and a number of country studies. Lundvall is among the contributors.

3. The emergence of the national innovation systems literature

The literature on NIS emerged as mentioned in the late 1980s. The first to use it in public was Christopher Freeman in a book about the Japanese innovation system (Freeman, 1987). Applying a Schumpeterian perspective, Freeman saw economic growth as resulting from innovation and diffusion of technology. However, in contrast to Schumpeter, Freeman was interested in the abilities of different nations to exploit this process to their own benefit and what policy might contribute in this respect. These abilities, Freeman pointed out, varied a lot, and that needed to be explained. He used the national innovation system term for the factors within each nation that could be used to explain these differences.[5]

At the time Freeman was also engaged in an international research project together with a large number of other scholars on 'technical change and economic theory' resulting in a book with the same name. This book (Dosi *et al*., 1988), which became very influential, contained a special section on 'national innovation systems' with contributions from among others Nelson, Freeman and Lundvall. While the chapter by Nelson concentrated on 'institutions supporting technical change in the US', and Freeman once more focused on the Japanese case,

the chapter by Lundvall was entitled 'Innovation as an interactive process: from user–producer interaction to the national system of innovation'. As the title indicates, Lundvall was to a larger extent than the two other writers concerned with the theoretical basis for assuming that such national systems exist and the implications that this might have for policy. Nelson expressed this difference in ambition well in the introduction to the said section:

> The Nelson and Freeman chapters simply assume that there are national systems, and that borders matter. Lundvall presents a theory as to why this might be the case. (Nelson, 1988: 310)

This theory, with its emphasis on interactive learning, was laid out in much more detail a few years later by Lundvall and colleagues in the collective volume: *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning* (Lundvall, 1992).

Although Freeman was the first to use the term in a publication, he was quick to point out that:

> according to this author's recollections, the first person to use the expression 'National Systems of Innovation' was Bengt-Åke Lundvall. (Freeman, 1995: 5)

This may be the case but it is difficult to verify with certainty (Sharif, 2006). As Lundvall pointed out in his first published contribution on the topic:

> the basic ideas presented … reflect a collective effort at the IKE group, at the Aalborg University, where a research team, studying Industrial Development and International Competitiveness, has pursued theoretical and empirical work, based on a dual inspiration from French industrial economics and British innovation theory. (Lundvall, 1988: 366)

The IKE group — literally the 'International Competitiveness Group' — was started in 1977 at the newly founded Aalborg University Center in Northern Jutland in Denmark with Lundvall as the leading figure (he had been affiliated with the university since 1973). In 1979 the group published a research program on 'industrial development and international competitiveness' (Andersen *et al*., 1979). The international competiveness of a country, it was argued, was based less on costs and prices than on command of technology, the advance of which was in need of explanation (and hence research). It was not sufficient, it was pointed out, to see technological advance as a mere reflection of investments in R&D, since a large share of this advance was the result not of R&D but of learning (Andersen *et al*., 1979: 44). Learning, it was argued, might also induce R&D investments, which hence should be seen as partly endogenous (Andersen *et al*., 1979: 44).

The IKE group — literally the 'International Competitiveness Group' — was started in 1977 at the newly founded Aalborg University Center in Northern Jutland in Denmark with Lundvall as the leading figure

Since then a strong emphasis on learning — not only in high tech but everywhere — has been a hallmark of research by the IKE group. Several projects analyzed learning in various sectors and contexts such as, for example, agriculture and food (Lundvall *et al*., 1983). An important conclusion from this work was that learning and innovation commonly occur through interaction between holders of different types of knowledge such as, for example, users and producers of technology (Lundvall, 1985). Such interactive learning, it was pointed out, is conditioned by institutional and cultural factors, related to nation states, which hence need to be taken into account (Lundvall, 1992). From the very start the researchers in the IKE group found it natural to study this dynamics from a systems perspective. In early work the concept 'national system of production'[6] was used for this purpose (Andersen *et al*., 1979) but as the research developed this gave way to the term 'national system of innovation' (Lundvall, 1988, 1992).

Godin (2009) has recently argued that the 'national innovation system' approach grew naturally out of work at the OECD. It is certainly correct that the 'system' term has been widely used both in the OECD and other contexts for a long time. However, as shown above, the researchers in IKE group used a 'system' approach to the study of the national economy already in the 1970s. The inspiration for this, as is well documented (see e.g. Lundvall, 2004, and above), was clearly not the environment at the OECD but heterodox economic analyses inspired by the works of Karl Marx (who arguably had a system approach). In fact, the influence of Marxian thinking on advances in innovation theory revealed here is by no means unique. Already Schumpeter expressed his deep intellectual debt to Marx' dynamic approach (Schumpeter, 1937/1989: 166).

Thus, while there are strong reasons to doubt that the 'national innovation system' approach is something Lundvall imported from the OECD as Godin posits, Lundvall did get a connection to the OECD *after* he had published his most influential works on the subject. Between 1992 and 1995 Lundvall worked as Deputy Director at the directorate for Science, Technology and Industry at the OECD in

Paris. During his tenure there and afterwards he did much to propagate the NIS approach. This resulted in a series of publications from the OECD during the 1990s.[7] Several studies of NIS in individual countries have also emerged, including Lundvall's own study of Denmark (Lundvall, 2002).[8] The strong focus on NIS in the OECD from the mid-1990s onwards probably owes much to Lundvall's influence there.

4. From producers to users: the role of the 'national innovation systems' literature in the world of science

This section moves from the (original) producers of the NIS literature, and the context within which this new branch of scholarly work developed, to the users of this literature within the world of science. To research this particular case of user–producer relationships we will use citations in scholarly journals included in the ISI Web of Science to the three most important publications on the subject, that is, Freeman (1987), Lundvall (1992) and Nelson (1993), between 1993 and 2008. Figure 3 shows the citations to these three books from 1993 (when the most recent of these was published) onwards. The total number of citations to these books grew rapidly from the early 1990s until 2003, after which it flattened out, with a new peak in 2007, largely due to a jump in the number of citations for Lundvall (more than 100 that year).[9] The Lundvall and Nelson volumes soon took over the role of Freeman's book as the users' favourites, reflecting, probably, the more explicit focus on NIS by Lundvall and Nelson. Since the beginning of the millennium the Lundvall volume has been the most cited among the three. This volume also has a higher number of total citations (over the entire period) than the two other books.

However, the evidence presented above may indicate that the number of citations of the three NIS books, after growing rapidly year after year for 15 years or so, now has ceased doing so. There may be several reasons for this. First the three NIS books may be victims of their own success. The NIS term may have become so widely diffused that it is now considered a part of everyday language, implying that it may no longer be seen necessary to refer to the originators of the concept. Second, research may have progressed. New contributions, suggesting various types of improvements, may have emerged, in which case it may be more natural to cite these than the older works. Third, the NIS literature may after years of expansion have reached out to most potential users, in which case it would be natural to expect the growth of the field to slow down. Finally there is the possibility that the NIS literature is not considered so relevant any more by many researchers, and that they therefore have stopped citing it.

There may be something to be said in favor of all four interpretations, and it is difficult to discriminate conclusively between them with the available information. However, it is worth noting that the data on new publications on innovation, using a system approach, indicates that the literature has continued to grow very rapidly also after 2003 (Figure 2). Hence, the research area as such does not appear to have run out of steam, indicating, perhaps, that the last interpretation is the least likely.

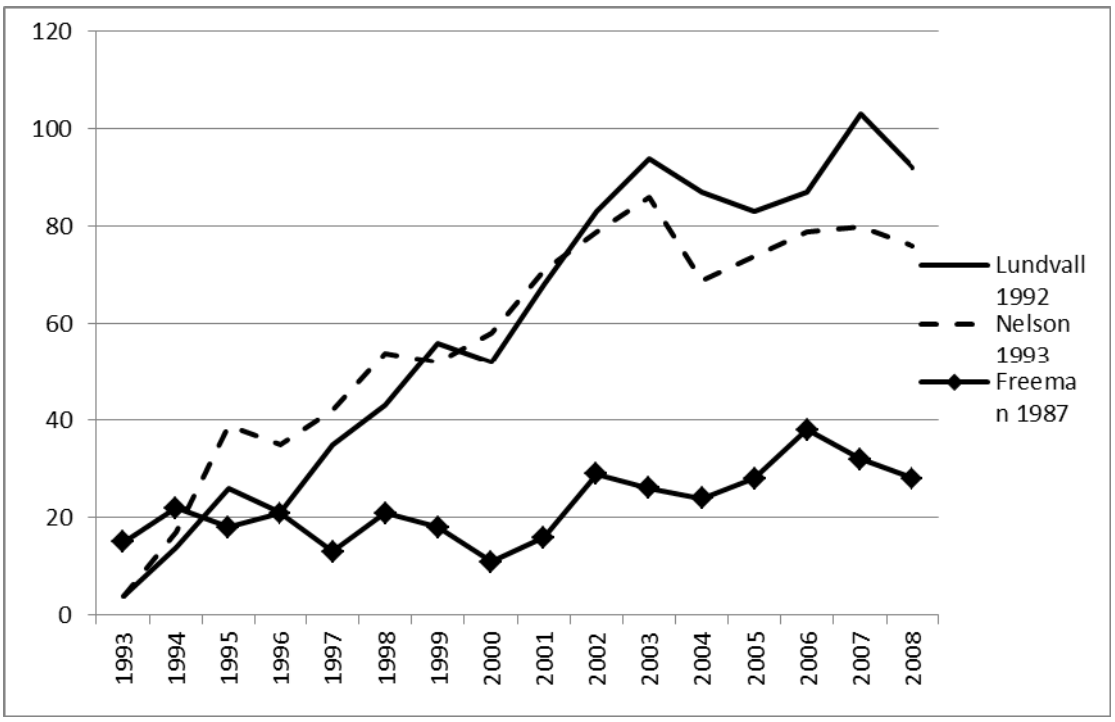

Figure 3. Citations to the three most important national innovation systems books, 1993–2008
Source: Own calculations based on data from ISI Web of Science

In total, 343 different journals cite the three NIS books. However, most of these cite very little. Table 3 lists the 10 most important journals accounting for 44% of the total number of citations in journals included in the Web of Science to the three books. In addition to the share of citations from the journal in the total number of citations to the three books, Table 3 also includes information on the subject area(s) of the journal and its five-year impact factor (the average number of citations to an article in the journal over a five-year period after it was published). The latter is often used as measure of the 'quality' of the journal. However, citing behavior varies across different scientific fields, and the calculated impact factors may be influenced by such differences, so some caution is advisable when interpreting these statistics.

Research Policy is in a class of itself with 15% of the citations. This is three times the level of the second most citing journal, *European Planning Studies*. Thus scholars publishing in *Research Policy* are particularly eager users of this literature. *Research Policy* also ranks first among the top citing journals when it comes to impact factor, nearly twice as high as the second journal on the list when ranked after impact factor, *Scientometric*s. This suggests that *Research Policy* may have played a very special role in promoting work on NIS and scholarly work on innovation more generally (on the latter see Fagerberg and Verspagen, 2009).

The 10 journals cover 12 different subject areas, so it is evident that the NIS literature attracts interest from journals in a variety of scientific fields, many of which have a multidisciplinary orientation. The two most frequent subject-areas are management and planning and development (which includes research policy). Most of the journals cover several subject areas. For example, of the four journals focusing on management, two also cover aspects of engineering, one combines it with multidisciplinary sciences and the last one, *Research Policy*, with planning and development. There are also two economics journals among the top 10, both rather heterodox in their orientations (*Cambridge Journal of Economics* and *Journal of Evolutionary Economics*).

A more comprehensive picture of the user communities can be obtained by taking into account all citations, not just those in the top 10 journals. To do so we exploit the fact that each citation, through the journal in which it occurs, has an association with one or more subject-areas. By adding these up, and fractionalizing when an article is associated with more than one subject area, it is possible to get a better overview of the orientation of the users towards different subject areas (which can be disciplines or specializations within and across these). However, since there are several hundred such areas, we found it useful for our discussion here to aggregate these areas into a smaller number of classes, using an aggregation scheme developed in a previous paper (Fagerberg and Sapprasert, 2010).[10] Figure 4 gives the percentage share of the top 10 subject area classes in the total number of citations to the three NIS books up to and including 2008. These 10 subject classes cover 94.6% of the total number of citations to the (core) NIS literature during this period.

Figure 4 shows that the NIS literature is used by a number of different communities, of which management, planning and development, economics, and geography and environment are the most important. Together these four communities account for close to one half of the total number of users of this literature. However, although most of the users are in the social sciences (broadly defined to include management, economics, etc.), there is also a fair number of users in engineering and other natural sciences, emphasizing once more the strong cross-disciplinary appeal of this literature.

To what extent does this pattern deviate from what should be expected from an 'average' field within the world of science? We can get an impression of this by controlling for the size of the subject area (class) in the Web of Science. This is done in Figure 5, which reports specialization indices for the 10 largest user communities. If the share of citations of, say, management in the total number of citations

Table 3. Three national innovation systems books: ten most important journals

No.	Journal	%	Subject area(s)	Five-year impact factor
1	*Research Policy*	15	Management; planning and development	4.0
2	*European Planning Studies*	5	Planning and development	1.1
3	*International Journal of Technology Management*	4	Engineering, multidisciplinary; management; operations research and management science	1.0
4	*Technovation*	4	Engineering, industrial; management; operations research and management science	1.9
5	*Regional Studies*	4	Environmental studies; geography	2.1
6	*Technology Analysis and Strategic Management*	3	Management; multidisciplinary sciences	1.0
7	*Cambridge Journal of Economics*	3	Economics	1.0
8	*Technological Forecasting and Social Change*	2	Business; planning and development	2.1
9	*Scientometrics*	2	Computer science, interdisciplinary applications; information science and library science	2.3
10	*Journal of Evolutionary Economics*	2	Economics	rm4

Source: Own calculations based on data from ISI Web of Science

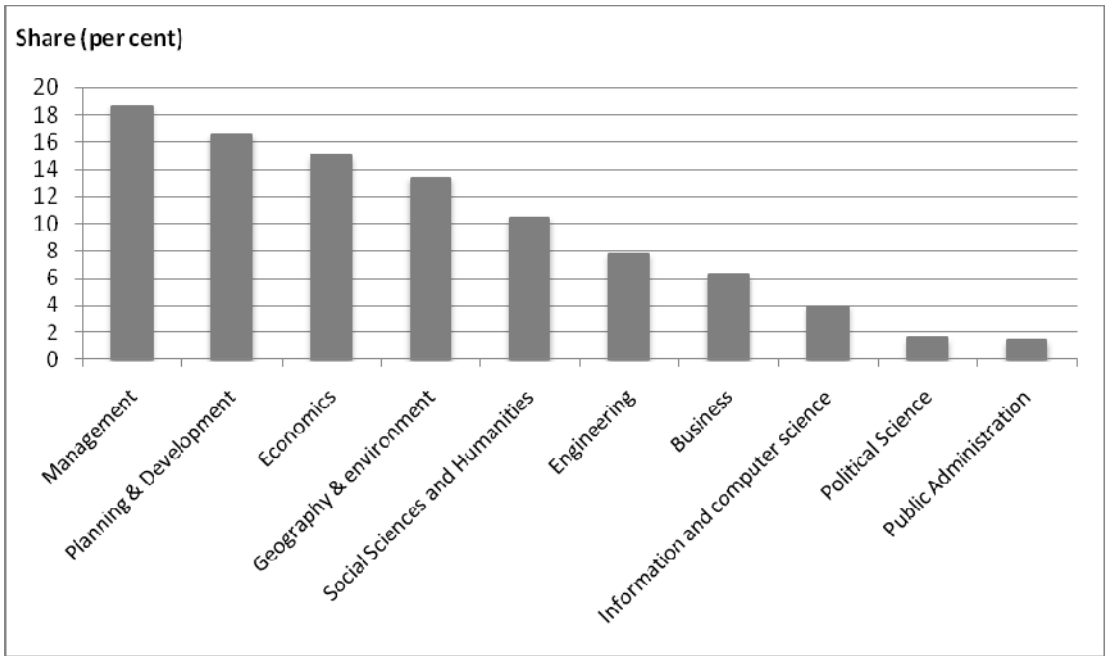

Figure 4. Share of ten most important user communities in total citations of national innovation systems books, percentages
Source: Own calculations based on data from ISI Web of Science for the years 1987–2008

to the three NIS books exceeds the share of management-citations in all citations in the Web of Science, the index will be above 1 and *vice versa*. The result shows that the reason why planning and development looms so large here is not that this field in itself is large (it is not), but that the scholars within this field are extremely eager users of the NIS literature. The same holds, to a lesser degree but still very significantly, for management. Also scholars within economics, geography and environment, business, and public administration tend to be more interested in the NIS literature than the share size of their respective fields would indicate.

Another relevant comparison might be between the users of the NIS literature and users of other types of work on innovation. Based on the expert assessment dealt with in section 2, we identified a sample of central works on innovation (all works

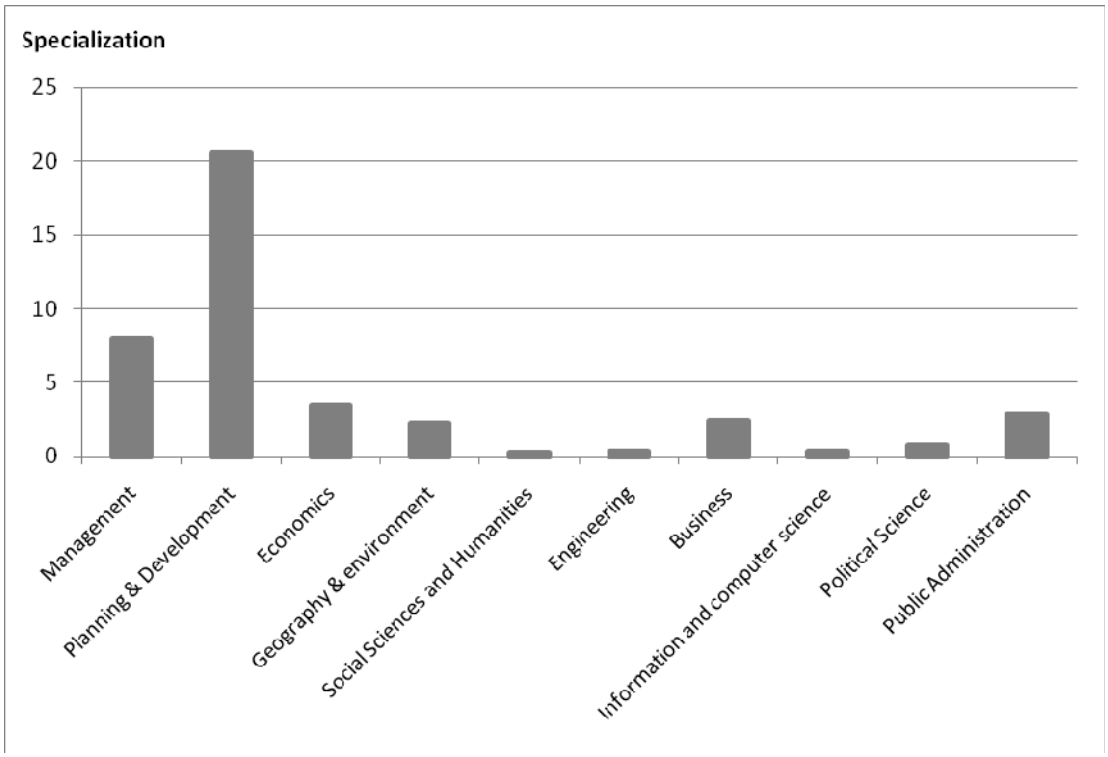

Figure 5. Specialization of ten most important national innovation systems user communities
Source: Own calculations based on data from ISI Web of Science for the years 2003–2008
Note: Index (mean = 1)

with a J-index above 6, 40 works in total). This includes, of course, the three NIS books but for the purpose of the comparison these books (and two other publications that also focused on NIS[11]) were excluded. The results, in the form of specialization indices, are reported in Figure 6.

If a community uses the two types of literature to the same extent, the index will be unity. Hence, an index above unity indicates that members of the community are using the NIS literature more frequently than other types of work on innovation and *vice versa*. It is shown that the NIS literature is three times as popular as other central works on innovation among planning and development scholars. Also researchers focusing on geography and environment, and (the policy-oriented field) public administration, hold the NIS literature in relatively high esteem when compared to their interest in works on innovation more generally. In contrast, scholars within business, management, and information and computer science appear to be less interested in the NIS literature than their usage of the innovation literature more generally would suggest.

5. Conclusions

The term 'national innovation systems' surfaced for the first time in print during the late 1980s and in the years that followed several important contributions using this term appeared. Using bibliometric evidence this paper has investigated the role that this new strand of research plays within innovation studies and the world of science more generally. It is shown that experts in this area consider the central contributions to the NIS literature to be among the most important — not to say the most important — works on innovation published during the last two decades. It is also shown that emergence of the NIS literature coincides with an upturn in the scholarly interest in innovation more generally.

The way in which this new approach has contributed to the development of the field arguably has much to do with its explicit focus on policy and the holistic and systemic perspective it offers on policy-related matters. This has attracted the attention of a large number of scholars worldwide working on issues such as science policy, research policy, technology policy, innovation policy and regional policy. The NIS literature has contributed to the integration of these (previously much more separate) fields by pointing to the interactions between different policy areas in promoting (or hampering) innovation and, hence, economic performance of countries or regions. This new current of research has therefore been especially popular in journals that deal with such policy-related matters and allow for cross-disciplinary perspectives.

There have been some attempts to discuss the origins of the NIS approach by focusing on the choice of terminology, particularly the usage of the word 'system' (Godin, 2009). However, over the years, terms involving the word 'system' have been used by many different authors in a variety of contexts,

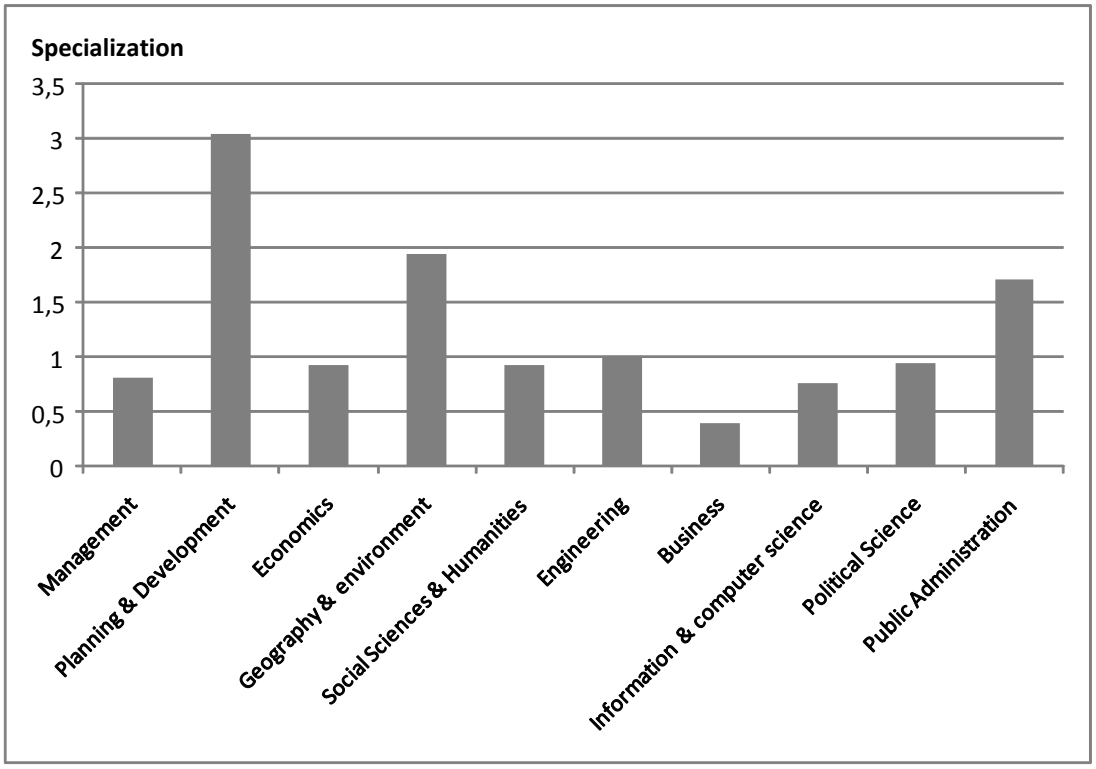

Figure 6. National innovation systems users compared with users of other types of work on innovation
Source: Own calculations based on data from ISI Web of Science for the years 2003–2008
Note: Index (mean = 1)

and it is difficult to conclusively link the emergence of the NIS approach directly to one of those previous usages. As noted, Christopher Freeman, the first scholar to use the NIS term in published work, pointed to Bengt-Åke Lundvall as the originator of the term.[12] Although this is difficult to verify with certainty (Sharif, 2006), what seems clear is that Lundvall and the IKE group in Aalborg played a very important role in developing this new approach. Their collective work (Lundvall, 1992) has become the most cited work worldwide on the topic with close to 100 citations per year (and nearly 1,000 citations altogether) in scholarly journals. Any publication within the social sciences that becomes that widely cited must be regarded as a true classic. This is an extraordinary achievement, and taking into account that this work originated in a small, new university in the Danish periphery, only adds to it.

Appendix 1. Sources with number of chapters and references

Name of author/editor	Title	Year of publication	Number of chapters (references)
M Dodgson and R Rothwell	*Handbook of Industrial Innovation*	1994	35 (1,247)
P Stoneman	*Handbook of the Economics of Innovation and Technological Change*	1995	13 (1,630)
L Shavinina	*International Handbook on Innovation*	2003	71 (4,303)
J Fagerberg *et al.*	*The Oxford Handbook of Innovation*	2004	22 (1,688)
M S Poole and A H van de Ven	*Handbook of Organizational Change and Innovation*	2004	13 (1,958)
J Tidd *et al*.	*Managing Innovation*	2005	13 (1,084)
B-A Lundvall *et al.*	*Handbook of Innovation Systems and Developing Countries*	2009	13 (975)
B Hall and N Rosenberg	*Handbook of the Economics of Innovation* (2 volumes)	2010	29 (4,518)

Notes

1. Seven of these have 'handbook' in the title, the eighth is a highly regarded textbook in the management of innovation. Of these eight (see Appendix 1), two have an explicit economics orientation, two focus on management and organization, one considers innovation in the developing world, while the remaining three are characterized by a broad, cross-disciplinary orientation.
2. The J-index is the number of citations to a particular contribution divided by the chance of being cited (the number of handbook chapters published after the contribution), multiplied by 100 (i.e. expressed as a percentage of the maximum).
3. If as happened in a few cases, a publication received citations from more than one handbook but one handbook was found to be completely dominating (more than two thirds of the references coming from one handbook), the references coming from that handbook were dropped when calculating the J-index.
4. In cases when two publications have the same J-index the most recent was ranked first.
5. Freeman also used the term — albeit briefly and without explanation — in an unpublished paper prepared for the OECD in 1982 (see Freeman, 2004).
6. The adoption of this term was, according to Andersen *et al*. (1979), inspired by French neo-Marxist economists, especially Palloix (1977, 1978) and GRESI (1976). Lundvall (2004) mentions the same sources but uses the label 'French structuralist economists'.
7. See, in particular, OECD (1997, 1999, 2002). For an overview and discussion of OECD's work on this topic, see Godin (2009).
8. Space does not allow us to go into detail about the vast amount of literature that has emerged on innovation systems (for an overview, see Edquist, 1997, 2004).
9. For all three books there is a decline in the number of citations from 2007 to 2008, the last available year when this analysis was done. However, since it is possible that the statistics were not complete for the most recent year (registration often takes time, issues may be delayed, etc.), one should not jump to strong conclusions from this (scant) evidence.
10. This aggregation scheme is based on the assumption that scholars with similar citing behavior can be said to belong to the same user community, while those whose citations patterns differ significantly, belong to different communities. See Appendix B in Fagerberg and Sapprasert (2010) for further details.
11. A table documenting these 40 top works (when ranked after J-score) is available from the authors on request. The five works not included in the sample (with which the three NIS books were compared) were — in addition to the three NIS books — Edquist (1997), a collective work on innovation systems edited and introduced by Edquist, and an early paper by Lundvall on the subject (Lundvall, 1988). These two publications, ranked 34 and 35 on the top 40 list, had J-scores of 7.2 and 6.8, respectively.
12. According to Richard Nelson (private correspondence) the idea of a national innovation system, if not the term, was by the 1980s very much 'in the air' breathed by scholars within what he calls 'the extended SPRU community'. Hence, in Nelson's view, the concept was there implicitly, and what the publications of the late 1980s and early 1990s did was to put it down in writing.

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