Sun, Y.,T, and Grimes, S (2016) 'The emerging dynamic structure of national innovation studies: a bibliometric analysis'. Scientometrics, 106 :17-40.

Abstract: The state is still the significant unit for innovative studies during the age of R&D globalization and innovation regionalization. Using the bibliometric method, this paper attempts to provide a comprehensive picture of national innovation studies based on data derived from the Web of Knowledge. In particular, we identify the most significant countries and institutions, major journals, seminal contributions and contributors, and clusters in the network of citations in the field of national innovation studies. The results are useful for understanding and promoting the field of national innovation.

Key words: innovation studies, bibliometric, national innovation system, HistCite

1 Introduction

In what is termed the ‘knowledge-based economy’, the vital factors for economic growth and the wealth of nations are science, technology and innovation (STI). Although few scholarly publications on innovation appeared before the 1960s, the starting point of innovation studies is Schumpeter

(1934, 1942) (Carlsson 2007). Even when innovation studies grew in popularity from the 1960s onwards, most scholars, following on from Schumpeter, paid more attention to the firm level as opposed to the national level, since allegedly, enterprises felt their future depended on their ability to innovate (Christensen 1997; Christensen and Raynor 2003).

A 1945 report, entitled 'Science, the Endless Frontier: a Report to the President', by Vannevar Bush (1945), head of the US Office of Scientific Research and Development, is regarded as a pioneering work in national scientific and technology policy. With the growing awareness of the need for public policies at the national level to stimulate innovation, there was a greater interest in the role of STI within national prosperity and international competition. However, at this stage the understanding of innovation activity was influenced more by a linear research model, from basic research to applied and development research rather than a systems model. Japan's growth model in the 1980s raised concern within the international community. In the process of studying Japan's economic powerhouse, scholars found that firms do not normally innovate in isolation, but rather through collaboration and by means of interdependence with other organizations, and this helped to shape the notion of an innovation system. Since the early 1990s, national innovation studies began to emerge and rapidly increase in importance. Politicians began paying more attention to innovation and the policy discussion centered around the problem of how to enhance national indigenous innovation

capacity with a systems approach (Goto and Wakasugi 1987; Hu and Mathews 2005, 2008). Thus national innovation studies developed as a result of the interaction between the nation-state and the systems approach to innovation.

With globalization, a combination of revolutionary technologies in transportation and communications, the increasing power of transnational corporations (TNCs) and special regions such as Silicon Valley have become the drivers of the world economy, but without taking economic power away from the nation-state (Dicken 2007). In contrast, globalization and increased competition between TNCs have strengthened the role of the nation-state in innovation. In many countries the state has played and continues to play an important role in the development of innovation. The state is the significant unit for comparing levels of innovative activity internationally, with the national interest being of prime importance within global governance. Economic growth theory focuses on the wealth of nations as the valid unit for comparing economic completion internationally. Innovation is a crucial factor for competing with other states and for explaining differences in levels of growth between countries, although explaining differences in levels of innovation between countries is challenging. Case studies show sharp differences between national systems of innovation in attributes such as institutional setup, and R&D investment and performance (Nelson 1993). Others stress the importance of the state for making and implementing policy, with the role of nation-state being seen

as containers of distinctive institutions and practices, and as regulators of economic activity and transactions (Dicken 2007). Indeed, the system of national innovation can be seen as a set of interrelated institutions that produce, diffuse and adapt new technical knowledge, be they industrial firms, universities or government agencies (Niosi 2002). In other words, most public policies influencing innovation processes as a whole are still designed and implemented at national level, while the importance of the nation lies partly in the fact that it captures the policy dimensions of innovation.

The emergence of national innovation studies reflects a shift from the linear model to the systems model, with the focus of studies moving from single-firms to multi-actors. The innovation system (IS) approach stresses the notion of innovation as a collective and interactive process among a wide variety of actors, firms as well as non-firms, organizations such as universities, research institutions, government agencies, financial institutions and so on, rather than as something in isolation (Malerba 2002). The innovation system approach places innovation and the learning process at the centre, and by emphasizing interdependence, non-linearity and the role of institutions, adopting a holistic and interdisciplinary perspective, and employing historical and evolutionary perspectives, can encompass both product and process innovation, as well as subcategories of these types of innovation (Edquist

2004). When the idea of the innovation system was first discussed in the middle of the 1980s, nobody expected that it would become as widely diffused as it is today.

It is obvious that the IS concept is not equivalent to the concept of the national innovation system (NIS), although many scholars use the IS to represent the NIS[1]. The "innovation system" concept was introduced by Lundvall (1985), but without the adjective "national" being added (Lundvall et al. 2002). NIS also makes use of the basic ideas of "national systems of production" from Friedrich List to explain economic growth and the development gap from the perspective of innovation (Lundvall 2007). Since the NIS concept is the first application of IS, most people know about IS from NIS and tend to think that the NIS concept is an expansion of "innovation systems" (Niosi 2002).

The NIS can be seen as an analytical framework which serves as both model and tool, emphasizing the characteristics of innovation, rapid technological change and globalization (Sun and Liu 2010). The extreme specialisation among policy institutions and analysts has become such a practical issue that NIS as an analytical concept helps to overcome this problem and has been very much welcomed particularly by those responsible for innovation and science policy (Sharif 2006). The basic motivation for the study of innovation provided by Schumpeter is the need to understand the nature

[1] In this paper, the term of *national innovation system* is equal to the term *national system of innovation*.

and source of economic growth, which is different from the explanation offered by endogenous growth theory (Carlsson 2007), since it is clear that the neoclassical assumption about agents making choices between well-defined alternatives cannot apply (Sharif 2006). Having identified gaps in neoclassical economic thinking, scholars and policy makers in the innovation field proposed the NIS as an alternative that would make up for those inadequacies.

In sum, innovation studies at the national level should be a primary theme for the knowledge-based economy and integrated into studies of national economic growth. In recent years, scholars have published several excellent theoretical surveys of the NIS literature but there appears to be a lack of a comprehensive survey on national innovation studies (e.g. Edquist 2004; Corlsson 2007; Sharif 2006; Lundvall 2007; Gordin 2009; Fagerberg and Sapprasert 2011; Teixeira 2014). This paper attempts to provide a comprehensive picture, showing the relative positioning of topics within the national innovation studies literature both through quantitative and bibliometrical surveys based on data derived from the Web of Knowledge. HistCite, a software tool for analyzing and visualizing citation linkages between scientific papers, is applied to investigate a large body of literature. We try to map the whole dynamic picture of national innovation studies, identifying major countries and institutions, key journals, the seminal contributions and the contributors, clusters in the network of citations within the field of national innovation studies.

2 Method and data

A bibliometric method is used to quantify and compare scientific activities at various levels of aggregation including institutions, countries, authors, journals and so on. Citation analysis is one of the fastest growing areas of research in the bibliometric analysis, and many papers have examined both individual articles and conducted citation analyses over time (Walters 2011). A process and software called HistCite provides a good tool for historical analysis, which could be applied to explore the evolutionary characteristics of national innovation studies (Garfield et al. 2002). Its inputs are bibliographic records (with cited references) from the "Web of Knowledge" or other similar sources. Its outputs are various tables and graphs with informetric indicators about the knowledge domain under study (Garfield et al. 2006). HistCite software has been common used visualize development path of study field (Lucio-Arias and Leydesdorff 2008; Garfield 2009).National innovation studies as an interdisciplinary research is classified as social science and includes research area such as economics, management, sociology and policy studies. We use the Social Science Citation Index (SSCI) of the Web of Knowledge (WoK) as our data source.

Thomson Reuters' WoK was used as a data tool. At first, we opened the web page of "basic search" in the database of "Web of Science^{TM} Core Collection", and the words "national + innovation" were

inserted in the search box as “topic”. Second, we selected the “timespan” from 1963 to 2012 and the settings “Social Sciences Citation Index (SSCI) --1956-present” in “Web of Science Core Collection: Citation Indexes”. Finally, we searched, selected and downloaded all publication records on national innovation.

Standard bibliometric analysis was carried out in HistCite using data downloaded from the WoK. These imported records are defined a knowledge domain (collection). Between 1963 and 2012, there were 3579 published records, 6948 authors, 1225 journals and 129424 cited references. In order to learn the development trend of national innovation studies and the dynamic relations among published records, we added all publications that cited the 3579 publications as well as all the references quoted in those citing papers. The resulting aggregated database is referred to as the national innovation research collection (NIRC). In addition, the time window is one year in this work.

Every publication of the knowledge domain is described by its references and citations inside and outside the domain. The citation is actually calculated though the frequency of each publication as references. Thus, the local citation score (LCS) is based on the citation frequency within the basic collection- NIRC, and the global citation frequency, that is, how often each paper is cited in the entire SSCI realm (Garfield et al. 2002). Since impact of national innovation studies within NIRC is

a major concern for scholars in this field who are our primary readers, we consider only the LCS and without regard to the global citation in this article. Obviously, the limitation is that we could not explore the actual outreach of national innovation into other domains within the SSCI realm, let alone within the WoK realm.

TLCS-total local citations scores means all local citations within the basic collection- NIRC. TLCS/x means total citation score excluding self-citations. ALCS-the average local citation scores means the local citation scores per paper. LCS/t means the score per year, which shows the average citation score since the publication date. LCSe shows the LCS for the period from the arbitrary cut-off year until the last year of the collection time span. LCSb shows the LCS only from the beginning of the collection to an arbitrary cut-off year. LCS (e/b) equals LCSe divided by LCSb. When LCS (e/b) is greater than 1, this means that citations tends to increase; in contrast, when LCS (e/b) is less than 1, citations tends to decrease.

[Figure 1 about here]

According to figure 1, before 1990, studies in national innovation were still in the incubation period, with few scholars interested in this topic and only a few contributions. Since the early 1990s, however, there has been a dramatic and monotonic rise in publications. The number of articles published annually was about 100 after 2000, and reached 450 by 2012. In relation to citations, the

total local citations scores (TLCS) was similar to that of article records before 1990. After 1990, the curve of TLCS has an “inverted U-shape”, reflecting fluctuations in growth before reaching a peak in 2002, and then declining rapidly. This rapid growth in the number of records from the early 1990s shows that innovation studies at the national level became an important field of work among the international community. Indeed, innovation is the key driver of economic growth in the knowledge-based economy. In this article, the state is the main rival unit under globalization, which means that besides transnational corporations (TNCs), the state is also the principal agent of competition within the context of globalization. Analysis of competition between countries became a very interesting and significant issue for policymakers, entrepreneurs and academics.

National innovation studies became a rapidly emerging field form the 1990’s onwards partly in response to the increased demand within academia and policymaking related to economic trends during this period. Within the policymaking realm, economic recession in Europe encouraged governments and international organizations to explore the potential for economic growth. Examples of this were the Swedish Board for Technical Development, which initiated the study ‘Sweden’s Technological System’ in 1988, and the Technology/Economy Programme (TEP) initiated by the OECD in 1988 (Sharif 2006). In the academic realm, scholars attempted to explain national differences between economies, particularly with reference to Japan’s economic miracle in the late

1980s. During these discussions, the NIS concept and national innovation studies emerged rapidly. The fall in the number of citations more recently partly reflects the citation life cycle of recently published papers, but it also reflects the fact that fewer seminal papers have been published since 2002 (Walters 2011).

[Table 1 about here]

It must be admitted that various document types have different functions and meanings for scholars. While different types of documents are awarded various levels of significance by academics, the total number of publication records and the local citation scores can reflect the overall influence of a particular publication to national innovation studies. To be specific, more than 80% of publications were journal articles, followed by conference proceedings, reviews, books reviews, editorials and other material (Table 1). While published journal articles constituted the main contribution to the field of national innovation, conference proceedings were also important. They are usually distributed to researchers in book or CD format either before or after conferences. The average local citation scores (ALCS), the local citation scores per paper for proceedings papers was higher than for other types of publications, indicating that they were quite influential in diffusing new developments in this area. It is also interesting to note that ALCS for literature reviews, while lower than that of conference proceedings, was higher than for published papers. Thus, while articles are the most

significant contributions to national innovation studies, both proceedings papers and reviews are more influential in terms of citations.

3 The most significant country and institution of contributing to national innovation studies

At first, we pay attention to the country and institution of contributing to national innovation studies. Table 2 shows both the records and TLCS of papers from various countries published from 1963 to 2012. Among the 3579 records that explicitly analyzed or compared countries, the US is the undoubted leader, accounting for 28.3% of the total, followed by the UK, Canada, Australia and the Netherlands. Around 44.4% of the total number of papers was from the first group, which include the US and the UK, with a large gap between them and the remaining countries. China, with 2.4% of total records was the only developing country in the list of top ten countries by records. Although national innovation studies relates to the context of national politics, economy and society, most of the literature was published in local journals in the local language (Van Leeuwen et al. 2001). Since these local journals, however, were not included in the SSCI realm that favors international journals in English, this might partly explain the high degree of visibility of North America, UK , and Australia.

Indeed, the output (records) and impact (citation) of publications are completely different indicators. However, in terms of TLCS, the US and the UK remained as the top group, meanwhile Denmark and Sweden replaced Italy and France in the list of top 10 countries by records. Eight countries overlap in two lists of top 10 countries in terms of records and citations, which means that there is some relation between quality and quantity of publication at the country level.

[Table 2 about here]

In terms of the geographical distribution of contributions, the US and Canada (North America) account for 33.5% of total records. Apart from China and Australia, the remaining eight countries accounting for 32.4% of total records are in Europe, thus confirming that both North America and Europe are the two key centres for the field of national innovation. These 12 countries published 72.7% of the total number of papers, with China being the only emerging country and the only representative from Asia. Because of rapid economic growth since the 1990s, Asia's role in the world economy has risen, with China and Japan becoming the second and third largest economies since 2010. Scholars are increasing their focus on rapid economic growth and NISs in Asia, particularly in China and also on Japan and South Korea, despite increasing attention is being focused on the rise of innovation in Asia by North America and Europe, and this national innovation studies in Asia have been lagging compared with the US and the UK (Teixeira 2014).

Although China is a rising science and innovation power, and both Japan and South Korea are major global R&D centres, studies of national innovation are still in the early stages despite China's presence in the list of top ten countries. As mentioned above, the main reason for this is that most national innovation studies of these countries were published in local journals with the local language. For example, most of China's innovation studies were published in two top Chinese journals-*Studies in Science of Science* and *Science Research Management* that are not included in the SSCI realm. Meanwhile, according to Journal Citation Reports Social Sciences Edition 2013, there were no journals from Mainland China and just four journals from Taiwan. In contrast, 1318 journals were from the US.

Of the 2468 institutions that contributed to the field of national innovation, Table 3 identifies the top 10 institutions in terms of records and TLCS. Published records are still regarded as the primary contribution by academics to their institutions. Among the top 10 institutions, Harvard University is foremost, with most contributions from Harvard Business School and also from Harvard Medical School, with contributions from the latter focusing on innovation issues relating to healthcare. The Belfer Center for Science and International Affairs in the John F Kennedy School of Government and the Department of Health Policy and Management in the Harvard School of Public Health also contributed to these papers. While Harvard University is foremost university, it does not dominate

this list. Indeed, Harvard has a competitive advantage within national innovation studies, but it is not sufficient to get significantly further ahead of other universities. The US leading position in this field is explained more by the contribution of a group of well-known universities as opposed to one university like Harvard. In second place was the University of Manchester, with most contributions coming from the Business School's Manchester Institute of Innovation Research (MIOIR). In third place was The Science Policy Research Unity (SPRU) in the School of Business, Management and Economics of the University of Sussex. Apart from the University of Toronto, all ten of the top contributing institutions were located in the US and UK.

[Table 3 about here]

Our data on local citations, however, shows a very different picture from that of the records, with the top four institutions being located in Europe. The University of Sussex being the undisputed leader in relation to TLCS, indicating that SPRU, which was established by Christopher Freeman in 1965, continues to be the most powerful research institution in the field of national innovation (Fagerberg 2004). Since its establishment, SPRU has become a global leader in research, science consultancy, and in technology and innovation policy management. Despite having fewer records than the top ten institutions, the University of Cambridge and the University of Aalborg have had a considerable impact. The University of Aalborg's strength in the field of national innovation is centered in the IKE

(Innovation, Knowledge and Economic Dynamics) Research Group of the Department of Business and Management, which is directed by Bengt-Åke Lundvall.

In the case of Cambridge the main contributions to national innovation studies came from researchers such as Daniele Archibugi and Steven Casper in the Judge Business School. What is interesting about these researchers are that neither of them came from two major centres of innovation research in the university: The Centre for Science and Policy (CSaP) and the UK-Innovation Research Centre (UK-IRC), both of which promote interaction between researchers and policymakers. It is possible that scholars lack of connections with a recognized research centre may have had some negative impact on citation numbers. As mentioned above, academia and policymaking proposed national innovation studies simultaneously for different missions, and generated different influences. The primary concern of academia was to promote theoretical developments to explain and guide applied work, and also the free exploration by scholars. The research mission of policymakers, on the other hand, is mission oriented, including improvements in policymaking and the promotion of innovative activities. For example, CSaP helps promote engagement between its network members, policy professionals, scholars, business leaders and others who are interested in the relationship between science and policy, and UK-IRC was set up in response to the Government's "Innovation Nation" White Paper.

While both Harvard and the University of Manchester contributed a number of records, they are in seventh and ninth places respectively on the TLCS list, and their impact is limited compared with that of Sussex, Cambridge and Aalborg. Because there is no significant relationship between the number of records and the TLCS, which are two different aspects of a publication, we use the indicator - total citations of all publications rather than the average citation per publication. Indeed, the impact of a publication is determined by several factors. In terms of our research, it is clear that seminal papers play a very important role in the TLCS of an institution. For example, although the University of the Basque Country had only two publications, they succeeded in being present on the TLCS list. Harvard is another case with 51 records. However, the number of local citations of a paper by Furman, Porter and Stern of Harvard University, entitled 'The Determinants of National Innovation Capacity' and published in 2002, was 63, while all the remaining 50 papers received only 23 citations. Furthermore, according to extant literature, international cooperation is seen to generate higher impact scores in comparison with publications that result from one institute (Van Leeuwen, 2009). The University of the Basque Country is a good example to prove this. Its two papers were published through international cooperation, with its faculty members being as second/third authorship instead of first authorship.

4 Major journals, seminal contributions and contributors on national innovation

4.1 The main journals for national innovation studies

The 3579 papers were published in 1225 journals, with the top 10 journals publishing 17.8% of all papers. In terms of records, the most important journals were Research Policy (RP) with 4.8%, the International Journal of Technology Management (IJTM) with 2.2% and European Planning Studies with 1.7%, indicating that papers were spread among a wide number of outlets (Table 4). In addition to the number of records, and considering the effect of the period since publication on the number of citations, we also analyze the average LCS per year since the publication date of papers (LCS/t) rather than the TLCS, which provides an indication of the impact of journals in the field of national innovation. The most important journal in terms of LCS/t is RP whose LCS/t is more than seven times that of Regional Studies, which is in second place. Other journals included in the list by LCS/t include: the Journal of Substance Abuse Treatment (JSAT), Cambridge Journal of Economics (CJE), the Journal of International Business Studies and the Journal of Marketing, while those in the list by records included the IJTM, Energy Policy, R&D Management and Scientometrics.

[Table 4 about here]

In general, more than half the journals could be classified in the field of technology and innovation management (TIM), while the remainder refer to economics, energy, business, marketing and so on, indicating that national innovation studies is an interdisciplinary field. RP was launched in SPRU by

Freeman, its founding editor and is a multi-disciplinary journal devoted to the policy and management problems posed by innovation, R&D, technology and science. The journal's high impact factor (2.598) reflects its status as a leading academic journal in this field although the impact factor as a measurement of journal influence not entirely accurate (Moed and Van Leeuwen 1995; Van Leeuwen and Moed 2005; Bollen et al. 2005; Linton 2006; Van Leeuwen 2012). Regional Studies, which is a central forum for debating recent progress on regional development and policy from an interdisciplinary perspective, is a most important outlet for work on national innovation, and its publications reflect the importance of knowledge stickiness in space for innovation. Table 4 shows that the impact factor for journals in business and marketing are higher than for those of TIM journals, but because of the varying missions and scope of different journals, it is difficult to compare the impact factors of journals in different fields (Sombatsompop and Markpin 2005; Linton 2006; Dorta-González and Dorta-González 2013).

It is interesting that the JSAT, the only journal outside the field of economics, management and business, published several articles with high levels of citations on national innovation with reference to healthcare systems. In fact JSAT not only published articles addressing assessment techniques and treatment approaches of substance abuse and addictive disorders, but also on health services research.

4.2 Seminal contributions to national innovation studies

During the period of bibliometric analysis (1963-2012), articles were published at different stages. The time interval between the publication date and 2012 would influence the total number of citations of adsfn article. Generally speaking, the longer the published time is, the more citations would be expected, assuming the quality of articles is similar. Considering the time interval, the LCS/t - the average LCS per year since the publication date is a more effective indicator than either the TLCS or the TLCS/x - total citation score, excluding self-citations in identifying seminal contributions. In terms of the level of citations, only a small number of the 3579 articles published between 1963 and 2012 could be regarded as "seminal" which is defined by LCS/t.

Table 5 lists 10 seminal articles published during this period. Since national innovation is a relatively new field of research, emerging in the 1990s, the scale of its academic impact has expanded gradually. Of the 10 seminal articles, only three were published before 2000, with four published in 2002, an important year for this area of work. None of these papers on national innovation focused on a particular country or on a comparison of different countries, and were theoretical rather than empirical in approach. Eight of the 10 articles appeared in RP, and the remainder in CJE. It indicates that RP became the preferred journal for authors in this field, helping to develop an identity for this

group of researchers. Freeman and Carlsson each contributed two articles, while other contributors included Cooke, Uranga and Etxebarria, Etzkowitz and Leydesdorff, Furman, Porter and Stern.

[Table 5 about here]

Among the topics which the seminal contributions focused on were national innovation systems, national innovative capacity, regional innovation systems and innovation systems. According to LCS/t, TLCS and TLCS/x, the most seminal article was "The dynamics of innovation: from National System and 'mode 2' to a Triple Helix of university-industry-government relations" published in Research Policy. It will still keep a high level of citations according to LCS (e/b). Most seminal contributions have an LCS (e/b) bigger than 1, which indicates that their citation appeared an increasing trend.

4.3 The seminal contributors to national innovation studies

Of the 6948 authors who contributed to national innovation studies during this period, three lists according to records, TLCS and LCS/t can be identified. The most prolific authors according to records were Roman, Knudsen and Nioso. However, few researchers in the field of innovation are familiar with these authors because their work examines organizational change and adaptation in substance abuse treatment published by JSAT, indicating that healthcare is an area of work attracted to innovation studies. The most widely cited authors were Freeman, Leydesdorff and Lundvall, with

Freeman and Lundvall being the founding fathers of the NIS approach and Leydesdorff developing the scientometrics approach for studying national innovation. The most highly cited authors annually were Roman, Leydesdorff and Lundvall.

[Table 6 about here]

Apart from Guan from China and Gadelha from Brazil, all of the seminal contributors were from developed countries in North America and Europe, including the US, Canada, the UK, the Netherlands, Denmark, Italy, Spain and Germany. Guan's work focuses mainly on China and Gadelha's on Brazil and while they also carry out international comparative research, they tend not to focus on theoretical issues.

5 Clusters in national innovation studies

Because of the vast quantity of analytical studies in the field of national innovation, it is difficult to develop an effective classification. With the help of HistCite, a citation network of highly cited papers has been produced which can throw some light on cluster and how linkages based on these clusters have evolved over time. These clusters could be named by key nodes' topics. By means of an algorithm and network analysis, HistCite removes all nodes part from the 100 of those connected with the most highly cited papers based on LCS and the ties between them (See Figure 2). Although this new field of innovation studies only took shape in the 1990s, we inputted data based on

contributions from 1963 onwards. In Figure 2, the size of nodes indicates the number of citations, with a minimum citation node of six and a maximum of 79.

[Figure 2 about here]

At first, we will look at three small components. The biotechnology innovation policy studies include three nodes (321, 617 and 1079[2]), referring to innovation systems, technology policy, organizational learning and institutional adaptiveness. Networking and innovation studies had three nodes (681, 563 and 1173) looking at the relationship between networking and regional innovation. A third one looking at cultural influences in national innovation had six nodes (81, 122, 224, 296, 431 and 691). A paper by Scott Shane published in 1992 in the Journal of Business Venturing asked why some societies are more inventive than others, and suggested that some societies might have a comparative advantage related to culture (Shane 1992). He also found that rates of innovation were closely related with the cultural value of uncertainty acceptance, but that lack of power distance and individualism are also related to high rates of innovation (Shane 1993), and that uncertainty-accepting societies may be more innovative than uncertainty-avoiding societies because of the greater legitimacy of those roles (Shane 1995). Follow-up studies analyzed the relationship between national culture and cross-border acquisition performance and new product development.

[2] The code corresponds to the literature in Appendix Table 1

National innovation system is the largest cluster with 60 nodes. The five biggest nodes in the network around the top five seminal articles (241, 422, 636, 853 and 902) were vital contributions to national innovation studies (Table 5). Most authors agree that the idea of NIS came from researchers like Freeman (1987), Lundvall (1992) and Nelson (1993). The expression "national system of innovation" was first used in published form by Freeman (1987). Two major books on NIS were Lundvall (1992) and Nelson (1993), but using different approaches to the study of NIS. Lundvall (1992) is a more theoretical work and seeks to develop an alternative approach to the neo-classical economics tradition by placing interactive learning, user-producer interaction and innovation at the centre of the analysis (Lundvall 1992:1). By contrast, Nelson (1993) emphasizes empirical case studies more heavily than the development of theory and some of the studies focus narrowly on the R&D systems of nations. Teixeira (2014) divided literature of NIS into policy-oriented studies, research-oriented studies and conceptual/critical meta-literature, providing us with a framework for seeking study themes in the network. According to the relationships within the network, there are five clusters in the field of NIS studies.

Internationalization of innovation systems. The era associated with the emergence of the NIS coincides with the need for globalization theory. In the context of increased globalization of scientific and technological activity, it is necessary to review the international dimension of the NIS (Niosi and

Bellon 1994). The term “techno-globalism” is used to describe the phenomena of globalization experienced by the world of invention and innovation (Archibugi and Michie 1995). Some 10 years later, the critical meta-literature on the internationalization of innovation systems (1224) shows that there are four aspects, including empirical studies of internationalizing innovation systems, internationalization/globalization of R&D, institutional barriers to internationalization and other related studies (Carlsson 2006). In order to respond to “techno-globalism”, the “national system of innovation historical perspective” (241) argues that national and regional innovation remains essential domains for economic analysis. NIS derives from networks of relationships which are necessary if firms are to innovate, while external international connections as part of the firm’s network are of growing importance and influence.

Regional innovation system. Generally speaking, Cooke is the forerunner of regional innovation systems (RIS) (Cooke 1992 ,1994), and the classical paper of this theory is “Regional innovation systems: Institutional and organisational dimensions” (422) (Cooke et al. 1997). The regional innovation system is part of a national innovation system, as different sectors interact with regional governance and innovation support infrastructures as well as at the national level. The regional innovation system concept, however, complements rather than replaces the national innovation system concept (Cooke et al. 1998; Cooke 2001).

Triple Helix theory. The most influential paper in this area "From national systems to a Triple Helix of university-industry-government relations (636) (Etzkowitz and Leydesdorff 2000) deepened our understanding of national innovation systems. Triple Helix is an interface and linkage between the concept of innovation system and organization. Three selection environments are specified in the Triple Helix model: (1) wealth generation (industry), (2) novelty production (academia), and (3) public control (government). The Triple Helix model (Leydesdorff and Van den Besselaar 1994) is organized with the intention of crossing boundaries with institutional analysis of knowledge infrastructure. The Triple Helix model provides us with a heuristic for studying these complex dynamics in relation to developments in the institutional networks of carriers. Furthermore, this model reduces somewhat the complexity by using university-industry-government relations for specifying the historical conditions of the non-linear dynamics (Leydesdorff and Meyer 2006).

National Innovative Capacity. After the appearance of the classical paper "The determinants of national innovative capacity" (902) in 2002, studies of national innovative capacity began to appear. The concept of innovative capacity, created by Suarez-Villa in 1990 (Suarez-Villa 1990), was proposed as an index that could provide regular diagnostics of national performance in invention over time. Furman, Porter and Stern (FP&S) (902) introduced a novel framework based on the

concept of national innovative capacity in 2002. The national innovative capacity framework draws on three distinct areas of prior research: ideas-driven endogenous growth theory (Romer 1990), the cluster-based theory of national industrial competitive advantage (Porter 1990), and research on national innovation systems. National innovative capacity depends on the strength of a nation's common innovation infrastructure, the environment for innovation in a nation's industrial clusters, and the strength of linkages between these two (Furman et al. 2002). Based on FP&S framework, Furman and Hayes (2004) investigated the factors that enabled such emerging innovator economies to achieve successful catch-up while some historically more innovative countries experienced relative declines in innovative productivity (1205). Hu and Mathews (2005) extended and modified the FP&S approach by applying it to five "latecomer" countries from East Asia (1373), with their newest work of being "China's National Innovative Capacity" (1977) (Hu and Mathews 2008).

Meta-Analyses. Critical analysis papers using literature surveys of the concept and its use in theory and policy also formed vital nodes in the network. One such paper looked at how the Aalborg version of the concept evolved from a combination of ideas that moved from production structure towards including all elements and relationships contributing to innovation and competence building (853, Lundvall et al. 2002). It also looked at analytical and methodological issues arising from various

systems concepts – national, regional, sectoral or technological systems, all involving the creation, diffusion, and use of knowledge. Systems consist of components and relationships between them and their characteristics and attributes (854, Carlsson et al. 2002). Other more recent, comprehensive publications such as 1473 (Sharif 2006) and 2224 (Godin 2009) examined the roots of NIS.

[Table 7 about here]

Besides the collection of national innovation studies by TLCS, other roots of national innovation studies were found, which related to the top 30 most cited publications. There are several theories to support the development of national innovation studies, such as the competitive advantage of nations, absorption capability, evolutionary theory, diffusion of innovations, knowledge and R&D spillovers, the production of innovation, the knowledge-creating company, institution theory, technological paradigms and technological trajectories, sustained competitive advantage, clusters, interorganisational collaboration and so on (Table 7).

The main contributions to national innovation studies were initially published in book form rather than as journal papers (see Table 7). There were several possible reasons for this: firstly, this allowed authors to present related ideas in a unified volume rather than separately in journal papers; secondly, an edited book is typically less rigorous than the peer review process for international journals;

finally, an edited book can set a marker for a new milestone in a field of research. Edited books also have the advantage of being assigned as textbooks for graduate students.[3]

6 Discussion and Conclusions

It has been shown that over time several seminal contributions in the new field of national innovation studies have been made from a small number of leading academic institutions and published in special academic journals. This new field of national innovation studies emerged as an invisible academic network based on journal articles and citations of scholars from academic institutions in particular countries.

The study includes 3579 papers from 2468 institutions in 1225 journals with 129424 references and citations. According to TLCS, the leading academic institutions included the following universities: Sussex, Cambridge, Aalborg, Amsterdam and Pennsylvania, all either in the EU, particularly the UK or the US. The key journals in which these papers were published were Research Policy, Regional Studies, Journal of Substance Abuse Treatment, Cambridge Journal of Economics and Technological Forecasting and Social Change. The seminal articles included

[3] A suggestion from Naubahar Sharif, Associate Professor, Division of Social Science, Hong Kong University of Science and Technology.

Etzkowitz and Leydesdorff (2000), Furman, Porter and Stern (2002), Lundvall, Johnson, Andersen and Dalum (2002), Freeman (1995) and Cooke , Uranga and Etxebarria (1997) and among the prominent authors were Roman, Freeman, Lundvall, Furman, Leydesdorff.

While drawing an overall picture of national innovation studies, we also seek to explain the emergence of this new field of work, and the role played by the invisible network of academics. As mentioned above, initially, much of the research output was published in book form rather than in journals, suggesting that the scholars involved worked together through meetings and conferences due to the demands of policymaking and research project implementation. Then, journal publishing took over from book publishing, which appears that 1995 is the demarcation point. Over time, outstanding authors publishing seminal papers in leading journals emerged particularly since 1995.A particularly good example was Freeman, the founder and first director of SPRU of the University of Sussex, which went on to become the leading world centre for science policy. He also established and was the first editor of Research Policy in which he published many seminal papers.

Several clusters related to different aspects of innovation studies are identified by our citation network, including three small clusters around biotechnology innovation policy, networking and

innovation and cultural influences on innovation. The largest cluster -national innovation systems - includes five sub-clusters: internationalization of innovation systems, regional innovation systems, the triple helix theory, national innovation capacity and literature surveys. At the same time, it also reveals the relations between these popular concepts. A new field looking at the social and economic context of innovation also emerged. National innovation studies evolved in a dynamic manner. Based on a systems approach, the innovation system is a core concept in this field and is identified as the biggest cluster in the network of citations, but only forms part of the broader field of innovation studies. All clusters seek to explain innovation at the national level, why there are differences in innovation between different countries, and the role of institutions, organizations and cultural influences in these differences. The innovation system perspective also contributes towards explaining these differences.

It is also important to consider in what direction national innovation studies going. Will it continue to prosper or fail and if it does prosper, in what form? Obviously, the nation continues to be the most significant unit for innovation studies, and while there have been few seminal works since 2002, there is no decline in national innovation within society. The new area of growth is national innovative capacity, which integrates several classical theories and has a seminal analytical framework for national innovation analysis. With this most recent tool to

explain differences in innovation between countries, the academic community needs to enrich this field by developing new theory to explain national innovative capacity.

Acknowledgments: The authors gratefully acknowledge the financial support from National Natural Science Foundation of China (NSFC) under the Grant Nos. 71203020, the Fundamental Research Funds for the Central Universities (DUT15ZD111), and the EU 7th Framework Programme-Marie Curie International Incoming Fellowships (MC IIF) and Yu-tao SUN truly appreciates the supports from Dr. Cong Cao—Associate Professor and Reader at the University of Nottingham; Dr. Naubahar Sharif, Associate Professor, Hong Kong University of Science and Technology.

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Tables

Table 1 Publications in the field of national innovation by types (1963-2012)

#	Document Type	Recs	Percent	TLCS
1	Article	2961	82.7	1954
2	Proceedings Paper	275	7.7	462
3	Review	174	4.9	211
4	Book Review	75	2.1	1
5	Editorial Material	71	2	14
6	Others	23	0.6	6
7	Total	3579	100	2648

Notes: Others include meeting abstract, notes, corrections, discussions, letters, reprints, etc.

Table 2 Top 10 countries in the field of national innovation studies by records and TLCS

#	Country	Recs	Percent	TLCS	#	Country	TLCS	Recs	Percent
1	the US	1012	28.3	866	1	the US	866	1012	28.3
2	UK	577	16.1	661	2	UK	661	577	16.1
3	Canada	186	5.2	111	3	Netherlands	170	122	3.4
4	Australia	158	4.4	75	4	Denmark	131	40	1.1
5	Netherlands	122	3.4	170	5	Germany	123	102	2.8
6	Germany	102	2.8	123	6	Canada	111	186	5.2
7	Spain	98	2.7	91	7	Spain	91	98	2.7
8	China	86	2.4	71	8	Australia	75	158	4.4
9	Italy	83	2.3	55	9	China	71	86	2.4
10	France	79	2.2	47	10	Sweden	71	64	1.8

Note: China refers to mainland China. Unknown: publications with no clear information about country or region are excluded. Unknown have 595 records and 239 TLCS.

Table 3 Top 10 institutions in the field of national innovation studies by records and TLCS

#	Institution	Recs	Percent	TLCS
1	Harvard University (US)	51	1.4	23
2	University of Manchester (UK)	47	1.3	66
3	University of Sussex (UK)	41	1.1	157
4	University of Toronto (CA)	40	1.1	22
5	University of North Carolina (US)	39	1.1	16
6	University of California Berkeley (US)	37	1	42
7	Ohio State of University (US)	29	0.8	21
8	University of Minnesota (US)	29	0.8	31
9	London School of Economics and Political Science (UK)	27	0.8	3
10	Columbia University (US)	26	0.7	42
#	Institution	TLCS	Recs	Percent
1	University of Sussex (UK)	157	41	1.1
2	University of Cambridge (UK)	120	20	0.6
3	University of Aalborg (DK)	114	13	0.4
4	University of Amsterdam (NL)	104	21	0.6
5	University of Pennsylvania (US)	100	22	0.6
6	Boston University (US)	88	23	0.6
7	Harvard University (US)	86	51	1.4
8	State University of New York (US)	82	2	0.1
9	University of Manchester (UK)	66	47	1.3
10	University of Basque Country (ES))	65	2	0.1

Note: unknown means publications with no clear information about institutions are excluded. Unknown have 107 records and 6 TLCS. Abb of country name: Denmark (DK), Netherlands (NL), Spain(ES), United States (US), United Kingdom (UK).

Table 4 Top 10 journals in the field of national innovation studies by records and LCS/t

#	Journal	Recs	LCS/t	IF2013
1	Research Policy	173	91.32	2.598
2	International Journal of Technology Management	77	3.62	0.492
3	European Planning Studies	60	7.68	1.025
4	Technological Forecasting and Social Change	57	9.17	1.959
5	Technovation	56	9.07	2.704
6	Regional Studies	48	12.07	1.756
7	Technology Analysis & Strategic Management	46	5.46	0.841
8	Energy Policy	42	3.05	2.696
9	R&D Management	41	2.82	1.266
10	Scientometrics	37	2.63	2.274
#	Journal	LCS/t	Recs	IF2013
1	Research Policy	91.32	173	2.598
2	Regional Studies	12.07	48	1.756
3	Journal of Substance Abuse Treatment	11.45	14	1.867
4	Cambridge Journal of Economics	9.48	11	0.914
5	Technological Forecasting and Social Change	9.17	57	1.959
6	Technovation	9.07	56	2.704
7	European Planning Studies	7.68	60	1.025
8	Technology Analysis & Strategic Management	5.46	46	0.841
9	Journal of International Business Studies	5.44	23	3.594
10	Journal of Marketing	4.24	7	3.819

Note: LCS/t shows the average LCS per year since the publication date. The impact factor considers all journals currently listed in the 2013 Journal Citation Reports® (Thomson Reuters, 2014).

Table 5 TOP ten seminal articles in the field national innovation studies by LCS/t

#	Year	NO.	Title	Journal	Author	LCS/t	TLCS	TLCSx	LCS(e/b)
1	2000	636	The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations	RP	Etzkowitz H, Leydesdorff L	6.08	79	75	17.5
2	2002	902	The determinants of national innovative capacity	RP	Furman JL, Porter ME, Stern S	5.73	63	62	4.33
3	2002	853	National systems of production, innovation and competence building	RP	Lundvall BA, Johnson B, Andersen ES, Dalum B	5.09	56	56	7.67
4	1995	241	The national system of innovation in historical perspective	CJE	Freeman C	3.94	71	71	6.25
5	1997	422	Regional innovation systems: Institutional and organisational dimensions	RP	Cooke P, Uranga MG, Etxebarria G	3.19	51	50	15
6	2002	854	Innovation systems: analytical and methodological issues	RP	Carlsson B, Jacobsson S, Holmen M, Rickne A	2.91	32	32	4
7	2006	1424	Internationalization of innovation systems: A survey of the literature	RP	Carlsson B	2.86	20	20	2.75
8	2006	1473	Emergence and development of the National Innovation Systems concept	RP	Sharif N	2.43	17	16	6.5
9	2002	852	Continental, national and sub-national innovation systems - Complementarity and economic growth	RP	Freeman C	2.27	25	25	11
10	1999	529	Localised learning and industrial competitiveness	CJE	Maskell P, Malmberg A	2.21	31	31	9/0

Notes: LCSb: The LCSb shows the LCS only from the beginning of the collection to an arbitrary cutoff year. LCSe: The LCSe shows the LCS for the period from the arbitrary cutoff year until the last year of the collection time span. LCSx: The LCSx shows the total local citation score excluding self-citations. RP means Research policy, and CJE means Cambridge Journal of Economics.

Table 6 TOP 10 seminal contributors in the field of national innovation studies by records, TLCS and LCS/t

#	Author	Affiliation	Recs
1	Roman PM	University of Georgia (US)	13
2	Knudsen HK	University of Kentucky(US)	11
3	Niosi J	University of Quebec (CA)	10
4	Archibugi D	Italian National Research Council (IT)	9
5	Gadelha CAG	Oswaldo Cruz Foundation(BR)	9
6	Guan JC	University of Chinese Academy of Science	9
7	Leydesdorff L	University of Amsterdam (NL)	9
8	Mowery DC	University of California, Berkeley (US)	9
9	Grupp H	The Fraunhofer Institute for Systems and Innovation Research (DE)	8
10	Link AN	The University of North Carolina(US)	8
#	Author	Affiliation	TLCS
1	Freeman C	SPRU, University of Sussex(UK)	104
2	Leydesdorff L	University of Amsterdam (NL)	96
3	Lundvall BA	Aalborg University (DK)	89
4	Etzkowitz H	Newcastle University (UK)	82
5	Cooke P	Cardiff University (UK)	80
6	Furman JL	Boston University (US)	74
7	Shane S	University of Pennsylvania (US)	69
8	Johnson B	Aalborg University (DK)	68
9	Etxebarria G	University of Basque Country (ES)	65
10	Uranga MG	University of Basque Country (ES)	65
#	Author	Affiliation	LCS/t
1	Roman PM	University of Georgia (US)	9.7
2	Leydesdorff L	University of Amsterdam (NL)	9.39
3	Lundvall BA	Aalborg University (DK)	7.94
4	Knudsen HK	University of Kentucky(US)	7.82
5	Archibugi D	Italian National Research Council (IT)	7.57
6	Freeman C	SPRU, University of Sussex(UK)	7.11
7	Furman JL	Boston University (US)	6.95
8	Etzkowitz H	Newcastle University (UK)	6.29
9	Cooke P	Cardiff University(UK)	5.91
10	Johnson B	Aalborg University (DK)	5.84

Note: There are 9 anonymous papers excluding this table. Abb. of Countries' name: China (CN); The Netherlands (NL); Denmark (DK); Italy (IT);Canada (CA);Spain(ES); Brazil(BR) ; Germany (DE).

Table 7 TOP 30 most cited literature in the field of national innovation studies

#	Title/Press or Journal	Date	Authors	Citations	Percent
1	National System of Innovation: towards a theory of innovation and interactive learning. Francis Printer, London	1992	Lundvall B-A(ed.)	270	7.5
2	National innovation system: A comparative analysis. Oxford University Press, New York	1993	Nelson R. (ed.)	265	7.4
3	The competitive advantage of nations, Free Press, New York	1990	Porter M.	210	5.9
4	Absorption capability: a new perspective on learning and innovation, Administration Science Quarterly	1990	Cohen,WM; Levinthal D.	180	5
5	Technology policy and economic performance: lessons from Japan . Francis Printer, London	1987	Freeman C.	147	4.1
6	An evolutionary theory of economic change. Harvard University Press, Cambridge,MA	1982	Winter S.	146	4.1
7	Diffusion of Innovations, The Free Press, New York	1995	Rogers M.E.	106	3
8	System of Innovation: technologies, institutions, and organizations, Routledge, Taylor & Francis Group	1997	Edquist C (ed.)	103	2.9
9	Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations, Quarterly Journal of Economics	1993	Jaffe AB; Trajtenberg M Henderson R	87	2.4
10	Culture's Consequences: International Differences in Work-Related Values, Beverly Hills CA: Sage Publications	1980	Hofstede G. H.	85	2.4
11	Innovation and Learning: The Two Faces of R&D, The Economic Journal	1989	Cohen,WM Levinthal, D.A.	81	2.3
12	The dynamics of innovation: from National Systems and 'Mode 2' to a Triple Helix of University-Industry-Government Relations, Research Policy	2000	Etzkowitz H	79	2.2
13	The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies, SAGE Publication Ltd	1994	Gibbons M	79	2.2
14	Sectoral patterns of technical change: towards a taxonomy and a theory. Research Policy	1984	Pavitt K.	79	2.2
15	The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation. Oxford University Press	1995	Nonaka I, Takeuchi H.	77	2.2
16	The Iron Cage Revisited: Institutional Isomorphism and Collective. Rationality in Organizational Fields. American Sociological Review	1983	DiMaggio J.P; Powell W.W.	73	2
17	The National system of Innovation in Historical Perspective, Cambridge Journal of Economics	1995	Freeman C.	71	2
18	Patent statistics as economic indicators: a survey, Journal of Economic Literature	1990	Griliches, Z	70	2

19	The Theory of Economic Development: An inquiry in to profits, capital, credit, interest and the business cycle. Harvard Business School Press, Boston	1934	Schumpeter J.A.	66	1.8
20	R & D spillovers and the geography of innovation and production, American Economic Review	1996	Audretsch D.B.; Feldman M. P.	65	1.8
21	The determinants of national innovative capacity, Research policy	2002	Furman JL, Porter ME, Stern S	63	1.8
22	The Regional World: Territorial Development in a Global Economy, New York: Guiiford Press	1997	Storper M	62	1.7
23	Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change, Research policy	1982	Dosi G.	61	1.7
24	Institutions, institutional change and economic performance, Cambridge: Cambridge University. Press	1990	North, D.C.	61	1.7
25	Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology. Administrative Science Quarterly	1996	Powell WW Koput K. W. L. Smith-Doerr	59	1.6
26	Firm Resources and Sustained Competitive Advantage, Journal of Management	1991	Barney J	58	1.6
27	Organizational Innovation: A Meta-Analysis Of Effects Of Determinants and Moderators, Academy of Management Journal	1991	Damanpour F	56	1.6
28	National systems of production, innovation and competence building, Research Policy	2002	Lundvall BA	56	1.6
29	Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation, Progress in Human Geography	2004	Bathelt H;Malmberg A;Maskell P	54	1.5
30	Regional Innovation Systems: The Role of. Governance in a Globalized World, London: UCL Press	1998	Braczyk, H.J., Cooke, P., Heidenreich, M. (eds)	54	1.5
31	Technical Change and Economic Theory, Pinter Publisher, London and New York	1988	G.Dosi et al (eds)	54	1.5

Note: No.31 paper has the same records with No.30 and No.29, so we remain it.

Appendix Table 1 A reference between code and literature in Figure 2

No.	Code	Literature	TLCS
1	64	Kitschelt H, 1991, INT ORGAN, V45, P453	6
2	81	Shane SA, 1992, J BUS VENTURING, V7, P29	22
3	86	Lall S, 1992, WORLD DEV, V20, P165	27
4	91	Mowey DC, 1992, RES POLICY, V21, P125	9
5	116	Niosi J, 1993, TECHNOL SOC, V15, P207	26
6	122	Shane S, 1993, J BUS VENTURING, V8, P59	35
7	172	Niosi J, 1994, TECHNOL SOC, V16, P173	10
8	224	Shane S, 1995, J INT BUS STUD, V26, P47	16
9	225	Shane S, 1995, J MANAGE, V21, P931	10
10	241	Freeman C, 1995, CAMBRIDGE J ECON, V19, P5	71
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