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Visualizing the GVC research: a co-occurrence network based bibliometric analysis

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Abstract During the past 30 years there has been growing interests in global value chains (GVC) across various disciplines including economics, business & management, economic geography, operational research, computer science, engineering, and so forth. In order to further explore GVC research, this paper employs bibliometric analysis based on co-occurrence network; specifically, it investigates the temporal evolution of disciplines and keywords co-occurrences, as well as the reference co-citation analysis between 1995 and 2014, in order to uncover the evolution of disciplines and research fronts, and identify the intellectual base of global value chains research.

Keywords Global value chain · Disciplinary distribution · Research fronts · Intellectual base

Introduction

Globalization has experienced two great unbundlings: rapidly falling transportation costs—a trend which has been going on since the late nineteenth century-caused the first unbundling, namely the end of the necessity of making goods close to the point of consumption. More recently, rapidly falling communication and co-ordination costs have fostered a second unbundling which spatially unpacked the factories and offices themselves, and the globalization paradigms shift from trade-in-goods to trade-in-tasks. The second unbundling has variously been called fragmentation, offshoring, vertical

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specialisation and slicing up the value-added chain or global value chain (Baldwin 2006). An OECD (2013) survey reported that for a group of 300 global companies with sales of over USD 1 billion, on average, 51 % of component manufacturing, 47 % of final assembly, 46 % of warehousing, 43 % of customer service, and 39 % of product development took place outside the home country.

The booming of global value chains has attracted researchers from various disciplines including economics, business, management, computer science, engineering, operation research and management science, geography and so forth. Different researchers study global value chains from their own unique lens, ranging from trade policy making, international investment, economic development, to industry competiveness and upgrading (Frederick 2014); however, none of them get the whole truth, which is a fantastic phenomenon in scientific research and deserves exploring from the viewpoint of bibliometry.

This paper employs co-occurrence networks analysis with the aim to investigate: firstly, the evolution of the disciplines engaging in global value chains research in the past 20 years; secondly, the temporal shifts of research topics; third, the intellectual base and academic communities of global value chains research. The findings might be beneficial not only for global value chains researchers, but also for policymakers.

This paper consists of three parts. The first part is a brief introduction of the methodology. The second part is the visualized results including output of the past 20 years, disciplines co-occurrence analysis, keywords co-occurrence analysis, and reference co-citation analysis. The third part is a brief summary of the findings.

Data and methodology

We started searching the following keywords from the Core Collection of Web of Science on August 15, 2015: "global supply chain(s)", "global value chain(s)", "global production networks", "international production networks", "vertical specialization", "offshore outsourcing", and "production fragmentation", and 2280 literatures were obtained. The data including title, authors, institutions, year of publication, journal name, abstracts, keywords, subjects, disciplines, and references etc. of each literature was downloaded for further process. We excluded "editorial material" and "book review" with the consideration that journal articles have the maximum impact on a particular field of research and are considered as validated knowledge.

The analysis of communication networks enables a better understanding of routing, transmission patterns, and information flow (Rabbat et al. 2008). Co-citation network analysis is the most commonly used techniques in bibliometric analysis and is useful for identifying academic communities and examining the cognitive structures of disciplines; the technique emphasizes the unique value of higher order interrelationships between documents or between authors (Chen et al. 2002) and attempts to identify high density areas in a citation network by clustering highly co-cited documents, consequently research fronts can be identified by agglomerations of papers based on common references (Schiebel 2012). Three main steps are required to perform a co-citation analysis. First, a relevant pool of documents has to be selected from the extant body of literature. During this process, valuable information can already be gained from a citation analysis of the initial sample of articles, the retained core articles, and perhaps even their citing articles (children) and referenced works (parents). The second step consists of the retrieval of co-citation counts between any two pairs of core articles, which are then compiled in the raw

co-citation matrix. Finally, either the co-citation matrix or its corresponding correlation matrix is analyzed (Charvet et al. 2008).

A clear drawback of co-citation clustering is that it can only classify a fraction of the citing literature (Zitt and Bassecoulard 1994). Combining various bibliometric analyses can reveal details of research subjects for specific disciplines, because each bibliometric analysis exhibits certain advantages (Chang et al. 2015). Therefore, besides reference co-citations, disciplines co-occurrence, and keywords co-occurrence networks were employed in this paper. The advantages of combining different kinds of co-occurrence analysis are: firstly, it is possible to investigate a wide spectrum of questions such as scholarly communication, research front, intellectual structure of research fields (Qiu et al. 2014), and study cross disciplines (Yan and Ding 2012); secondly, it may improve the capability of quantitative techniques to depict structural and dynamical aspects of scientific research, and makes it possible to identify and link specialty literature not only within a given period, but also through time (Braam et al. 1991).

The primary purpose of the co-word analysis methodology developed in the 1980s was to help researchers analyze the dynamics of science and technology (Chen et al. 2002). Researchers have used co-word analysis to examine subject domains in various fields and chronological changes (Cho 2014). The disciplines co-occurrence analysis examines the cross-disciplinary involvement and cooperation in a certain research field; the cross-disciplinary feature of global value chains makes it necessary to employ this technique. In this paper, both keywords co-occurrence and discipline co-occurrence networks were decomposed into four stages between 1995 and 2014 with a time slice of 5 years, in order to reveal the evolution of research fronts and disciplines by observing existing cluster with an exceptional growth, completely new cluster with its root in other clusters and existing cluster with a topic shift (Glänzel and Thijs 2011); the records before 1995 were excluded because of the sparse distribution.

Ucinet software and Pajek software were employed in this paper to generate the co-occurrence networks. UCINET is a social network analysis program developed by Steve Borgatti, Martin Everett and Lin Freeman, and the free trial version may be downloaded at http://www.analytictech.com/ucinet/trial.htm; Pajek is free for noncommercial use and may by downloaded at http://vlado.fmf.uni-lj.si/pub/networks/pajek/. Figure 1 illustrates the procedure of the co-occurrence networks generation.

Results and discussion

The output of GVC research between 1983 and 2014

Figure 2 shows the output of GVC research since 1983 (2015 is excluded because of the incomplete data). The output presents obvious periodical characteristics:

Before 2000 the literatures grew slowly. There were merely 42 records in 17 years with the average annual output of only more than two records; there was no record in 1984. Moreover, there was nearly no important literature in this period.

There was an accelerated growth between 2001 and 2008, with an average annual output of 33 records, just a little lower than the total output between 1983 and 2000. The most influential literatures were published in this period: Gereffi (2005), Henderson et al. (2002), Coe et al. (2004), Humphrey and Schmitz (2002), Coe et al. (2008a), Hummels

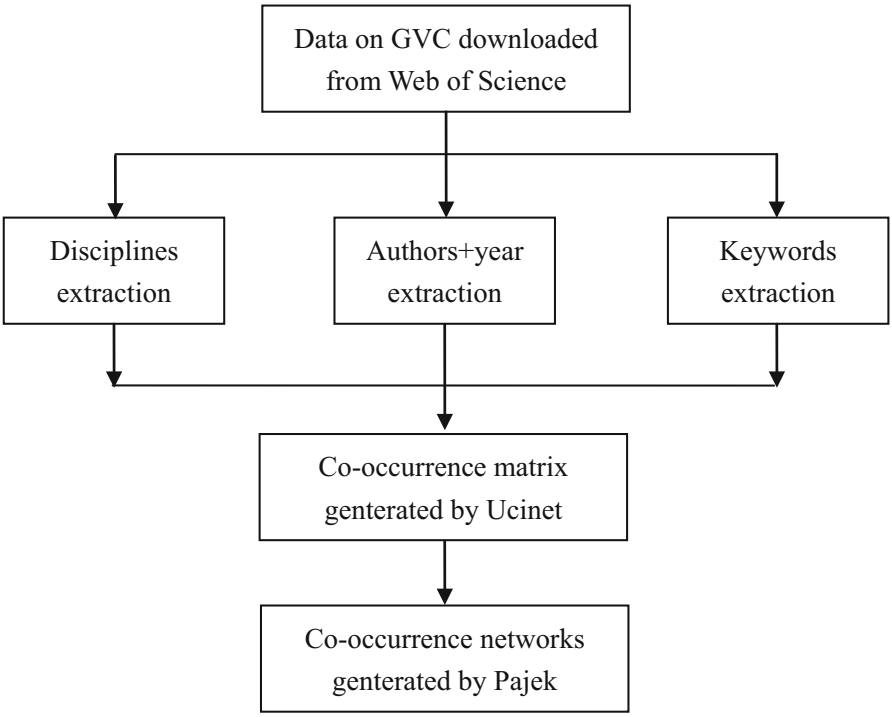


Fig. 1 The flow chart of co-occurrence networks generation

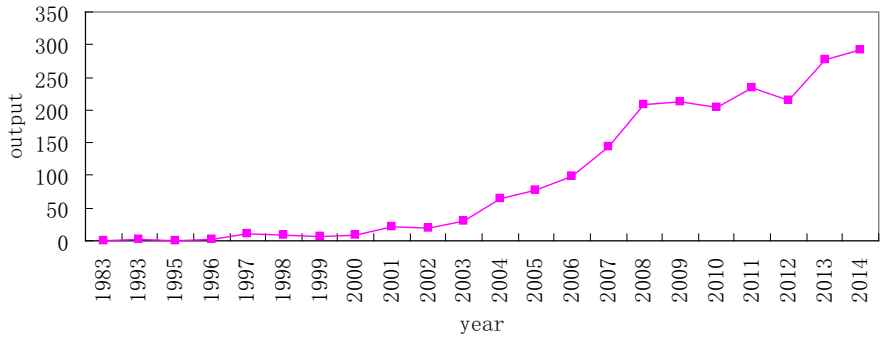


Fig. 2 The output of GVC research between 1983 and 2014

et al. (2001), Yi (2003), Giuliani et al. (2005), Hess and Yeung (2006), and Ponte and Gibbon (2005).

Between 2008 and 2012 the yearly output remained high but the growth was stagnant except 2011; it might be inferred that global value chains researches encountered some turning points. After 2012 there was another burst of output.

Disciplines co-occurrence analysis

Figure 3 illustrates the temporal evolution of disciplinary co-occurrence networks between 1995 and 2014 with a time interval of 5 years; the networks are obtained by Uncinet and visualized by Netdraw; the size of each node is proportionate to its degree and the thickness of the links represents the tie strength.

As can be seen from Fig. 3a that there were only 15 disciplines related with global value chains research during 1995–1999, showing that there were relatively few concerns on this topic; the network was loose and there was a core cluster centered on "business & economics", with "geography", "public administration", "international relations", "government & law", and "sociology" directly linked.

The disciplines grew dramatically and reached 28, nearly doubled, during 2000–2004 (see Fig. 3b). The network was denser than the previous period; the top four disciplines by degree were "computer science", "business & economics", "engineering", and "telecommunications". "Business & economics" was a central and bridging node in the network and closely linked with "operations research & management science", which had strong connection with "engineering" and moderate tie with "computer science". "Computer science" was another central node in the network, together with "engineering" and "telecommunication", formed the technical base of global value chains and accelerated its development.

There was another rapid increase of disciplines during 2005–2009 and concentrated on two obvious (see Fig. 3c) clusters, one of which was mainly composed of social sciences and centered on "business & economics", and the other consisted of natural sciences and took "computer science" as the core. Among the 49 disciplines, the top three disciplines by degree were same as the previous period: "business & economics" took the lead by degree, followed by "computer science", "engineering"; "environment sciences & ecology", and "geography" emerged as the mainstream disciplines. The tie strength between "business & economics" and "operations research & management science" was the highest among all the links and the latter had the second highest tie strength with "engineering", highlighting that "operations research & management science" was an important discipline in global value chains research.

The number of disciplines amounted to 57 during 2010–2014 with a slight increase compared with the previous period (see Fig. 3d). The network can be divided into three clusters centered around three core discipline respectively: "business & economics", "engineering", and "environmental sciences & ecology". "Computer science" dropped out of the top five disciplines by degree and was replaced by "public administration"; it is worth noting that "environmental sciences & ecology" was playing an important role in the network and grew into a cluster center mainly consisted of "biology", "pharmacy", "environmental sciences", and "health", implying that these disciplines were paying more attentions on global value chains research. The disciplinary cooperation can be inferred from the tie strengths in the network: the highest was 101 occurred between "engineering" and "operations research & management science"; "geography" had strong links with both "business" and "environmental sciences & ecology" amounted to 70 and 65 respectively.

In order to provide more detailed information on the evolution of disciplines, Table 1 lists the top disciplines in four periods between 1995 and 2014 with a time slice of 5 years sorted by records and degree. An overview of the disciplines in different stage concluded

Fig. 3 The temporal evolution of disciplinary co-occurrence networks. **a** 1995–1999 Disciplinary co-occurrence network. **b** 2000–2004 Disciplinary co-occurrence network. **c** 2005–2009 Disciplinary co-occurrence network. **d** 2010–2014 Disciplinary co-occurrence network

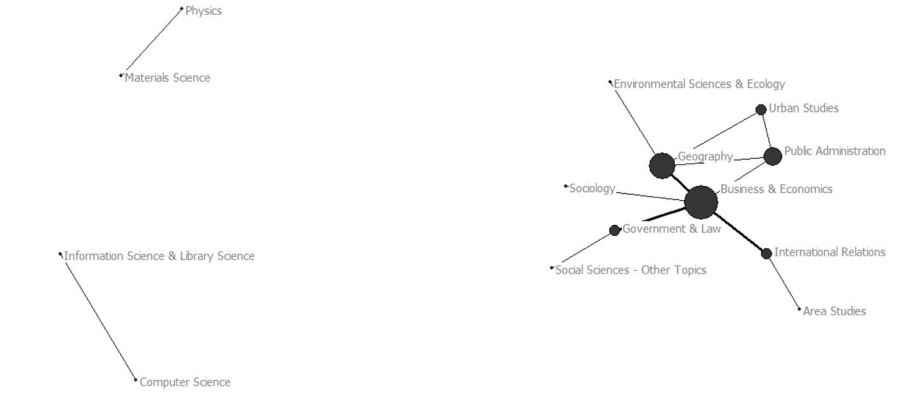
that the "business & economics" ranked first in all stages, followed by "engineering", "computer science", "geography", "operation research & management science", etc.

The disciplines in stage I (1995–1999) were very limited and the records of document were rather low. Both disciplines and records in stage II (2000–2004) increased rapidly, and most of the newly emerged disciplines belonged to applied natural sciences. In stage III (2005–2009) there was a rocketed growth of records of document and another fast increase in disciplines compared with the previous stage; the disciplines nearly reached stable in this period. The records of document kept growing during stage IV (2010–2014); there existed a significant change in disciplines that "environmental sciences & ecology" entered the top 5 disciplines, implying that the global value chains research was attracting more and more concerns in the fields of environment and ecology.

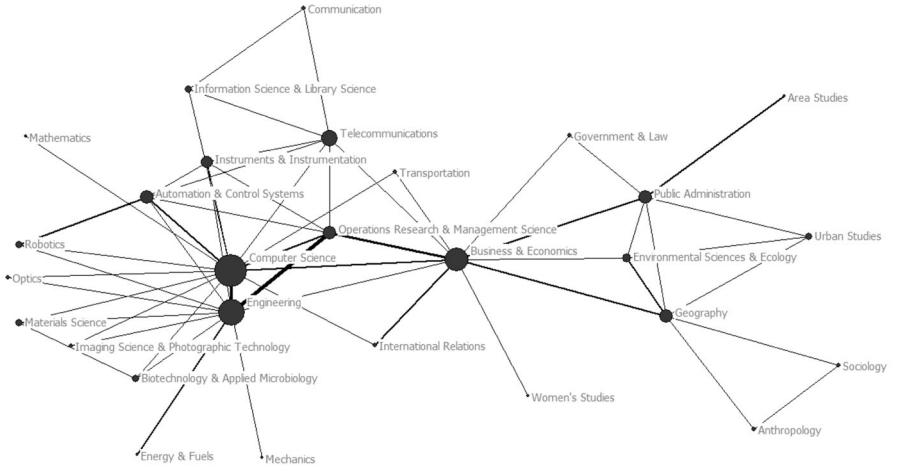
In summary, there were few disciplines during the initial stage of global value chains research; the disciplines were booming and diverse between 2005 and 2009. The dominating discipline was "business & economics", and others were "engineering", "computer science", "geography", and "operations research & management science", etc., among which the most frequent co-occurrences arose. The discipline "environmental sciences & ecology" has been on the rise recently, and the reasons might be: firstly, processes at each stage in global supply chains chain create environmental impacts (Yu et al. 2014). Energy use and carbon emissions are closely associated with global supply chains and logistics (Kamakaté and Schipper 2009). Developed regions externalize environmental impacts through importing goods, by contrast, less developed regions, and the less developed countries may recognize the value of resources and the cost of pollution and launch stricter environmental policies to prevent further ecologically unequal exchange with developed countries. Secondly, the firm-based environmental standards of multinationals with extensive global production networks might contribute to a leveling up of environmental standards in subsidiaries and their local suppliers in developing countries (Rock et al. 2006). Further, customers and legislation alike broaden a company's environmental responsibility to include organisations' upstream as well as downstream in the supply chain (Kovács 2008). Thirdly, increasingly stringent end-market environmental regulation, as well as growing concern over the need to protect a firm's reputational capital and operating legitimacy, are two key drivers of the adoption of firm-based environmental standards (Angel and Rock 2005). Firms develop green strategies to reduce environmental impacts while achieving economic benefits and competitiveness (Marchi et al. 2013)

Keywords co-occurrence analysis

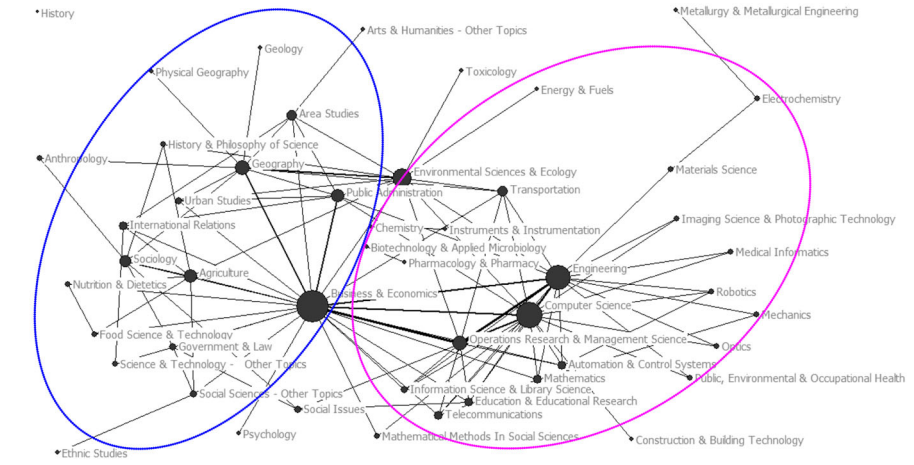
Keywords co-occurrence analysis is a useful tool to detect the research fronts. The keywords co-occurrence networks were generated by inputting the dichotomized co-occurrence matrices into Ucinet. In the original keywords co-occurrence matrices, most of the values in the cells were 0 and the rest were above 1, the matrices were dichotomized by setting the threshold value at 1. Figure 4 is the decomposed keywords co-occurrence networks during 1995–2014 with the time slice of 5 years in order to present a temporal evolution of the research fronts; each node represents a keyword or research topic, and the size of each node is proportionate to its degree.


Physics
Materials Science
Environmental Sciences & Ecology
Urban Studies
Geography
Public Administration
Sociology
Business & Economics
Government & Law
International Relations
Social Sciences - Other Topics
Area Studies
Information Science & Library Science
Computer Science

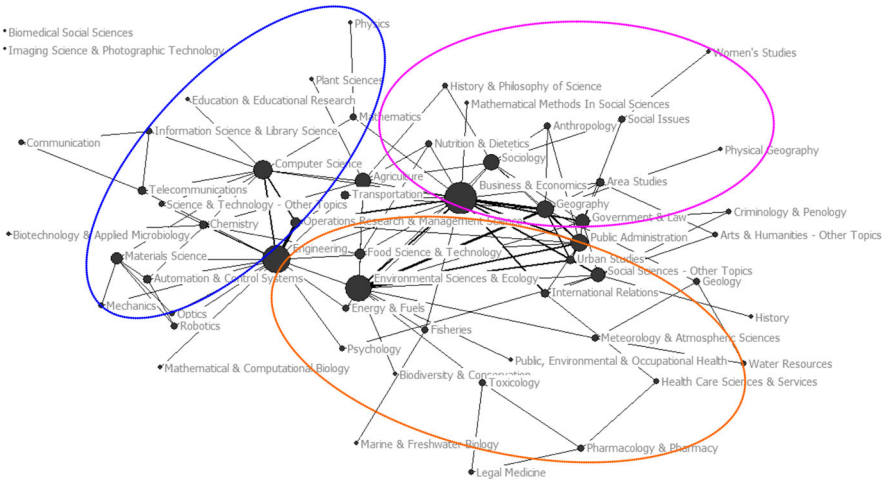
(a)


Communication
Information Science & Library Science
Telecommunications
Mathematics
Instruments & Instrumentation
Transportation
Automation & Control Systems
Operations Research & Management Science
Robotics
Computer Science
Business & Economics
Optics
Engineering
Materials Science
Imaging Science & Photographic Technology
International Relations
Biotechnology & Applied Microbiology
Energy & Fuels
Mechanics
Women's Studies
Government & Law
Area Studies
Public Administration
Urban Studies
Environmental Sciences & Ecology
Geography
Sociology
Anthropology

(b)


History
Arts & Humanities - Other Topics
Metallurgy & Metallurgical Engineering
Geology
Physical Geography
Toxicology
Energy & Fuels
Electrochemistry
Area Studies
History & Philosophy of Science
Anthropology
Geography
Environmental Sciences & Ecology
Materials Science
Public Administration
Transportation
Urban Studies
Chemistry
Instruments & Instrumentation
Imaging Science & Photographic Technology
International Relations
Biotechnology & Applied Microbiology
Medical Informatics
Sociology
Pharmacology & Pharmacy
Agriculture
Engineering
Nutrition & Dietetics
Business & Economics
Robotics
Computer Science
Mechanics
Food Science & Technology
Operations Research & Management Science
Optics
Government & Law
Science & Technology - Other Topics
Automation & Control Systems
Mathematics
Public, Environmental & Occupational Health
Information Science & Library Science
Social Sciences - Other Topics
Education & Educational Research
Social Issues
Telecommunications
Psychology
Mathematical Methods In Social Sciences
Construction & Building Technology
Ethnic Studies

(c)



(d)

Fig. 3 continued

As can be seen from Fig. 4a that there were relatively few keywords during 1995–1999 and the network is loose with three main separate clusters. The biggest node was "globalization" with the highest degree of 9, followed by "commodity chains" and "global commodity chains"; the nodes around them constituted the core cluster of network of this period. The direct neighboring nodes of "global commodity chains" are "rescaling of activities", "OEM", "industrial upgrading", "OBM", "path dependency", "eastern Europe", and "foreign direct investment". It is worth mentioning that "rescaling of activities" was of vital importance in this cluster owing to its bridging role in the network, therefore this topic was crucial then although its degree was low.

There were fewer nodes in Fig. 4b than Fig. 4a because the setting of the threshold exclude the keywords with low frequencies, however, the network was more concentrated. The topic "globalization" was also the biggest node in Fig. 4b and was a bridging node in the main cluster. "Global production networks" emerged while "global commodity chains" vanished, indicating a benchmarking paradigm shift during 2000–2004. The nodes directly linked with "global production networks" were "embeddedness", "logistics", "Singapore", "supply chain management", "globalization", "clusters", and "industrial districts", implying that they were the main research fronts in this period.

The network of Fig. 4c was more complicated and denser than the previous ones with much more nodes and links, implying that the research topics had been gaining diversities in this period. As can be seen from Fig. 4c that the biggest five nodes were "global value chains", "globalization", "governance", "outsourcing", and "innovation". The fact that the degree of "global value chains" was higher than that of "global production networks" meant the former had been winning more acknowledgements by researchers and the latter was an alternative topic. Through further analysis we found that the topics with the highest co-occurrence frequencies with "global value chains" were "governance", "innovation", "upgrading", and "networks", thus we may conclude that these topics together with afore mentioned with highest degree were the main concerns during this period.

Table 1 Top disciplines in four periods between 1995 and 2014 (time slice: 5 years)

Stage I (1995–1999)			Stage II (2000–2004)			Stage III (2005–2009)			Stage IV (2010–2014)		
Discipline	Records*	Degree	Discipline	Records	Degree	Discipline	Records	Degree	Discipline	Records	Degree
Business & economics	10	5	Business & economics	64	11	Business & economics	413	24	Business & economics	635	20
Geography	5	4	Engineering	38	12	Engineering	165	18	Geography	216	10
Government & law	4	2	Computer science	30	15	Computer science	158	19	Engineering	204	11
International relations	4	2	Operations research & management science	20	6	Operations research & management science	156	9	Operations research & management science	150	5
Sociology	3	1	Geography	16	6	Geography	89	10	Environmental sciences & ecology	127	16
Computer science	2	1	Public administration	13	6	Public administration	69	8	Computer science	111	11
Public administration	2	3	Area studies	6	1	Environmental sciences & ecology	51	13	Public administration	110	10
Area studies	2	1	International relations	6	2	Information science & library science	29	2	Government & law	60	8
Urban studies	1	2	Sociology	6	2	Automation & control systems	22	5	International relations	54	4
Social sciences—other topics	1	1	Automation & control systems	5	6	International relations	22	5	Social sciences—other topics	50	8
Information science & library science	1	1	Environmental sciences & ecology	4	4	Sociology	19	7	Sociology	42	9
Environmental sciences & ecology	1	1	Energy & fuels	4	1	Area studies	17	6	Urban studies	32	4
Physics	1	1	Information science & library science	3	3	Social sciences—other topics	16	4	Transportation	29	4
Materials science	1	1	Transportation	3	2	Urban studies	16	4	Agriculture	24	9

Table 1 continued

Stage I (1995–1999)			Stage II (2000–2004)			Stage III (2005–2009)			Stage IV (2010–2014)		
Discipline	Records*	Degree	Discipline	Records	Degree	Discipline	Records	Degree	Discipline	Records	Degree
			Robotics	3	3	Mathematics	15	5	Information science & library science	22	3
			Telecommunications	3	7	Telecommunications	15	5	Anthropology	18	3
			Mathematics	2	1	Government & law	14	4	Area studies	16	4
			Urban studies	2	3	Agriculture	13	8	Automation & control systems	11	4
			Government & law	2	2	Mathematical methods in social sciences	12	2	Physical geography	10	1
			Anthropology	2	2	Transportation	12	6	Telecommunications	9	4

* Records refers to the counts that a discipline appears at a certain stage; degree is calculated by Ucinet, refers to the number of links between a discipline and others in the network

The research topics were even more diverse than the previous periods and the network was more concentrated with more links in Fig. 4d. The top five nodes by degree are "global value chains", "global production networks", "China", "globalization", and "India"; among them two topics were Asian countries owing to their active participation and crucial role in global value chains. Such topics as "upgrading", "governance", "development" had more co-occurrence frequencies with "global value chains", and it may be inferred that they were the hot topics then.

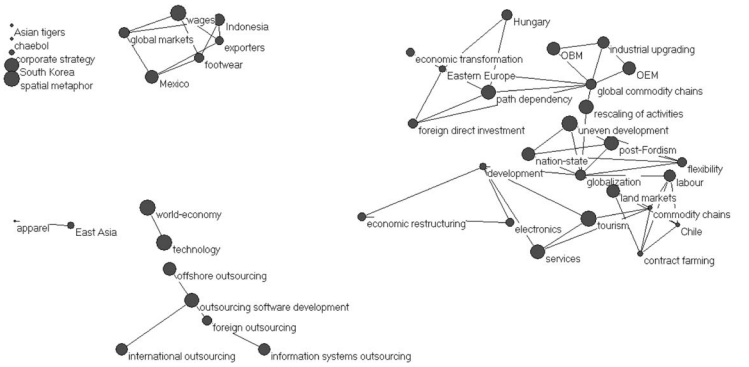
In order to thoroughly examine the shifts of research fronts, the evolution of keywords during the 20 years between 1995 and 2014 was divided into four stages with time slice of 5 years; each stage includes 20 keywords sorted by degree, records, and *k*-core (Table 2); degree reflects the links of a node with others in the network, records are the counting of the documents in which a certain keyword are mentioned, while high *k*-core value represents high power of influence (Zhu and Guan 2013).

An overview of the keywords showed that some topics were stable while others were changing. "Globalization was a top topic in each stage, indicating that it was an important background of global value chains. "Foreign direct investment", which was closely related with global value chains, appeared in stage I, stage III and stage IV; "China", "global production networks", "innovation", and "supply management" emerged in stage II, stage III and stage IV; the occurrence of "corporate social responsibility" in stage III and stage IV meant that recently global value chains research go beyond economic concerns towards social issues such as inequality, child labor, sweatshops, environment pollution and so on.

Further investigation of the keywords of each stage can reveal more detailed information of the evolution of research fronts.

"Global commodity chains" (GCC) and "commodity chains" emerged in stage I (1995–1999). The concept of GCC was defined by Terrence K. Hopkins and Immanuel Wallerstein in 1986 as a network of labor production process whose end results is a finished product, which was initially developed to understand the geographic expansion and contraction of early modern capitalism, but by the mid-1990s GCC was adopted by development scholars to capture the emerging patterns of fragmentation and geographic spread of production activities, and development challenges in export-orientated industries (Frederick 2014); it is not surprising that such keywords as "development", "flexibility", "post-Fordism", "labor", "exporters", "foreign direct investment", and "global market" were the hot topics in this stage; moreover, some countries or regions such as "eastern Europe", "Chile", "Indonesia", and "Mexico" were early active players in GCC.

According to Kuhn (1962), scientific revolutions are an integral part of science and science progresses through such revolutionary changes. Kuhn characterized the structure of scientific revolutions in terms of the dynamics of scientific paradigms. The revolutionary transform of science from one paradigm to another is now widely known as a paradigm shift. An abrupt disappearance of a few key documents in the leading cluster in 1 year and the rapidly increased number of documents in the leading cluster in the following year indicate an important type of specialty change—rapid shift in research focus—that is an indicator of "revolutionary" changes (Chen et al. 2002). Stage II (2000–2004) experienced a milestone of significant paradigm shift marked by the disappearance of "global commodity chains" and the emergence of two close framework "global production networks" and "global value chains". The appearance of some of the keywords in this stage proved the paradigm shift: "clusers", "industrial districts", "embeddness" and "vertical specialization. What are the dynamics underpinning the paradigm shift? GCC approach was the first to analyze both firm and inter-firm networks on a local and global scale, permitting researchers to forge the macro–micro links between firms previously assumed to be



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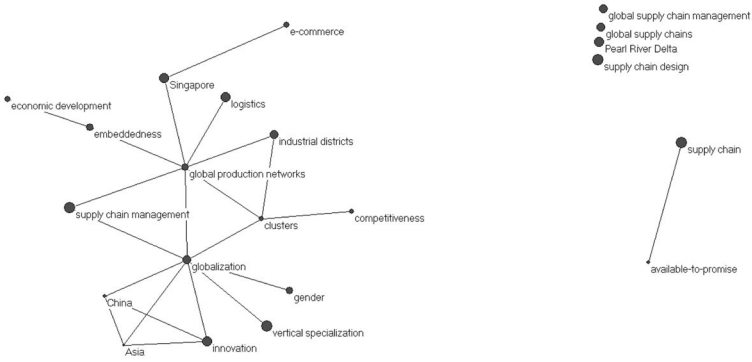

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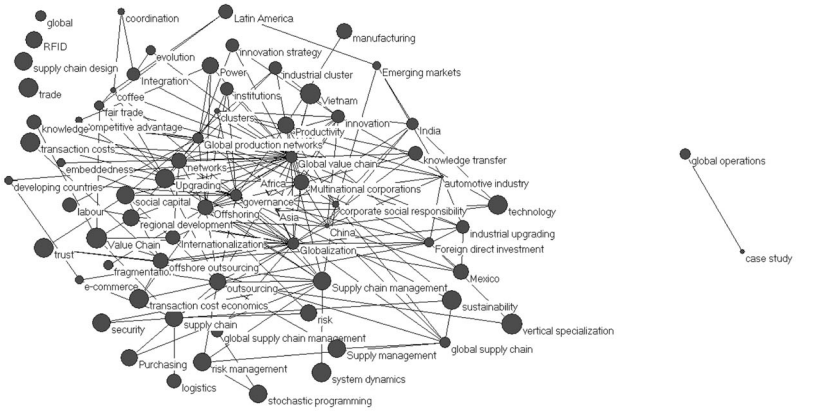
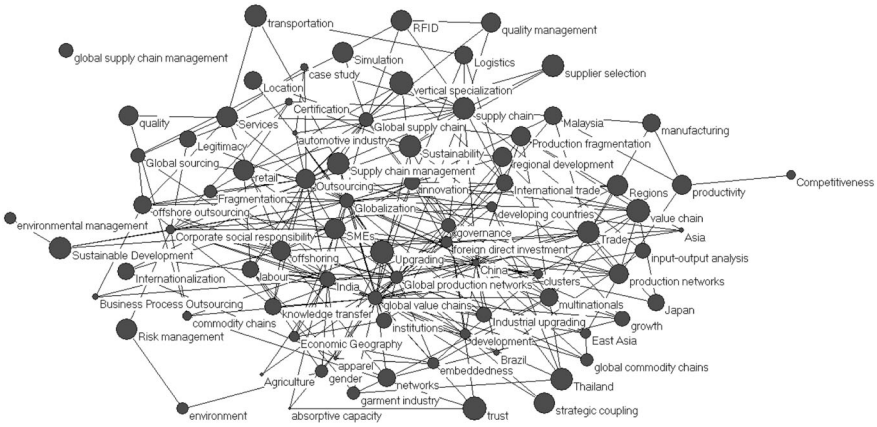


(c)

Fig. 4 The temporal evolution of the keywords co-occurrence networks. **a** 1995–1999 Keywords co-occurrence network. **b** 2000–2004 Keywords co-occurrence network. **c** 2005–2009 Keywords co-occurrence network. **d** 2010–2014 Keywords co-occurrence network



(d)

Fig. 4 continued

discreetly contained within global, national, and local units of analysis (Gereffi and Korzeniewicz 1994). A number of scholars prefer the phrase "global production networks" (Dicken 2003; Ernst and Ravenhill 1999; Henderson et al. 2002) because the term network implies multiple relational forms and directions and avoids the linear connotation of "chains," while production is intended to convey not just economic activity but also "the social processes involved in producing goods and services and reproducing knowledge, capital and labour power" (Henderson et al. 2002). It also avoids potential confusion in the use of the term commodity, which is often used to refer to undifferentiated, low-margin products (Levy 2008). Both "global production networks" and "global value chains" occurred in stage II, however, the latter was at the periphery with only 1 record and was excluded in the top keywords list. The regional or national keywords mentioned in stage I disappeared while "Asia", "China", and "Singapore" sprung, indicating the research change in regional focus caused by international industry's shifting from Latin America and eastern Europe to Asia, and China was a representative of the developing countries which actively participate in the global value chain while Singapore was a representative of the newly emerging market countries. "Post fordism", characterized by small-batch production, economies of scope, specialized products and jobs, new information technologies, emphasis on types of consumers in contrast to previous emphasis on social class, the rise of the service and the white-collar worker, and the feminization of the work force (Huxley 2008), was among the disappeared keywords in stage II, most probably caused by the trade-in-goods shifting to trade-in-tasks, and was another sign of paradigm shift from GCC to GPN. Such keywords as "clusters", "innovation", "industrial districts", "embeddedness", "vertical specialization" and e-commerce etc. had been growing into the hot topics because they were important components of global value chains. There was a highest record of "supply chain management" in this stage, other similar keywords includes "supply chain", "logistics", "global supply chains" and "supply chain design", indicating that supply chain management was closely related with global value chains research. Actually, supply chain management research has some common traits with global value chains. It can be concluded from Charvet F F et al. (2008): First, supply chain management

Table 2 The evolution of top 20 keywords in four stages

Stage I (1995–1999)				Stage II (2000–2004)				Stage III (2005–2009)				Stage IV (2010–2014)			
Keywords	Degree	Records*	*k*-core	Keywords	Degree	Records	*k*-core	Keywords	Degree	Records	*k*-core	Keywords	Degree	Records	*k*-core
Globalization	9	4	4	Globalization	8	9	3	Global value chains	30	81	5	Global value chains	37	139	6
Global commodity chains	7	3	3	Global production networks	7	81	2	Globalization	29	44	5	Global production networks	25	77	6
Commodity chains	7	1	3	Clusters	4	2	2	Governance	18	21	5	China	26	61	6
Development	5	2	3	Asia	3	2	3	Outsourcing	14	42	5	Globalization	25	41	6
Eastern Europe	5	1	3	China	3	2	3	Innovation	10	17	5	India	18	22	6
Flexibility	4	1	4	Innovation	3	2	3	Upgrading	11	16	5	Offshoring	15	40	6
Nation-state	4	1	4	Singapore	2			China	12	20	5	Outsourcing	16	46	6
Post-Fordism	4	1	4	Supply chain management	2	13	2	Offshoring	10	23	5	Innovation	15	29	6
Chile	4	1	3	Industrial districts	2	2	2	Supply chain management	11	43	5	Corporate social responsibility	15	20	6
Labour	4	1	3	Embeddedness	2	2	1	Global production networks	12	27	5	Foreign direct investment	15	18	6
Land markets	4	1	3	Available-to-promise	2	2	1	Networks	9	15	5	Offshore outsourcing	10	45	6
Path dependency	4	1	3	Gender	1	2	1	Corporate social responsibility	10	12	5	SMEs	10	12	6
Exporters	3	1	3	e-commerce	1	3	1	Foreign direct investment	10	14	5	Production networks	9	10	5

Table 2 continued

Stage I (1995–1999)				Stage II (2000–2004)				Stage III (2005–2009)				Stage IV (2010–2014)			
Keywords	Degree	Records*	*k*-core	Keywords	Degree	Records	*k*-core	Keywords	Degree	Records	*k*-core	Keywords	Degree	Records	*k*-core
Footwear	3	1	3	Vertical specialization	1	2	1	Multinational corporations	10	14	5	Value chain	9	17	5
Foreign direct investment	3	2	3	Competitiveness	1	2	1	Clusters	9	8	5	Labour	9	8	5
Global markets	3	1	3	Economic development	1	2	1	Automotive industry	6	5	5	Supply chain management	8	40	5
Indonesia	3	1	3	Supply chain	1	2	1	Industrial upgrading	6	8	5	International trade	8	18	5
Mexico	3	1	3	Logistics	1	3	1	Productivity	6	4	5	Trade	8	13	5
Services	3	1	3	Global supply chains	0	3	0	Social capital	6	5	4	Development	7	16	5
Tourism	3	1	3	Supply chain design	0	2	0	Offshore outsourcing	6	33	4	Institutions	7	17	5

* Records are the counting of the documents in which a certain keyword are mentioned; degree is calculated by Ucinet, refers to the number of links between a keyword and others in the network; *k*-core is also calculated by Ucinet, in an undirected graph *k*-core is a connected maximal induced subgraph which has minimum degree greater than or equal to *k*

research also covers a wide spectrum of disciplines. Supply chain management is a relatively young and developing field, with cross-functional nature, and can find its root in logistics disciplines, production and operations management; there lies an explosion of interest across industrial engineering, information systems, management and strategy, and marketing. Second, like the concept of global value chains, supply chain management demands clarifying various definitions and core concepts, as well as establishing a uniform conceptual framework. For instance, the difference between "integrated logistics management" and "supply chain management" requires presenting a conceptual framework emphasizing the supply chain structure, key business processes, and management components. Third, there also exits some paradigms in supply chain management. While there is significant convergence in thought within the logistics literature as to the meaning of supply chain management, the convergence across the full spectrum of academic interest still appears to be lacking, and it will be critical to integrate different streams of research.

"Global value chains" dominated stage III (2005–2009) with a sharp increase of records amounting to 81 and the highest degree of 30, surpassing "global production networks" which with only 27 records and degree of 12. However, it does not imply a paradigm shift from GPN to GVC; in practice these two frameworks are not conflicting and adopted alternatively. The core of GVC and GPN is similar: the nexus of interconnected functions, operations and transactions through which a specific product or service is produced, distributed and consumed. There are two crucial differences between GVC and GPN. First, GVCs are essentially linear structures, whereas GPNs strive to go beyond such linearity to incorporate all kinds of network configuration. Second, GVCs focus on the governance of inter-firm transactions while GPNs attempt to encompass all relevant sets of actors and relationships (Coe et al. 2008a). In the past decades the publications of such authoritative international organizations as United Nations, World Bank and World Trade Organization inclined to use the concept of GVC, which might have demonstration effects on researchers, consequently GVC occurred more frequently than GPN in literatures.

During this stage research mainly concentrated in "governance" and "upgrading"; the research focus shift in this stage was proved by the exclusion of more than half of the keywords (including "Asia", "Singapore", "industrial districts", "embeddedness", "available-to-promise", "gender", "e-commerce", "vertical specialization", "competitiveness", "economic development", "logistics") covered various disciplines such as economic geography, sociology, economics, strategic management, and operation management, from the top list of stage III. "Corporate social responsibility (CSR)" appeared in this stage. CSR seeks for balancing long-term economical, environmental and social benefits. It was introduced in global value chains originally aiming to improve the conditions of workers and protect workers' rights, and focusing on minimal standards in the areas of wages, hours, and occupational safety and health provides corporations with legitimacy (Anner 2012). Some other issues on CSR in global value chains research include debates on the added costs caused by CSR compliance (Lund-Thomsen and Nadvi 2010), mitigating global supply chain risk (supply-side disruption risks, social risks, and demand-side uncertainty) from CSR activities (Cruz 2013), selection socially responsible supplier (Griffis et al. 2014).

k-Core, degree and records in this stage were much higher than the previous stages, implying that there were more output and the research topics interconnected more closely than before, therefore stage III was of vital importance in global value chains research and marked a rapid growth.

Compared with the prior stage, research topics varied slightly in stage IV (2010–2014) while records of some research topics grew rapidly. "Global value chains" also dominated this stage with both the highest record of 139 and degree of 37, followed by "global production networks" with lower record of 77 and degree of 25, showing that the two concepts were studied alternatively and the former had won more acknowledgement by researchers, that is why "global value chains" occurs more frequently in researches. "Governance" and "upgrading" was no longer the main concern, while "China" and "India" were attracting more attentions in this period owing to their further involvement in global value chains.

In summary, there were relatively few research topics during the first two stages (1995–2004) and the co-occurrence networks were loose; however, these two stages laid foundations for global value chains research, that is, the emergence of global commodity chains in the first stage was the origin of global value chains and global production networks later on, and the second stage (2000–2004) experienced the paradigm shift marked by the concept of "global production networks" replaced "global commodity chain". The latest two stages (2005–2014) witnessed the emergence of diverse research topics on "global value chains". The concept of "global value chains" had been dominating the research in the past 10 years while "global production networks" appeared alternatively with lower standing. Although the research topics had been changing with some topics emerged while some vanished, such topics as "globalization", "foreign direct investment", "global value chains", "global production networks", "China", "innovation", and "supply management" had been remained as the focus in nearly all stages.

Reference co-citation analysis

The data downloaded was processed by Bibexcel, which is a free software and available at www.umu.se/inforsk. The documents in the reference lists were extracted and their citation counts in the collection of reference lists can be obtained. Seventy-two documents with citation counts above 30 were selected as samples to construct the co-citation network. Figure 5 is the co-citation network of the sampling literatures; the size of each node is proportionate to its citation counts, and the links between the nodes represent the similarities formed in the process of co-citation.

Modularity is one measure of the structure of networks or graphs. It was designed to measure the strength of division of a network into modules (also called groups, clusters or communities). Networks with high modularity have dense connections between the nodes within modules but sparse connections between nodes in different modules. Modularity is often used in optimization methods for detecting community structure in networks. According to Newman and Girvan (2004), the number of the communities is determined by the maximum value of Modularity Q. In this paper Modularity Qs are calculated by Ucinet; the value reaches the peak when the network is designated into four clusters. Consequently, the co-citation network is divided into four clusters with different colors: blue is for cluster 1, yellow for cluster 2, green for cluster 3, red for cluster 4.

Text analysis was supplemented in order to learn the details of the documents in the clusters about motivation, methods, data, instruments, results, and conclusions that authors typically report when documenting and submitting their work for publication (Boyack et al. 2013).

As can be seen from the network, Gereffi (2005) titled *The global economy: organization, governance and development* is the biggest node with 380 citation counts and locates in the center, indicating that it is the most important literature on GVC research up

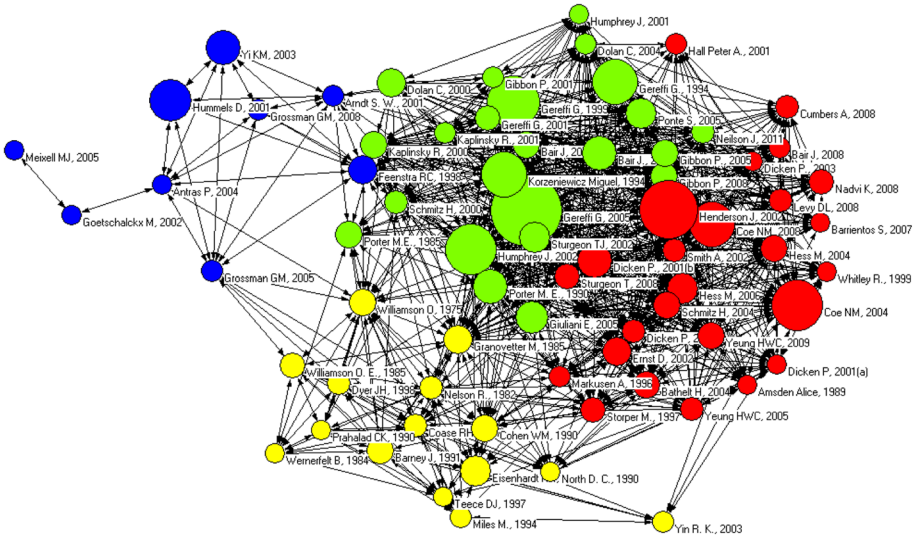


Fig. 5 Clusters of the sampling literatures

till now; Henderson et al. (2002), Gereffi (1999), Coe et al. (2004), Humphrey and Schmitz (2002), Coe et al. (2008a, b), Korzeniewicz (1994), Gereffi and Korzeniewicz (1994), Hummels et al. (2001) and Yi (2003) come next and constitute the core literatures on GVC research.

Next, this paper analyzes the clusters in depth.

Cluster 1 includes nine literatures. Six of them were from the perspective of economics and based on economic models: Yi (2003) developed a two-country dynamic Ricardian trade model to explain the trade growth; Antràs and Helpman (2003) developed a North–South model of international trade; Grossman and Helpman (2005) studied the determinants of the location of subcontracted activity in a general equilibrium model of outsourcing and trade; Meixell and Gargeya (2005) reviewed decision support models for the design of global supply chains; Grossman and Rossi-Hansberg (2012) proposed a theory of the global production process that focused on tradable tasks to study how falling costs of offshoring affect factor prices in the source country; Goetschalckx et al. (2002) reviewed the modeling and design of global logistics systems to demonstrate the savings potential generated by the integration of the design of strategic global supply chain networks with the determination of tactical production. Apart from the six literatures, Hummels et al. (2001) developed a concept of vertical specialization, Feenstra (1998) and Arndt and Kierzkowski (2001) proposed the idea of production fragmentation.

Cluster 2 consists of fifteen classical literatures which build the theoretical and methodological foundation of GVC research; Table 3 summarizes their contributions. It can be concluded that the theories are mainly from three disciplines: economics, strategic management, and sociology; among them strategic management theories are the major source. As far as the methodology is concerned, qualitative analysis and case study research are the most commonly used techniques.

Both cluster 3 and cluster 4 are the core contributors of GVC research, comprising twenty-two and twenty-six literatures respectively.

Table 3 Contributions of the literatures in cluster 2

Literature	Theoretical or methodological contribution
Wernerfelt (1984), Barney (1991)	Resource-based view
Coase (1937), Williamson (1975, 1985)	Transaction cost theory
Cohen and Levinthal (1990)	Absorptive capacity
Dyer and Singh (1998)	The relational view
Granovetter (1985)	Embeddedness
Winter and Nelson (1982)	An evolutionary theory of economic change
North (1990)	Institutional theory
Hamel and Prahalad (1990)	The core competence of the corporation
Teece et al. (1997)	Dynamic capabilities
Eisenhardt (1989), Yi (2003)	Case study research
Miles and Huberman (1994)	Qualitative data analysis

Cluster 3 mainly covers two research categories: GCC and GVC. Gereffi and Korzeniewicz (1994) was the founder of GCC research and Korzeniewicz (1994) also contributed to its introduction. GCC research focused on such subjects as governance in GCC (Bair and Gereffi 2001; Dolan and Humphrey 2000, 2004), upgrading in GCC (Gereffi 1999; Gibbon 2001) and assessment of GCC (Bair 2005). GCC research had been gradually shifting towards GVC since the new millennium marked by the emergence of some introductory literatures: Kaplinsky (2000), Kaplinsky and Morris (2001), Gereffi et al. (2001), Gibbon and Ponte (2005), and Gereffi (2005). The perspectives on GVC research centered on governance and upgrading in GVC. Besides GCC and GVC, there are some other subjects in cluster 3, for instance, Porter (1985) proposed competitive strategy, Porter (1990) built the classical diamond model of national advantage, and Schmitz and Knorringa (2000) discussed winners and losers in the global production market; further, it is worthwhile mentioning that Sturgeon (2002) titled *Building a New Paradigm for Industrial Organization: Production Network Models* proposed the concept of production network and laid the foundation for global production network (GPN) research. In summary, literatures in cluster 3 indicate that GCC research began from 1994, however, owing to the limitation of the narrow focus on commodity, the research gradually evolved into GVC with much wider perspective on value chain analysis, and after 2001 GVC research substituted GCC completely.

Cluster 4 contains 26 literatures. It can be concluded from this cluster that GPN research began to prosper from 2002 and engaged in various subjects: Henderson et al. (2002) was the most important contributor which proposes the framework of GPN for the first time; Ernst and Kim (2002) explored the relationship between GPN, knowledge diffusion and local capability formation; Barrientos and Smith (2007) investigated the ethical issue in GPN; Coe et al. (2004) discusses the connections between globalization process and regional development from the GPN perspective; Hess and Yeung (2006) assessed GPN in economic geography; Coe et al. (2008b) critically evaluated GPN perspective; Cumbers et al. (2008) discussed the fundamental role of labor agency in GPN; Levy (2008) offered a multidimensional and multi-level approach to understand power relation, ideology, and value appropriation in GPN; Yeung (2009) studied regional development and the comparative dynamics of GPN; Schmitz (2004) examined the issues of governance and

upgrading in GPN. Nadvi (2008) analyzed the relationship between standards and governance in the background of GVC; Sturgeon et al. (2008) was a case study using the GVC framework. GCC researches were limited in the assessment or comparison (Dicken et al. 2001; Bair 2008). Moreover, topic such as globalization and economic growth (Markusen 1996; Storper 1997; Whitley 1999; Dicken 2007), economic geography (Smith et al. 2002; Yeung 2005; Bathelt et al. 2004) are included in this cluster.

In order to further investigate the intellectual base of global value chain, it is necessary to analyze the information of the leading authors. Table 4 lists the top 20 contributors and their affiliated institutions sorted by h-index, records, and citation counts; nine of them were from the United Kingdom, accounting for 45 % of the leading authors, among whom five prominent authors Hess M, Dicken P, Coe NM, Henderson J, and Nadvi J were affiliated to University of Manchester and were contributors of "Manchester School"; eight authors were from the United States, two from Denmark, and one Singaporean author Yeung HWC received his Ph.D. from University of Manchester. It can be inferred from the origin of the authors that the United Kingdom was the main center of global value chain research, and another center was United States; authors from the two countries constituted nearly 90 % of the top authors; the most important author was Hess M with both the highest h-index and citation counts, and the most productive author included Yeung HWC and Coe NM with both the highest h-index and records.

Table 4 Top 20 contributors of global value chain research

Authors	Institution	h-Index	Records	Citation counts
Hess M	University of Manchester	10	12	1567
Humphrey J	University of Sussex	4	5	1384
Dicken P	University of Manchester	7	7	1188
Yeung HWC	National University of Singapore	10	15	1185
Gereffi G	Duke University	9	13	1136
Sturgeon T	Massachusetts Institute of Technology	4	4	979
Coe NM	University of Manchester	10	15	862
Yi KM	Federal Reserve Bank of Minneapolis	6	7	819
Henderson J	University of Manchester	4	4	811
Ponte S	Copenhagen Business School	9	14	459
Gibbon P	Danish Institute for International Studies	4	4	329
Barrientos S	University of Sussex	6	10	248
Tate WL	University of Tennessee	5	6	204
Nadvi K	University of Manchester	7	14	194
Feng KS	University of Maryland	6	8	153
Hubacek K	University of Maryland	5	6	140
Hughes A	Newcastle University	5	7	119
Rodrigue JP	Hofstra University	6	6	85
Wei YHD	University of Utah	5	9	75
Smith A	University of Southampton	4	6	68

Conclusion

This paper employs combined co-occurrence networks to comprehensively investigate the studies on global value chains during the past 30 years, with the aim of unveiling the evolution of disciplinary involvement, research fronts, as well as intellectual base, and the findings are as follows:

The disciplinary co-occurrence networks presented the evolution of various disciplines engaged in global value chains research. During the early period the disciplines were restricted in rather narrow domains such as "business & economics", "geography", "public administration", "government & law", and "international relations" with loose cooperation. With the rapid advancement of research between 2005 and 2009, more and more diverse disciplines involved and links among them became stronger. "Business & economics" had been the dominating discipline since the emergence of global value chains and had close co-occurrences with other top disciplines: "engineering", "computer science", "geography", "operations research & management science", etc.; recently "environmental sciences & ecology" had been on the rise.

It can be concluded from the keywords co-occurrence networks that although there were only limited topics, the period between 1995 and 2004 was fundamental for global value chains research in which the concept of "global commodity chains" emerged and then was replaced by "global value chains" or "global production networks" alternatively in the benchmarking paradigm shift. Based on the initial research, numerous research fronts sprang up during the past 10 years while some topics such as "globalization", "foreign direct investment", "global value chains", "global production networks", "China", "innovation", and "supply management" persisted; there has been more focus on "corporate social responsibility" lately.

The reference co-citation analysis showed that the leading contributors of GVC research were Gereffi (2005), Henderson et al. (2002), Gereffi (1999), Coe et al. (2004), Humphrey and Schmitz (2002), Coe et al. (2008a, b), Korzeniewicz (1994), and Gereffi and Korzeniewicz (1994). Four clusters formed in the sampling references illustrated the intellectual base of global value chain research: the main perspective of cluster 1 was economics; cluster 2 built the theoretical and methodological base of GVC research, including the theories of economics, strategic management, and sociology, as well as qualitative analysis and case study; literatures in cluster 3 indicated that GCC research began from 1994 and Gereffi and Korzeniewicz (1994) was the founder, however, owing to the limitation of the narrow focus on commodity, the research gradually evolved into GVC with much wider perspective on value chain analysis, and after 2001 GVC research substituted GCC completely; cluster 4 centered on GPN research which began to prosper from 2002 and engaged in various subjects, and Henderson et al. (2002) proposed the framework of GPN for the first time. Further investigation into the authors indicated that the most influential of them were from the United Kingdom and the United states, and five prominent authors Hess M, Dicken P, Coe NM, Henderson J, and Nadvi J affiliated to University of Manchester were the main founders of the renowned "Manchester School".

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