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Mapping the Landscape and Evolutions of Green Supply Chain Management

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Abstract: There is a growing need to integrate environmental considerations into supply chain management research and practice. Conceptual papers are being updated all the time to gain a systematic view of the framework in green supply chain management. The purpose of this paper is to visualize the research to-date on green supply chain management according to the intellectual framework and hot topics. Using bibliometric analysis, our paper will present a comprehensive summary of previous research on the knowledge domain. Exploring 1145 papers mainly published from 2000 to May 2017 in international peer-reviewed journals from social sciences citation index (SSCI), the basic distribution of publications are analyzed, and nine prominent research clusters in green supply chain management are visualized by a co-citation network. Key issues are highlighted and analyzed. As for future inquiries, there are numerous opportunities for more advanced theoretically-grounded research and exploration of more multi-functional and systematic approaches. In order to gain broader views of research, a triple bottom line approach can be widely applied to evaluation, impact mechanisms, decision making, drivers, risks and carrier analysis, as well as system contributions. This also provides an integrated point of view to understand the landscape of green supply chain management both for researchers and practitioners.

Keywords: green supply chains; sustainable supply chains; bibliometrics; knowledge mapping

1. Introduction

Environmental changes are upon us. Environment pollution and depletion of resources have been troubling human common life over the last decades. People have begun to be concerned about what we are doing to the climate, and governments are also taking actions to prevent environmental degradation. In the face of these problems, legislation enforcing stricter environmental regulations are being made all around the world. ISO 14000 standards provide operational guidelines and standards for the transformation of enterprises to eco-sustainable business practices [1]. It is regarded as the world standard for environmental management systems [2]. In the government policy guidance and related laws and regulations, combined with the consumer market for the growing demand for green products, many foreign manufacturing enterprises have begun to consciously combine the green supply chain theory and model to guide the overall strategic planning, specific operational practices, and the improvement of business efficiency and social responsibility to achieve the initial expected results [3,4]. Porter considers fundamentals of becoming green as a competency in innovation [5,6], not only for resource saving and eliminating waste, but for improving productivity. With this growing trend, environmental issues are being used by more and more forward-thinking companies to become more profitable while decreasing damage or deplete in environment. Therefore, green supply chain management attracts firms' attention, and gains researchers' increasing interest.

The concept of green supply chains originates from the concept of green purchasing proposed by Webb in 1994, first proposed for the Environmental Responsibility Manufacturing (ERM) study in 1996. It is normally identified as integrating environmental factors into the supply chain in procurement, product design, manufacturing, logistics and other aspects. Beamon adds to the traditional supply chain activities of remanufacturing, recycling and reuse, and proposes an extended supply chain: the green supply chain [7]. At present, the framework of green supply chain management has not yet become mature; the definitions and scope of it need improving. Handfield defines green supply chains as the application of environmental management principles to the entire set of activities across the whole customer order cycle, including design, procurement, manufacturing and assembly, packaging, logistics, and distribution [8]. Zhu regards the green supply chain as an important new archetype for enterprises to achieve profit and market share objectives by lowering their environmental risks and impacts while raising their ecological efficiency [9]. Srivastava gives a newly accepted definition that the green supply chain should be defined as integrating environmental thinking into supply-chain management, namely product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life [10]. In a nutshell, the core idea of green supply chain management is the integration of environmental considerations into supply chain management. The purpose is to improve competitive advantages, raise ecological efficiency, and lower environmental risks or impacts at the same time [9]. In respect to the scope of green supply chain management, various considerations exist. Similar to supply chain management, the boundary of green supply chain management is dependent on the goal of researchers [10]. Supply chains encompass all activities associated with the flow of goods from the raw materials stage (extraction) through to the end user, as well as information flows. The purpose of supply chain management is to integrate these activities to achieve sustainable competitive advantages [11]. In line with this definition and its extensions, purchasing, sourcing, manufacturing and relationships among supply chains are all identified in green supply chain management. Furthermore, the research on information flow, product flow, and logistics are all included. Sarkis points out that the major subcomponents of the green supply chain are inbound logistics (which includes procurement), material management, out-bound logistics, packaging, and reverse logistics issues [12]. In respect of research subjects as they refer to green design, performance evaluation, strategic practices, and collaboration among all links are covered. Green purchasing, green manufacturing/material management, green distribution/marketing and reverse logistics are summarized according to Hervani's article [13]. Steve integrates suppliers into environmental management processes, the product design process, the choice of product use materials [14], and the supply process optimization, which are covered in the implementation of environmentally friendly practices. These days, one of the bigger issues facing companies is the actions of suppliers. Thus, the topics of supplier selection and evaluation are becoming important. In terms of methodology, supply chain management, enterprise performance, environmental management, life cycle theory, enterprise competitive advantage, coordination theory, game theory, evaluation method, decision technology and other theories provide basic methods for correlated research. In the full scope of green supply chain management, there are also studies of decision-making mechanisms, cooperation mechanisms, restraint mechanisms, and the benefit of distribution mechanisms among member enterprises in connected research.

In a nutshell, the knowledge domain of green supply chain management is developing fast. More and more attention has been paid to integrating environmental considerations into research and practice of supply chain management, while conceptual papers are being updated all the time to gain systematic considerations. The purpose of this paper is to evaluate related publications, researchers, and journals, as well as provide quantitative analysis and visualization of accumulated literature according to the intellectual framework and hot topics. Using bibliometric analysis, our paper will present a comprehensive summary and a systematic review of previous research on green supply chain management in terms of dynamic development and intellectual relationships. On the basis of

the identified foundation of the research, key issues will be highlighted which should be addressed in the evolution of green supply chain management. Science mapping identifies major embodiments, intellectual milestones, evolutionary stages, and dynamics of transitions concerning green supply chain management. Conceptualization and methods or theories applied are also referred to. It contributes to structuring a theoretic outline of the knowledge domain and conveying future directions to both new comers and existing researchers in green supply chain management. As for practitioners, a snapshot of the knowledge domain is provided to investigate.

2. Methods and Materials

The accumulated literature is critical for understanding a knowledge domain, since it is a necessary step towards theory development [15]. Bibliometrics provides a statistical tool of knowledge carriers using of mathematical and statistical methods [16]. The main objects include literature (various publications, especially journal articles and quotations), authors (individual collective or group), and key words (document identifications) [17]. It can be applied to provide a quantitative analysis of academic literature or the evaluation of a knowledge domain, researchers, or a particular paper [18,19]. To construct relationships among publications and networks of cited references, co-citation analysis is the most commonly used bibliometric method to study the landscape of evolutions of a knowledge domain. Co-citation is defined as the frequency with which two documents are cited together by other documents [20]. According to Garfield's theory, the research paradigm of a knowledge domain can be identified by its intellectual base and research fronts. The intellectual base refers to the cited scholarly works, while research fronts refer to the citing works inspired by the corresponding intellectual base. It is generally recognized that research fronts rise from an intellectual base [21]. Therefore, co-citation analysis is a common method to characterize semantic similarity between publications based on citation graphs, or a network. If at least one other document cites two documents in common, these documents are said to be co-cited. The more co-citations two documents receive, the higher their co-citation strength, and the more likely they are to be semantically related.

Science mapping is graph representation of relationships between documents. Building varieties of bibliographic records as inputs and models, this is a generic process of detecting and monitoring the dynamics of evolutions or intellectual frameworks in domain analysis [22]. The scope of science mapping can be a scientific discipline, a knowledge domain, or a specific research question. We consider green supply chain management to be a knowledge domain. Using a time slicing technique, individual networks according to time series are synthesized to construct a landscape view of the relevant literature. The CoCit score proposed by Gmür which measures co-citation value or frequency is taken as a similarity indicator to build a similarity-between-pairs matrix, S. Hierarchical conglomerates analysis is applied to matrix S to co-citation clustering. Through visual encoding design, cited references with salient bibliometric metrics are represented in the heterogeneous network.

Since science mapping has developed, a further analysis of landscape view is the key to seize an outline of the knowledge domain. Analysis in our research is arranged into three sections. The first section provides basic bibliometric analysis, including analysis of publications, journals, categories and researchers due to regulations and emerging trends. The second section provides a landscape view of green supply chain management due to co-citation analysis. Clustering analysis is covered in this section. The last section identifies key issues. Only for emerging or narrowly defined issues might it be possible to provide a complete view of a knowledge domain. Except for the overall framework, highlighted nodes presented in the landscape view also play an important role in the evolution of a knowledge domain. Three widely accepted indicators—citation frequency, betweeness centrality, and burst detection—provide solutions to spot key issues in green supply chain management.

To form a systematic framework, quantitative and qualitative aspects are mixed to assess structural as well as content criteria [23]. Mayring proposes a process model containing four steps: material collection, descriptive analysis, category selection, and material evaluation [24]. The development of our research ideas is almost in line with the model. We first demonstrate a generic search strategy that

can be used to construct a representative dataset of bibliographic records of the knowledge domain research. The material to be collected is defined and delimitated. Next, formal aspects of the domain are assessed by exploration of basic bibliometric characters. Then, the progressively synthesized co-citation networks are constructed. Structural dimensions and related analytic categories are visualized, and structural and dynamic patterns and trends are identified. Finally, the development of a scientific domain and key issues in each cluster will be addressed to gain deepened understanding.

All documents connected are searched from the core collection of the SSCI index from Web of Science in order to ensure authority from 2000 to May 2017. We search "TS = green* supply chain" covering the title, abstract, keywords, or in some cases the full text. To cover documents of good quality, proceedings, reviews, editorials, and letters are all excluded from the research sample. Only articles are retrieved since they are commonly accepted and it is easy to calculate bibliometric records. As a result, 1145 articles and 9957 cited correlated references are selected which are suitable for the research. Limitations are inevitable in the selection of datasets. Our paper focuses more on the outline of green supply management, so that papers addressing specific operational or highly technical issues are excluded, such as life-cycle assessment, inventory management, and so on. Since the management is our point of view, research with a rather ecological perspective is also excluded.

3. Landscape Analysis

3.1. Basic Bibliometric Analysis

3.1.1. Analysis of Publication Data

Due to the basic bibliometric analysis of the research sample, the h-index of research in green supply chain management reaches 78, indicating that 78 papers have been cited over 78 times. The distribution of publications is shown in Figure 1. Before 2007, there were few papers related to the fresh subject, while these have expanded sharply since then. Until 2016, the quantity reached 244: 19.65% of the total. Quantity in 2017 (181 articles) is excluded since the data is not statistically significant, but it is obvious that the total amount will be more than ever before. As in other novel subjects, the amount of articles published each year is roughly exponential. Fluctuation appears with the increasing research in the systematic framework of the knowledge domain around 2012. Similarly, the sum of times cited per year also increases exponentially. The exponential growth is a typical characteristic of the emergence and development of new disciplines or research domains [25]. According to Price, this reflects the emerging trend in green supply chain management [26]. Obviously, the growth of citing articles tends to be more exponential, whose R-squared reaches 0.9591, and increases faster as well.

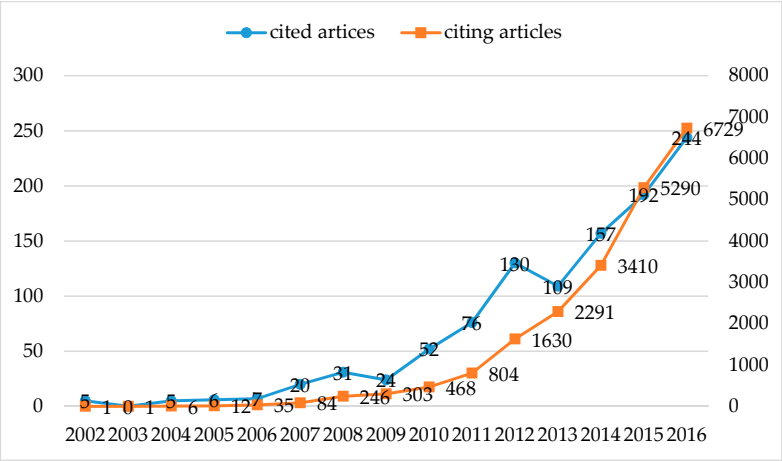

Figure 1. Quantity of publications each year.

3.1.2. Analysis of Journals and Categories

Figure 2 illustrates the distribution of categories around the knowledge domain (one article can be attributed to different categories). 29.3% of the total (336) articles are attributed to environmental sciences, while articles attributed to management reach 27.3%. According to the categories in Web of Science, research on green supply chain management integrates environmental sciences, management sciences, operations management, engineering, manufacturing, and other categories. In respect to the journals covered, quantity of publications, proportion of total publications, impact factors, h-index, and other indicators are all explored to evaluate the quality and influence of each journal as indicated in Table 1. The instances from the *Journal of Cleaner Production* and *International Journal of Production Economics* add up to nearly 23% of the total. One hundred and sixty-seven articles are from the *Journal of Cleaner Production*, which make up 14.6% of total. *Journal of Cleaner Production* focuses on cleaner production, and environmental and sustainability research and practice, whose impact factor is the highest (5.751). The h-index of the journal is 28, and 15 highly-cited articles are published in the journal, nearly 21.1% of highly-cited articles mentioned. In other words, although the average citations per item (19.56) of the journal is not high enough, the amount of influential articles takes the first place in the journal list. Both h-index (30) and average citation (38.31) of *International Journal of Production Economics* is higher, and 10 highly-cited articles are included. The journal covers all aspects of the subject in relation to manufacturing and process industries, as well as production. Corresponding research considers more of the material flow cycle of production, namely product life cycle-research, design, development, test, launch, and disposal. Supply management and distribution are also included. The first two journals represent basic characters of green supply chain management, considering sustainability or environmental issues as well as operations management or supply chain management in manufacturing and engineering. *Sustainability* is a newly founded journal related to sustainability and sustainable development. *Supply Chain Management—an International Journal* is also academically influential in the supply chain management domain, which can be reflected in its impact factor (4.072). Unlike the four journals mentioned above, the quantity of publications from *International Journal of Production Research* is far less steady. Recent research captures more operations management journals, namely *Journal of Cleaner Production*, *International Journal of Production Economics*, and *International Journal of Production Research*.

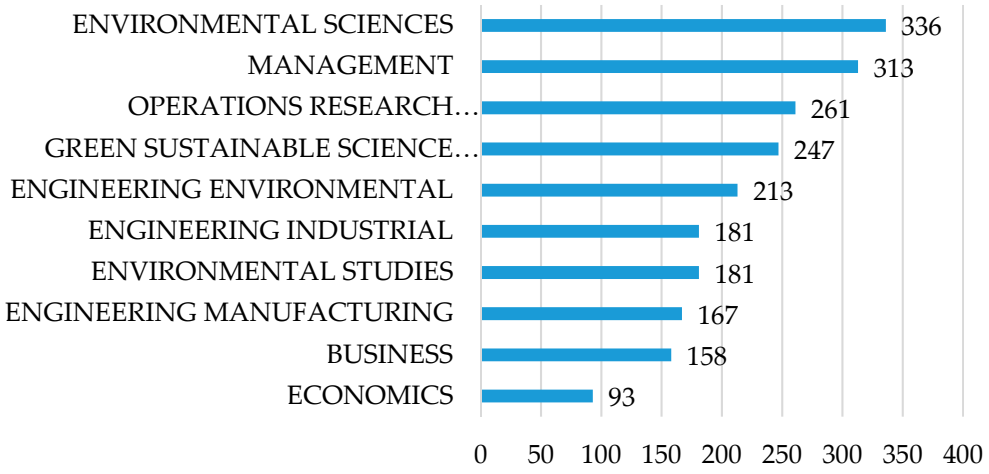

Figure 2. Research field analysis.

Table 1. Top journals and information listed.

Rank	Journals	Publications	Proportion	Impact Factor	Categories
1	*Journal of Cleaner Production*	167	14.623	5.715	Green sustainable science technology; Engineering, Environmental; Environmental science.
2	*International Journal of Production Economics*	94	8.231	3.493	Engineering, Industrial; Engineering, Manufacturing; Operations research management science.
3	*Sustainability*	47	4.116	1.789	Green sustainable science technology; Environmental sciences; Environmental studies.
4	*Supply Chain Management: An International Journal*	38	3.327	4.072	Business; Management.
5	*International Journal of Production Research*	37	3.24	2.325	Engineering, Industrial; Engineering, Manufacturing; Operations research management science.

3.1.3. Analysis of Researchers

Considering authors' contribution in the knowledge domain, as Table 2 indicates, the total amount of the top three authors' articles reached 10% of total publications searched. Sarkis J., Lai K.H., and Zhu Q.H. contribute a large amount to the knowledge domain. In addition, 20 of Zhu's articles and 13 of Lai's are composed with Sarkis. Taking the various indicators into account, there is no doubt that Sarkis can be considered one of representative founders in the development of green supply chain management, and 9 of the 66 highly cited papers are composed by his research group. In the view of citations, Zhu's research seizes more attention, and the amount of high-quality articles keeps rising. Her academic influence and potentiality in the knowledge domain cannot be neglected.

Table 2. Top authors and information listed.

Rank	Authors	Publications	Proportion	h-Index	Average Citations per Item	Highly Cited Papers
1	Sarkis J.	44	3.853	25	71.63	9
2	Zhu Q.H.	26	2.277	28	84.56	5
3	Lai K.H.	25	2.189	17	70.63	6
4	Jabbour C.J.C.	19	1.664	9	16.38	2
5	Govidan K.	18	1.576	11	33.40	3

3.2. Landscape Analysis

3.2.1. Landscape View

The following landscape view is generated based on the 1145 articles mentioned above. The top 35 most cited articles each year between 2000 and 2007 are selected to construct the co-citation network of highly cited references in green supply chain management. Individual networks are synthesized as seen in Figure 3. Each node represents one cited reference, while connections between nodes represent one or more co-citation links involving the two references. The size of each node is depicted with the citation frequency checked, while the thickness of connections is depicted with co-citation strengths. The synthesized network below contains 356 nodes with 1120 connections. The color of co-citation links shows the year in which the initial connection between the two documents was made. The color shift from cold to warm from left to right in the figure corresponds to the time when co-citation occurs for the first time. The colder, the earlier the co-citation is. Similarly, there are a number of treerings on each node, which represent the citation history of references, referring to co-citation frequency received in the corresponding time slice [26]. Large-sized nodes or nodes with red rings are of particular interest because they are either highly cited or have citation bursts or both. Purple treerings indicate high betweenness centrality, and red treerings indicate high burst detection, which will be explained in detail below.

Overall, articles with salient citation indicators in green supply chain management all gather in the orange and red part of the network, which means that articles newly published gain more attention and more potential in academic circles. This is easy to explain for a developing knowledge domain. The difference is the size of newly publications and the enormous contrast between fresh articles and proceedings. Further study around the nodes and connections will follow, and we will focus more on the right half of the network.

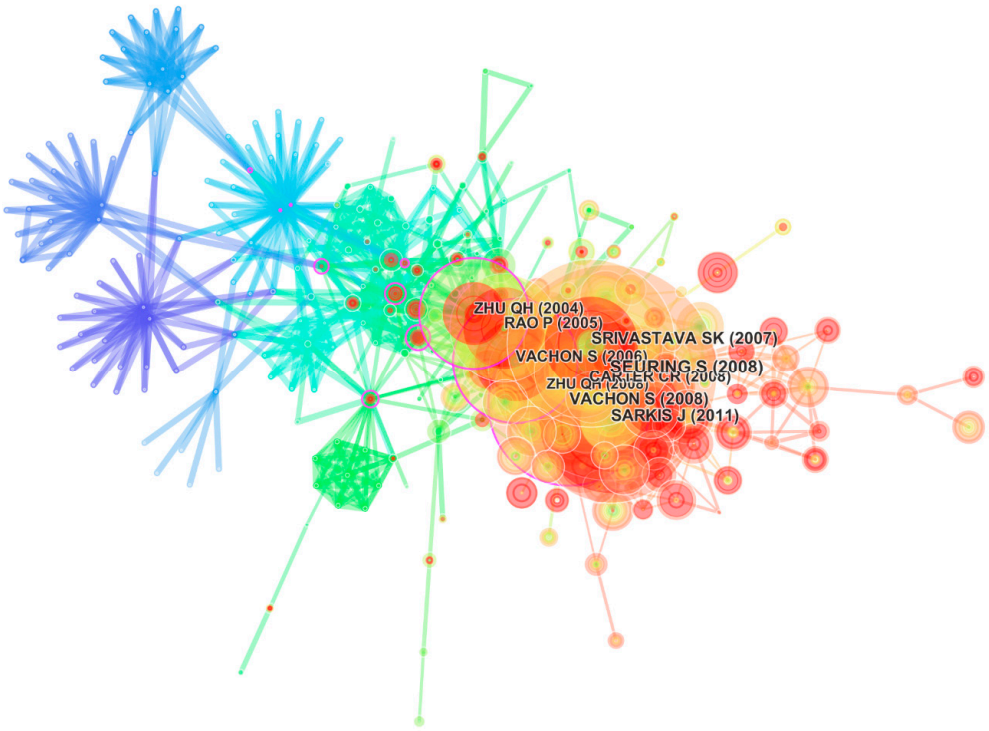

Figure 3. Cited reference network in green supply chains.

3.2.2. Clustering View

The purpose of this step is to detect major clusters in green supply chain management that indicate various characteristics, the embodiment and intellectual framework of the knowledge domain. In each cluster, we focus on cluster members and corresponding citing articles. The nature of each cluster is labeled from recurring key terms of citing articles [27], including title terms, keywords, and abstract terms. Issues with structural and temporal metrics inform us of research impact, evolutionary significance or other information around the cluster.

Using the applied hierarchical cluster analysis technique, the synthesized network is divided into 43 co-citation clusters (including isolated points). The nine largest clusters connected with each other form the largest connected digraph (see, Figure 4). The modularity and the silhouette of major clusters are sufficient high to pass the clustering test. Clusters are numbered from 0 according to the capacity of each cluster. The details of the prominent clusters are summarized in Table 3. In the noteworthy third column, the silhouette indicates the homogeneity of a cluster, meaning the cluster members were well matched with their cluster [28]. According to the silhouette value of each cluster, clusters #0, #1, and #3 relate more to other clusters, while the others are relatively separate. One other thing to note is that, in the visualization of the knowledge domain, the larger a cluster is, the more convincing it is. The largest cluster, #0, has 78 members and a silhouette value of 0.752, covering 148 citing articles. It is labeled as green supply chain management capability by the log–likelihood ratio. It is not only the biggest cluster in the knowledge domain in size, but links most with other clusters.

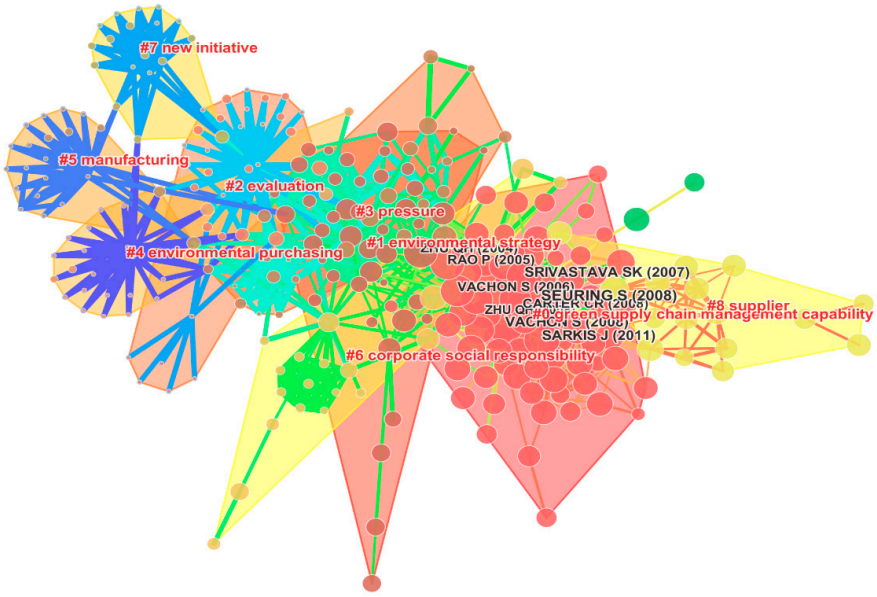

Figure 4. Prominent research clusters in green supply chains.

Table 3. Prominent research clusters in green supply chains.

Cluster	Size	Silhouette	Mean	Custer Label
0	78	0.752	2009	Green supply chain management capability
1	45	0.764	2001	Environmental strategy
2	32	0.931	1998	Evaluation
3	24	0.856	2001	Pressure
4	23	0.92	1994	Environmental purchasing
5	22	0.907	1997	Manufacturing
6	20	0.913	2002	Corporate social responsibility
7	18	0.939	1997	New initiative
8	16	0.954	2011	Supplier

Frontiers in cluster #0 cover the most popular topics in green supply chain management during the last decade, which attaches more attention for the landscape view. The 148 citing articles covered can be categorized into four research methodologies: surveys, case studies, theoretical and conceptual papers, and modelling or methodology detected. Empirical studies lead the main role, while modelling- or methodology-related issues are growing. Empirical studies in green supply chain management consist mainly of the first two methodologies. Case examples provide illustrative evidence for empirical studies, where descriptions of industry practice are given without aiming at theory development or testing [29]. Using surveys, the impact of green supply chain practices on performances are explored [30,31]. Sustainability allows companies to achieve competitive advantage by improving economic, environmental and social performance through the increase of material efficiency, energy saving, closed-loop control at industrial system level, and through increasing competitiveness [32]. The collaboration capability between suppliers in green supply chain management is also covered [33]. In terms of theoretical and conceptual papers, most of them adopt the methodology of literature analysis to gain a systematic, explicit, and reproducible framework of the existing body of recorded documents. Strategies, metrics, and framework of green supply chain management are discussed [34–37]. Basic components of the knowledge domain are also included, such as green purchasing, green marketing [38], and reverse logistics [39]. Compared with citing articles, the corresponding cited articles cover more research on the definitions, theory frame [10,29], and future directions [40]. Empirical research on collaboration and integration in green supply chain

management plays a significant role [41,42]. Results of the empirical studies provide basic theory or practice as foundations as well. Cluster #0's mean cited year occurs in 2009, and the popularity keeps rising in recent years. Furthermore, a good quantity of key issues belongs to the cluster. The cluster is dominated by representative terms such as supply chain management, capability, sustainability, performance, practices, etc. Research instruments include the supply chain operations reference model, rough set theory, plan-do-check-action (PDCA) cycle, thematic analysis, meta-analysis, and other research methods. Half of the research is around sustainable supply chains. Sustainable supply chain management is driving firms to extend their social, economic and environmental efforts across their supply chains. Several identified definitions addressed at least half of the proposed key business sustainability and supply chain management characteristics.

Cluster #1 is concerned about strategy level. The articles explore complementarities and search for low waste operations. Cluster #2 is more about the evaluation of green supply chains. Plant-level environmental investment and collaboration between suppliers are evaluated using multiple attribute utility theory, life-cycle assessment, or other tools. In Cluster #3, pressures and practice are the main objects. Pressures from stakeholders, government, as well as customers are initiatives in green supply management. Cluster #4 is not big enough as a specialty, but the members in the cluster were all published early in 1990s, except two published in 2001. Due to the published time and great influence, the half-life of the articles are all sufficiently long. Citing articles of the cluster only include three articles, explaining the role of risk in environment-related supplier initiatives [43], purchasing and greener manufacturing in dirty chains [44], and an empirical investigation about environmental purchasing and firm performance [45]. Cluster #5 is about the dirty chain in manufacturing firms. Cluster #6 researches corporate social responsibility, environmental decision-making, and supply chain networks. Cluster #7 concentrate on new initiatives in South East Asia. The last Cluster #8 puts an accent on incomplete information between suppliers and analyzes the influence it brings about.

3.2.3. Timeline View

Timeline visualization is an alternative approach for viewing the evolutions of clusters and their relationships (see, Figure 5). Each cluster is arranged along horizontal publication timelines from left to right. Clusters are displayed vertically in the descending order of their capacity. Cluster #0 is shown at the top of the science mapping and Cluster#1 follows. The colored links represent co-citation connections which appeared in the corresponding time. As we can see in the timeline view, the sustainability of each cluster varies. Some clusters keep active for over 10 years, such as Cluster #0 and Cluster #8, while others only sustain for a relatively short period, such as Cluster #5. In respect of sustainability, Cluster #0 and Cluster #8 remain active until 2017, while the others have disappeared for a long time or have now been transformed to the main clusters.

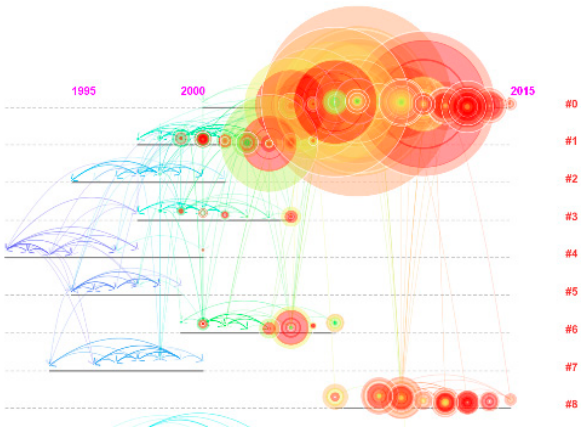

Figure 5. Prominent research clusters in green supply chains in timeline view.

Three stages in the development of green supply chain management are explored in timeline visualization. The first stage is from 1992 to 2000, where there are few high-profile references. The earliest article covered was published in 1992. Nearly all the articles published earlier (before 1994) belong to Cluster #4, which reflects environmental purchasing, except two belonging to Cluster #7. Before 2000, Cluster #2, #5, and#7 lead the mainstream, with a focus on evaluation or processes in green purchasing and dirty chain in manufacturing firms. Green supply chain management arises from the demand of industries and other corporate entities, especially for manufacturing corporates. Before 2000, more research focused on pollution prevention and resource utilization. Initiatives of green supply chain management are discussed to test whether green supply chain management may bring about economic benefits, an increase of productivity or improvement of the environment. In fact, the triple bottom line has brought researchers' attention since the origin of supply chain management, but current research fails to integrate the three impacts. Webb examines the environmental impact of some products, suggesting that environmental criteria should be used and putting forward the idea of recycling green procurement, but he has not risen to the green supply chain management point of view [46]. Michigan State University's Manufacturing Research Association (MRC) conducted an Environmentally Responsible Manufacturing study aimed at integrating environmental impact and resource utilization in the manufacturing supply chains. Later, the concept of the green supply chain was put forward. Subsequently, North America, Canada, Europe, Britain and other countries have begun a wide range of green supply chain management research. Min. H and Galle WP detect environmental protection factors in decision-making of suppliers and the role of green purchasing in reducing waste [47]. It is beneficial to make detailed decisions on the selection of suppliers and consideration of environmental factors, but not from the standpoint of supply chains yet. Sarkis points out that the major subcomponents of green supply chain are inbound logistics (which includes procurement), materials management, out-bound logistics, packaging, and reverse logistics issues [12]. Beamon focuses on environmental factors in the supply chain model, presents a broader supply chain design pattern, and puts forward the concept of green supply chain. For supply chain management, he proposes new business indicators, including material recovery rate, core return rate, waste ratio, eco-efficiency, etc. [7]. Handfield and Nichols give a more comprehensive definition across the whole customer order cycle. The latter three scholars have studied the green supply chain management from the overall point of view. The idea of the enterprise's strategic change and green design of supply chains are put forward in applications. In conclusion, the focus of early works is limited, since few of them cover adequately all the elements of green supply chain management. In contrast, the later works focus more on related supply chain issues and integration of supply chain management.

Clusters #1 and #3 almost start at the same time, around 2000, and are related with each other closely. Articles published early with strong bursts or highly citation frequency should be noted. Between 2000 and 2005, Cluster #1 develops fast, whereas Cluster #3 declines, and Cluster #6 begins to grow. Empirical studies on the impact of practices on performances have never stopped since the proposal of green supply chains. Research focused on strategy implications, concerning green and lean, appears during the period, and social responsibility is involved in inter-organizational management. Clusters #0 and #8 are hot domains in recent years, indicating that the concept of green supply chain and research on supplier management may be the frontiers of the subject. In addition, almost all the other clusters are related to Cluster #0, whether citing articles or cited articles, whether highlighted issues or common ones. In conclusion, clusters which occurred before 2005 can be considered as the basic foundation of green supply chain management. Though published early, their academic influence remains. Due to the serious issues caused by environmental problems, empirical research is made to study the influence green supply chains caused to manufacturing firms, and to propose decision-making for green supply chain practices. Problems of traditional supply chain management, such as incomplete information, are also covered. The third period is from 2005 to 2017. Since 2005, there has been a great-leap-forward development in the knowledge domain. As a novel knowledge discipline, more works attempt to conceptualize the entire domain or related research topics, such as

metrics and models, concerning the newly identified target. Equipped with improved methodology or modelling, attempts have been made to investigate the drivers or relationships to explain underlying phenomena. Relationships between green supply chain practices and performances always leads empirical studies. Decision-making models, supplier selection, collaboration or integration practices, and capability measurement or evaluations all play significant roles in Cluster #0. Formulation of practice and exploration of impact mechanism in green supply chain is the main duty in today's research, which calls for theoretically grounded research and exploration of multi-functional and systematic approaches.

4. Key Issues Analysis

4.1. Citation Frequency

Citation frequency is the most common indicator reflecting academic influence or research quality of articles, authors, and journals. The citation frequency among the data sample of a cited article is reflected in the landscape view, which corresponds to the node size. The top 10 cited papers of all years are identified by noting citation frequency (see Table 4), which connect closely with one another and lead to a core position in the network. The most frequently cited work in green supply chain management is Seuring's article published in 2008.

Table 4. Articles with top citation frequency listed.

Freq	Authors	Year	Title	Journal	Cluster
177	Seuring S.; Müller M.	2008	From a literature review to a conceptual framework for sustainable supply chain management	J. CLEAN. PROD.	0
141	Srivastava S.K.	2007	Green supply-chain management: A state-of-the-art literature review	INT. J. MANAG. REV.	0
134	Vachon S.; Klassen R.D.	2008	Environmental management and manufacturing performance: The role of collaboration in the supply chain	INT. J. PROD. ECON.	0
134	Sarkis J.; Zhu Q.H.; Lai K.H.	2011	An organizational theoretic review of green supply chain management literature	INT. J. PROD. ECON.	0
118	Carter C.R.; Rogers D.S.	2008	A framework of sustainable supply chain management: moving toward new theory	INT. J. PHYS. DISTR. LOG.	0
102	Vachon S.; Klassen R.D.	2006	Extending green practices across the supply chain: the impact of upstream and downstream integration.	INT. J. OPER. PROD. MANAG.	0
93	Zhu Q.H.; Sarkis J.	2004	Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises.	J. OPER. MANAG.	1
92	Rao P.; Holt D.	2005	Do green supply chain management lead to competitiveness and economic performance?	INT. J. OPER. PROD. MANAG.	0
88	Zhu Q.H.; Sarkis J.; Lai K.H.	2008	Confirmation of a measurement model for green supply chain management practices implementation.	INT. J. PROD. ECON.	0
80	Linton J.D.; Klassen R.; Jayaraman V.	2007	Sustainable supply chains: an introduction.	J. OPER. MANAG.	0

As we can see, nine of the top ten belong to Cluster #0, and five of the top ten belong to conceptual papers. The citation frequency of the top six articles is over 100. The article with the top citation frequency is a literature review to a conceptual framework for sustainable supply chain management published in 2008. The green supply chain is regarded as a notable component of the sustainable supply chain [29]. A considerable quantity of articles relate green supply chain management with sustainable supply chains, but no complete definition of green supply chain or sustainable supply chain is identified. Few publications give an explanation around the connections between sustainable supply chains and green supply chain management, and some even take them as nearly the same concept [48].

There is overlay with both conceptions, since green supply chain management and sustainable supply chains both integrate environmental thinking into supply chain management. However, sustainable supply chains concentrate on environmental issues and social issues, while green supply chain management focus more on environmental issues [29]. Ahi gives a comparative literature analysis of definitions for green supply chain management and sustainable supply chain management through published definitions analysis. The result shows that green supply chain management is generally more narrowly focused than that of sustainable supply chain management. Green supply chain management has an emphasis on the characteristics of environmental, flow, and coordination focuses. It is argued that sustainable supply chain management is essentially an extension of green supply chain management [49]. Seuring's work presents the framework of sustainable supply chain management in three parts, which are called triggers for sustainable supply chain management, supplier management for risks and performance, and supply chain management for sustainable products. The citation history of the article keeps rising since published, and its influence remains. Two distinct strategies—supplier management for risks and performance, and supply chain management for sustainable products—are identified. The research cited is dominated by green or environmental issues, so the summarization almost covers the contents of green supply chain management. The second article is Srivastava's article mentioned above. It is a state-of-the-art literature review of green supply chain management published in 2007 [10]. It does not have as much potential as the first article: there is no citation since 2016. It classifies green supply chain management on the basis of the problem context in a supply chain's major influential areas (see Figure 5), and methodology or approach adopted. Sarkis's new review categorizes green supply chain management literature under nine broad organizational theories. Carter's framework of sustainable supply chain management is based on resource dependence theory, transaction cost economics, population ecology, and the resource-based view of the firm. It demonstrates the relationships among environmental, social, and economic performance within a supply chain management context [39]. Linton's article is also an introduction to sustainable supply chains [50].

Zhu's early article studies the effect of quality management and just-in-time (or lean) manufacturing on relationships between operational practices and performance among Chinese manufacturing enterprises [51]. Rao's article endeavors to identify potential linkages and integration of green supply chain management as an initiative for environmental enhancement, but also economic performance and competitiveness [52]. Later, collaboration management takes place of the earlier subject. Vachon stresses the role of collaboration activities between supply chain members on environmental management and manufacturing performance [40]. He aims to extend the "collaborative paradigm" beyond a supply chain's core operations. Logistical (tactical level) and technological (strategic level) factors are both significant determinants in supply chain integration [41]. Inter-organizational interactions including joint environmental planning, shared information and working together to reduce environmental impacts are beneficial, especially collaboration with upstream. Zhu's newly released paper aims to construct the scale for evaluating green supply chain management practices implementation, and two measurement models are tested and compared. Internal environmental management, green purchasing, cooperation with customers including environmental requirements, eco-design practices, and investment recovery are taken into consideration [53]. As for the half-life of the articles most frequently cited, two articles composed by Zhu Q.H. can be regarded as more classic, since their half-life reaches 5. The top 10 articles are published in recent years.

There are limitations in citation frequency evaluation because of their reliance on citations accumulated over time. Therefore, an alternative method is to focus on newly published articles. The idea is to select the top 50 most downloaded items in the past 180 days in SSCI, according to the frequency that the full text of a record has been accessed or saved in the last 180 days. This count can move up or down as the end date of the fixed period advances. The result is shown in Figure 6, where red circles reflect downloaded items in recent days.

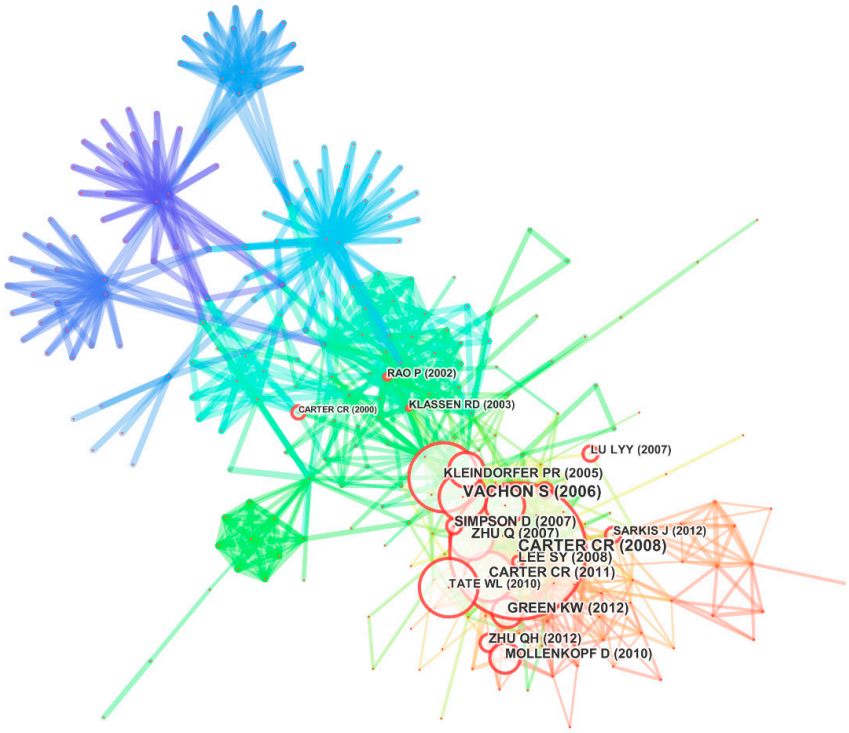

Figure 6. Cited reference network on green supply chain management in usage 180 days.

Due to the limitations of exploration on citation frequency, only the top three issues listed in Table 5 are mentioned above. Six of the 30 issues are published after 2010, including conceptual papers or literature reviews of sustainable supply chain management or green supply chain management [54,55], evaluation of relationships or impacts between green supply chain practices and performances [56,57]. Three experts, Carter C.R., Vachon S. and Zhu Q.H. all lead three issues in the list. Zhu's articles are concentrated on empirical research on exploring or evaluating relationships between green supply chain pressures, practices and performances based on hierarchy data of Chinese manufactures, and a variety of models are set up. Pressures incorporate three moderating factors—market, regulatory, and competitive institutional pressures—so that the impact mechanism among the three factors are explored based on a moderated hierarchical regression and coordination theory [9]. Implications for operations strategists and organizational sustainability planners from these relationships are also discussed [58], and three models used to evaluate the mediation relationships between the external and internal practices of green supply chain management with respect to environmental, economic, and operational performance are examined in the latest article [56]. Lu's work also provides a model to evaluate the effectiveness or performances of projects supplying green supply chain concept. A multi-objective decision making process is presented based on an analytical hierarchy process (AHP) decision-making method [59]. Green's paper assesses comprehensive green supply chain management practices and performance models accessing a structural equation modeling methodology as well. Economic, operational, and organizational performance are all covered in the study [57]. Carter is an expert in sustainable supply chains. Sustainable supply chain management evolves from a social and environmental perspective, through a corporate social responsibility perspective, to the beginnings of perspectives of sustainability as the triple bottom line [54]. His theoretical framework is improved compared with the one published in 2008. Triple bottom line approach is the wider set of criteria applied in implication of sustainability, which emphasizes different facets of social, environmental and economic. It can be used in both internal operations and external supply chains [60]. Mollenkopf examines the relationship among green, lean, and global supply chain strategies as found in the literature, covering drivers, barriers, converging, and contradictory points across the three supply

chain strategies. Managerial aspects are highlighted and integrated life cycle management is suggested for measurement application across the three supply chain strategies [61]. According to core periphery theory, nodes posed on boundary are more likely to extend, such as articles [55,56,59–61].

Table 5. Articles top downloaded in the past 180 days.

Freq	Authors	Year	Freq	Author	Year
118	Carter C.R.; Rogers D.S.	2008	44	Mollenkopf D.; Stolze H.; Tate W.L.	2010
102	Vachon S.; Klassen R.D.	2006	41	Kleindorfer P.R.	2005
92	Rao P.; Holt D.	2005	36	Zhu Q.H.; Sarkis J.; Lai K.H.	2012
62	Zhu Q.H.; Sarkis J.	2007	32	Tate W.L.; Ellram L.M.; Kirchoff J.F.	2010
58	Zhu Q.H.; Sarkis J; Geng Y.	2005	31	Sarkis J.	2012
52	Carter C.R.; Rogers D.S.	2011	30	Lu L.Y.Y.; Wu C.H.; Kuo T.C.	2007
48	Green K.W.; Zelbst P.J.; Meacham J.; Bhadauria V.S.	2012	25	Gonzalez P.	2008
48	Simpson D.; Power D.J.	2007	23	Vachon S.	2007
47	Lee S.Y.	2008	23	Klassen R.D.; Vachon S.	2003
46	Vachon S.	2007	22	Carter C.R.; Carter J.R.	2004

4.2. Betweenness Centrality

Betweenness centrality arises from the theory of structural hole. It is a structural indicator which is widely accepted in describing the ability of combining papers together in a network, especially for papers attributing to different clusters. Nodes with high betweenness centrality values are considered key turning points in evolutions of the knowledge domain, since they may lead to transformative discoveries with boundary spanning potentials [62]. The top 10 papers with highest centrality are listed in Table 6.

Table 6. Articles with top centrality listed.

Centr	Authors	Year	Title	Journal	Cluster
0.2	Zhu Q.H.; Sarkis J.	2004	Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises.	J. OPER. MANAG.	1
0.16	King A.A.; Lenox M.	2001	Lean and green? An empirical examination of the relationship between lean production and environmental performance.	PROD. OPER. MANAG.	6
0.15	Rao P.	2002	Greening the supply chain: a new initiative in South East Asia.	INT. J. OPER. PROD. MANAG.	1
0.14	Vachon S.; Klassen R.D.	2008	Extending green practices across the supply chain: The impact of upstream and downstream integration.	INT. J. OPER. PROD. MANAG.	0
0.13	Vachon S.; Klassen R.D.	2006	Environmental management and manufacturing performance: The role of collaboration in the supply chain	INT. J. PROD. ECON.	0
0.11	Klassen R.D.; Vachon S.	2003	Collaboration and evaluation in the supply chain: The impact on plant-level environmental investment	PROD. OPER. MANAG.	1
0.11	Hall J.	2000	Environmental supply chain dynamics	J. CLEAN. PROD.	1
0.11	Handfield R.B.; Nichols E.L.	1999	Introduction to supply chain management	–	7
0.11	Aragon-correa J.A.	1998	Strategic proactivity and firm approach to the natural environment	ACAD. MANAG. J.	2
0.11	Arundel A.; Sonntag V.	1999	Patterns of advanced manufacturing technology (AMT) use in Canadian manufacturing: 1998 AMT results: final report	–	2

The citation frequency of Zhu's work reaches 37 in 2012. It is the only article belonging to Cluster #1 as listed, and links Cluster #0 with Cluster #1. It can be regarded as a turning point from early articles to novel prosperities. It leads the initial attempt combining operation management in green supply chain management and firm performance. King's 2001 article links Cluster #6 and Clusters #0, #2 and other clusters. Rao P.'s articles are mostly concerned with initiatives in South East

Asia. His 2002 article is to bring out insights in greening process and inspire business, government and communities to create an atmosphere conducive to the process [63]. It belongs to Cluster #1, and is related to clusters concerning evaluation, pressure and supply chain network. Two articles composed by Vachon are also mentioned above. They are key bridges between Clusters #0 and #1. Research on the totality of green supply chains in both upstream and downstream perspectives results in new directions for integration management. The following five articles were all published early. The time span of Klassen's citing articles is wide. They explore two dimensions: collaboration and evaluation of green supply chains. Both customer- and plant-initiated collaboration are found to have a significant effect on investment in environmental technologies. Plant-level investment in environmental management is increasingly allocated toward pollution prevention [64]. Its citing articles cover evaluation [65], supplier selection [66], drivers [67], pressures [68], and integration [42] in green supply chain management. In the network, it is related to dimensions of green purchasing [69], framework of green supply chain management [10,50], and green supply chain practices. As the issue with highest half-life, the introduction book by Handfield belonging to Cluster #7 is also significant in origin of conceptualization [11]. Hall investigates environmental supply chain dynamics and detects the existence of a channel leader in supplier management [70]. Though the last two articles' citation frequency tested is low, they combine numerous issues published around 2000 shown in Figure 7. A relationship between strategic proactivity and approaches to the natural environment is found [71]. Patterns of advanced manufacturing technology (AMT) use in manufacturing is reported in the other work [72].

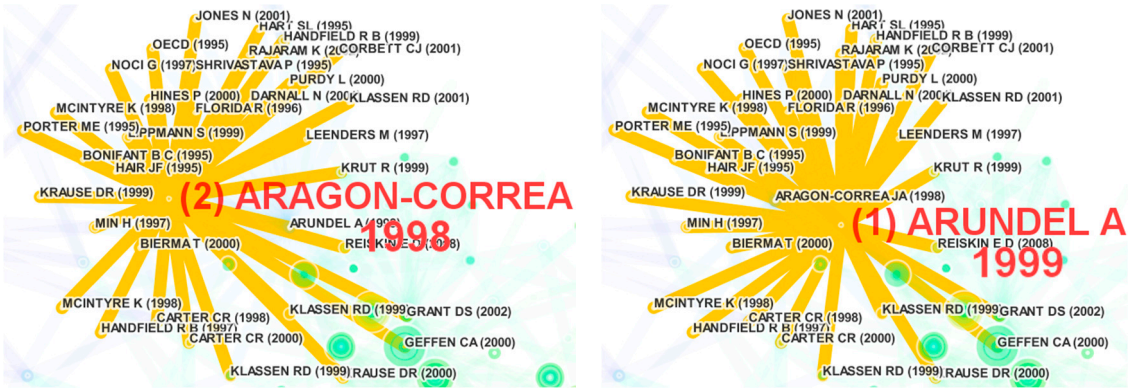

Figure 7. Co-citation links of the two issues.

4.3. Burst Detection

Burst detection is a computational technique applied to identifying abrupt changes [73], reflecting both structural and temporal significance. Issues with high bursts indicate that citations of this document increase rapidly in a given time period, which tend to be major milestones in the development of green supply chains (as listed in Table 7). As Figure 3 illustrates, nodes with red treerings signifying citation bursts gather around. One hundred and nineteen papers have bursts citations in the network, 28 of which are selected below. As Figure 8 indicates, references with strong bursts in the strength column tend are labeled with high-level concepts.

Table 7. Articles with top bursts listed.

Burst	Authors	Year	Title	Source	Cluster
30.68	Zhu Q.H.; Sarkis, J.	2004	Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises.	J. OPER. MANAG.	1
23.6	Rao P.; Holt D.	2005	Do green supply chain management lead to competitiveness and economic performance?	INT. J. OPER. PROD. MANAG.	0
15.48	Vachon S.; Klassen R.D.	2006	Extending green practices across the supply chain. The impact of upstream and downstream integration	INT. J. OPER. PROD. MAN.	0
15.19	Hervani A.A.; Helms M.M.; Sarkis J.	2005	Performance measurement for green supply chain management.	BENCHMARKING. INT. J.	0
13.77	Sarkis J.	2003	A strategic decision framework for green supply chain management	J CLEAN PROD	1
13.76	Zhu Q.H.; Sarkis J.; Geng Y.	2005	Green supply chain management in China: pressures, practices and performance	INT. J. OPER. PROD. MANAG.	0
13.39	Sarkis J.; Zhu Q.H.; Lai K.H.	2011	An organizational theoretic review of green supply chain management literature.	INT. J. PROD. ECON.	0
12.36	Green K.W.; Zelbst P.J.; Meacham J.; Bhadauria V.S.	2012	Green supply chain management practices: impact on performance	SUPPLY CHAIN MANAG.	0
11.86	Kleindorfer P.R.	2005	Managing disruption risk in supply chains	PROD. OPER. MANAG.	6
11.66	Geffen C.A.; Rothenberg S.	2000	Suppliers and environmental innovation: The automotive paint process	INT. J. OPER. PROD. MANAG.	1
11.56	Zhu Q.H.; Sarkis J.; Lai K.H.	2013	Institutional-based antecedents and performance outcomes of internal and external green supply chain management practices	J. PURCH. SUPPLY MANAG.	0
11.3	Ahi P.; Searcy C.A.	2013	A comparative literature analysis of definitions for green and sustainable supply chain management	J. CLEAN. PROD.	0
10.98	Diabat A.; Govindan K.	2011	An analysis of the drivers affecting the implementation of green supply chain management	RESOUR. CONSERV. RECYCL.	0
10.89	Bowen F.E.; Cousins P.D.; Lamming R.C.	2001	the Role of Supply Management Capbilities in green supply chain management	PROD. OPER. MANAG.	1
10.79	Brandenburg M.; Govindan K.; Sarkis J.	2014	Quantitative models for sustainable supply chain management: Developments and directions	EUR. J. OPER. RES.	0
10.6	Rao P.	2002	Greening the supply chain: a new initiative in South East Asia	INT. J. OPER. PROD. MANAG.	1
10.39	Govindan K.; Kaliyan M.; Kannan D.	2014	Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process	INT. J. PROD. ECON.	0
10.19	Klassen R.D.; Vachon S.	2003	Collaboration and evaluation in the supply chain: The impact on plant-level environmental investment	PROD. OPER. MANAG.	1
9.61	King A.A.; Lenox M.	2001	Lean and green? An empirical examination of the relationship between lean production and environmental performance	PROD. OPER. MANAG.	6
9.5	Srivastava S.K.	2007	Green supply-chain management: A state-of-the-art literature review	INT. J. MANAG. REV.	0
7.29	Hassini E.; Surti C.; Searcy C.	2012	A literature review and a case study of sustainable supply chains with a focus on metrics	INT. J. PROD. ECON.	0
7.26	Linton J.D.; Klassen R.; Jayaraman V.	2007	Sustainable supply chains: an introduction.	J. OPER. MANAG.	0
7.15	Kannan D. et al.	2013	Integrated fuzzy multi criteria decision making method and multi-objective programming approach for supplier selection and order allocation in a green supply chain	J. CLEAN. PROD.	8
6.87	Handfield R.; Steven V.	2002	Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process	EUR. J. OPER. RES.	3
6.87	Christmann P.; Taylor G.	2001	Globalization and the environment: Determinants of firm self-regulation in China	J. INT. BUS. STUD.	3
6.85	Tseng M.L.; Anthony S.F. Chiu	2013	Evaluating firm's green supply chain management in linguistic preferences	J CLEAN PROD.	8
6.85	Govindan K.; Kaliyan M.; Kannan D.	2013	A fuzzy multi criteria approach for measuring sustainability performance of a supplier based on triple bottom line approach	J. CLEAN PROD.	8
6.79	Pagell M.; Shevchenko A.	2014	Why research in sustainable supply chain management should have no future	J. SUPPLY CHAIN MANAG.	8
6.68	Simpson D.E.; Power D.J.	2005	Use the supply relationship to develop lean and green suppliers	SUPPLY CHAIN MANAG.	3
6.56	Carter C.R.; Kale R.; Mgrimm C.	2000	Environmental purchasing and firm performance: An empirical investigation	TRANSPORT RES. E-LOG	3

Figure 8. Top 20 references with strong citation bursts.

As shown in Figure 5, issues with red treerings appear in 2000, which is a consensus to the distribution of publications. Top issues with high citation bursts cover Clusters #0, #1, #3, #6 and #8. In order to cover the prominent clusters, Table 7 adds eight issues from Clusters #3 and #8 to the issues with top 20 strong citation bursts. The bursts of the first two articles are significantly higher than the others. As listed above, conceptual articles remain influential in the list. Hervani provides an overview of the various issues related to environmental (green) supply chain management performance measurement, which focuses on controls/pressures, inputs, tools, and outputs as major categories for evaluation and review [13]. Sarkis provides a strategic decision framework for green supply chain management focused on the components or elements. Issues facing the modeling approach are also discussed [74]. Frameworks for performance measures and a utility supply chain in setting performance indicators are provided [35]. Also, they provide an organizational theoretic review of green supply chain management literature [37]. Ahi identifies and analyzes the published definitions of green supply chain management and sustainable supply chain management [49]. The state-of-the-art literature review on green supply chain management by Srivastava is also included. The applications of operation research methods and related models in sustainable supply chain management are analyzed. Empirical research on relationships between practices and performances still leads the mainstream. Four articles have been mentioned above [41,42,51,52]. The earliest burst articles include Rao's initiative analysis around 2000. Components analysis, such as the product industry, green purchasing, and reverse logistics, is popular. Bowen provides an initial analysis of the role of supply management capabilities in green supply. Supply management capabilities are jointly connected to a strategic purchasing and supply process [75]. Strong partnerships with suppliers are a significant element of the successful application of innovative environmental technologies [76]. King examines the relationship between lean production and environmental performance [77]. His 2002 article is to bring out insights in greening process [64]. They explore two dimensions, collaboration and evaluation of green supply chains. Both customer- and plant-initiated collaboration are found to have a significant effect on investment in environmental technologies. Plant-level investment in environmental management is increasingly allocated toward pollution prevention [65]. "The lean and green supply chain: A practical guide for materials managers and supply chain managers to reduce costs and improve environmental performance" is put forward by the United States Environmental Protection Agency (EPA), providing a systematic approach to implementing a green supply chain in

2000. Since then, green is often combined with lean around supply chain strategies. Except members of Cluster #1, four articles from Cluster #3 are also published early. The subjects of determinants of environmental management, supplier selection, and empirical studies on performances and practices have been developing since then [45,78–80]. Gathering various ideas, the literature reviews begin to develop as mentioned above. As Figure 8 shows, though some of the articles are published early, most of their academic influence still exists. What should be noted is that the seven issues published later 2010 and four articles highlighted in Cluster #8 remain hot. Models and methodology research is growing these days. The tools most often used comprise the analytical hierarchy process or its close relative, the analytical network process, as well as life cycle analysis. These theoretical issues are compounded by measures that do not truly capture a supply chain's impacts and methods that are better at looking backwards than forwards [81]. Therefore, improvements of model research are in demand to evaluate performances and optimize decision-making under complex and changing circumstances. Numerous possibilities and insights can be gained from expanding the types of tools and factors considered in formal modeling efforts [82,83]. Besides conceptual articles mentioned above, Zhu's 2013 issue develops and empirically tests a theoretical model on the different types of institutional pressures motivating manufacturing enterprises to pursue green supply chain management practices and commensurate performance outcomes [84]. More and more works concentrate on the theory exploration under empirical results. At the same time, performances metrics or evaluation, decision making for supplier selection, and drivers or barriers to analysis of practices still remain [85–87].

5. Discussion and Conclusions

The paper visualizes the research to-date on green supply chain management according to the intellectual framework and evolutions through co-citation analysis. According to Mayring's four-stage model and bibliometrics, a systematic and explicit analysis is performed. Compared with other literature reviews, our research puts more stress on quantity analysis and the timespan involved. One thousand one hundred and fourty-five articles mainly published from 2000 to May 2017 in international peer-reviewed journals from SSCI are selected and researched. Landscape analysis enables the identification of the underlying domains both in structural and evolutional access. Furthermore, key turning points and influential articles are highlighted and analyzed to gain deepened understanding. Conclusions can be drawn as follows.

The subject green supply chain management has its roots in both environment management and supply chain literature. It refers to various categories, including management, operations research, environmental sciences, industrial engineering, and so on. It has expanded sharply since around 2007. Related research captures more operations management journals, such as *Journal of Cleaner Production* and *International Journal of Production Economics*. Sarkis J. and his co-authors have deep academic influence in the knowledge domain, among which Zhu Q.H.'s reputation and potential cannot be ignored.

Nine clusters of the knowledge domain are detected concerning terms including definition, framework, strategy level, decision-making, evaluation, pressure and practice, environmental purchasing, dirty chain, corporate social responsibility, new initiative, plant-level investment and incomplete information between suppliers and etc. Exploration of the largest cluster labeled green supply chain capability suggests that frontiers are dominated by representative terms such as supply chain management, capability, sustainability, performance, practices, collaboration capability between suppliers, etc. Research on the definitions, theory frame, future directions and empirical studies on collaboration or integration capabilities and practices analysis are served as foundations. It has been demonstrated that conceptual articles remain influential. Performances metrics or capability evaluation, decision-making for supplier selection, collaboration or integration practices, and drivers or barriers analysis of practices remain hot. Models and methodology research is growing these days. Improvements of model research are in demand to evaluate performances and optimize decision

making under complex and changing circumstances. Numerous possibilities and insights can be gained from expanding the types of tools and factors considered in formal modeling efforts.

As for evolutions, it reveals three stages. Green supply chain management arises from the demand of industries and other corporate entities, especially for manufacturing corporates. Before 2000, there are few works which cover all the elements of green supply chain management. Research focuses on evaluation or processes in green purchasing and dirty chains. Initiatives are discussed to test whether green supply chain management may bring about economic benefits, increase of productivity, or improvement of environment. Empirical studies on the impact of practices on performances have never stopped since the proposal of green supply chains. Between 2000 and 2005, research focuses on strategy implications, concerning green and lean appears during the period, and social responsibility is involved in inter organizational management. Though published early, their academic influence remains. Since 2005, there is a great-leap-forward development in the knowledge domain. As a novel knowledge discipline, more works attempt to conceptualize the entire domain or research topics related, like metrics and models, concerning the newly identified target. Equipped with improved methodology or modelling, attempt has been made to investigate the drivers or relationships to explain underlying phenomena. The later works focus more on related supply chain issues and integration.

As for future inquiries, formulation or managerial relevance of practice and exploration of impact mechanism in green supply chain is the main duty in today's research. Despite the fact that rich theories and rigorous methodologies are detected in green supply chain management, there are numerous opportunities for more advanced theoretically grounded research and an exploration of more multi-functional and systematic approaches. In order to gain broader views of research, the triple bottom line approach covering economic, social and environmental respects can be widely applied to evaluation, impact mechanisms, decision-making, drivers, risks and carrier analysis, as well as system contributions. It also provides an integrated point of view to understand landscape of green supply chain management both for researchers and practitioners. As a result of the limitations in bibliometric research, we will improve the exploration of empirical studies and analyze co-authorships network of green supply chain management in further research.

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