

Twenty years of green innovation research: trends and way forward

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Abstract

Purpose – This paper aims to analyze the publication structure of academic research on green innovation (GI) between 2000 and 2019.

Design/methodology/approach – Bibliographic data on GI are extracted from the Scopus database, and then they were analyzed through VOSviewer software.

Findings – This paper analyzes 653 publications on GI from 2000 to 2019. For so doing, the study identifies the most productive countries, universities, authors, journals and the most prolific publications in GI. Besides, the study uses VOSviewer software to visualize the mapping based on co-citation, bibliographic coupling (BC) and co-occurrence of keywords.

Originality/value – The main contribution of the study is that it provides an overview of the trends and trajectories of GI, which may help the researchers and the practitioners to comprehend the trends and future research directions.

Keywords Green innovation, Bibliometric analysis, Co-citation, Bibliographic coupling, Co-occurrence of keywords

Paper type Research paper

1. Introduction

Environmental pressures have stimulated firms' awareness of meeting increased demands from customers, markets, public and governments (Ansari *et al.*, 2020; De Prá Carvalho *et al.*, 2018). This rising global concern for the environment has led firms to adopt pro-environmental practices and activities at an increasing rate, facilitating such firms in becoming both competitive as well as green (Jabbour *et al.*, 2008). In this regard, green innovation (GI) has attracted significant attention from practitioners and academicians. Although GI is not a new topic in management literature, yet researchers continued to heed attention to this topic concerning its benefits for the organizations. Having said that, mainly, in the past few years, the research on this topic has gained significant momentum and appreciation from the academicians of several countries (Afshar Jahanshahi *et al.*, 2020; Lin



et al., 2020; Lisi *et al.*, 2020; Qiu *et al.*, 2020). Therefore, now it is peremptory to categorize and display the trends of publications in the said topic. By displaying and classifying the trends of publications in this topic allow us to comprehend the line of the research in the chosen area of the study. There are several ways to identify the trends of the publications, such as systematic literature review, meta-analysis and bibliometric analysis. In this study, we utilized the bibliometric analysis to examine the publications' trend of GI.

Bibliometric studies have become very common in a wide range of academic research, such as management (De Bakker *et al.*, 2005), economics (Castillo-Vergara *et al.*, 2018), finance (Paule-Vianez *et al.*, 2020) and entrepreneurship (Tan Luc *et al.*, 2020), to name a few. Past studies have analyzed different issues, including the trends of publications in a specific journal (Donthu *et al.*, 2020; Farrukh *et al.*, 2020a, b), the most cited papers (Ritter, 2015), leading authors (Heyduk and Fenigstein, 1984; Pasadeos *et al.*, 1999) and universities (Cancino *et al.*, 2017). For instance, Gaviria-Marin *et al.* (2018) conducted a bibliometric analysis to display the evolution of the *Journal of Knowledge Management*. Merigó *et al.* (2016) examined from an academic perspective, the development of academic research in innovation through an analysis of leading countries in innovation research between 1989 and 2013.

In this study, we followed a similar route as of Johann *et al.* (2020), Merigó *et al.* (2016) but with a focus on GI research, which has received far less attention from academic researchers. Besides, the scope of this current study is broader, and it aims at identifying the most productive countries, universities, journals and authors of GI taking into account several bibliometric indicators.

First, the work presents a trend of publications and citations between 2000 and 2019 and secondly, a global perspective analyzing the countries with the highest number of articles and citations. Third, the most productive institutes, universities, journals and authors are identified. Fourth, the study uses co-citation and bibliographic coupling to map the intellectual structure of green innovation research. Finally, based on our analysis, we suggest future research directions for green innovation research.

The main contribution of this research is that it offers a general overview of the prominent countries, universities, journals, authors and top-cited papers. This study can assist the editorial team of the journals in understanding the area where there is a potential for growth for future research. This study can also help the students in identifying the regions and the universities to pursue their research on GI. Besides, it may also assist the policymakers in identifying the leading countries in GI to understand the best ecosystem to conduct their research and development activities. Lastly, and most importantly, the study provides future research directions, which may help the researchers in identifying future research ideas.

The rest of the paper is structured as follows. The next section discusses the concept of GI, which is followed by a discussion on the methods used. Results and interpretations are given in section four. Lastly, a future research agenda and the conclusion are given in section five.

2. Literature

2.1 Concept of green innovation (GI)

Innovation is a process that involves the adoption of new policies, practices and processes to create products and services. GI is a type of innovation that is environmentally friendly. GI is the adoption of novel methods and techniques both in the management process and production through which adverse impacts on the environment can be minimized (Zailani *et al.*, 2015). GI minimizes or prevents environmental risks while saving the atmosphere and encouraging businesses to meet new market demands, build value and increase financial and nonfinancial performance. GI could improve the competitiveness of businesses and optimize their resource usage (Aguilera-Caracuel and Ortiz-de-Mandojana, 2013).

Businesses become more successful as a result of acquiring and maintaining strategic advantages that are embedded in strengthening brand identity and entering new markets,

thus fulfilling the environmental conservation criteria (Lai *et al.*, 2003). In an attempt to carry out environmental measures, businesses may create new goods, procedures and organizational technologies intended to improve the productivity and effectiveness level of the firms (Gluch *et al.*, 2009; Martínez-Ros and Kunapatarawong, 2019; Qi *et al.*, 2020).

Such writers also say that GI is interested in waste management, producing renewable goods, saving energy and water consumption, reducing carbon emissions, recycling and controlling the organizational climate. GI also boosts environmental management efficiency to satisfy environmental conservation requirements (Wang, 2020). A business committed to creating green technologies will not only conform to the environmental standards but also establish obstacles for certain rivals.

According to Hashim *et al.* (2015), GI helps to reduce the environmental effects of the company's operation by incorporating changes of organizational approaches, product design, practices, manufacturing techniques, resource usage and waste disposal procedures. GI is thus sponsored to have a favorable impact on the competitive edge (Zhang and Zhu, 2019). GI has become a central strategic concern for companies, which can be described as a combination of skills and knowledge that allows commercial innovation to be generated without harming the environment (Leal-Millán *et al.*, 2016). For this purpose, marketers should sell sustainable goods (environmental security in product design and packaging), which might result in differentiation. Additionally, implementing constructive, environmentally oriented management approaches would enable businesses to escape environmentalist restrictions or protests and also gain the trust of the stakeholders (Henriques and Sadorsky, 1999).

3. Methods

Bibliographic data on green innovation from the Scopus database were accessed in April 2020. The Scopus database from Elsevier is the most extensive abstract and citation database of the peer-reviewed scientific literature (Donthu *et al.*, 2020). We typed the term "Green innovation" and searched for it in the "Title, abstract, keywords" option. The search results showed 653 publications from 2000 to 2019.

In this study, bibliometric method is used to analyze the bibliographic data on green innovation. Bibliometric is a research field of library and information science (Bar-Ilan, 2008) that studies the bibliometric material with quantitative methods (Broadus, 1987). This technique is instrumental in classifying and analyzing the general trends of a specific issue, such as journal, research area or a country (Bonilla *et al.*, 2015; Martínez-López *et al.*, 2018). In the literature, bibliometric studies have been used to measure the relevance of a subject (Laengle *et al.*, 2017), the contribution of journals (Amiguet *et al.*, 2017), educational institutes (Martínez-López *et al.*, 2018) and countries (Bonilla *et al.*, 2015).

To map the bibliographic data visually, we utilized VOSviewer software (Van Eck and Waltman, 2010). The software is user-friendly and takes bibliographic data as input and produces easily interpretable visuals as output. With the help of VOSviewer, we developed intellectual networking based on BC, co-citation and keyword occurrence.

BC happens when two different documents/publications cite a third publication commonly (Kessler, 1963), while co-citation happens when two different documents receive a citation from a third document. Moreover, the co-occurrence of keywords analyzes the keywords that appear more frequently in the same publications.

4. Results

4.1 Publication trend

Figure 1 presents the results of the publication trends in GI research. The search record shows that the total number of publications is 653, and these publications received 9,223 citations.

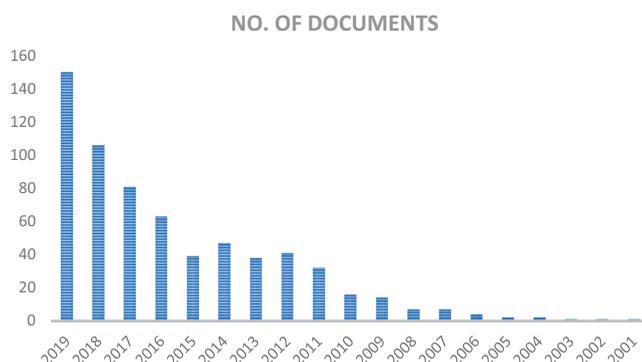


Figure 1.
Trends of publications

Year	The number of documents	The number of citations
2019	150	3,103
2018	106	2,131
2017	81	1,377
2016	63	940
2015	39	602
2014	47	407
2013	38	287
2012	41	161
2011	32	98
2010	16	49
2009	14	25
2008	7	14
2007	7	12
2006	4	6
2005	2	4
2004	2	3
2003	1	2
2002	1	0
2001	1	2
2000	1	0
Total	653	9,223

Table 1.
Trends of publication
and citations

Table 1 complements the results of **Figure 1**. The results in the table show that the year 2019 has been the most productive year with 150 publications and 3,103 citations. These facts show that GI research is taking off, but the rate is slow as compared to similar topics in the management and strategy. Since GI is attracting the attention of policymakers and researchers, we expect that there would be more studies in this field of study in the future.

4.2 Leading countries and regions in GI research

Many countries and regions published extensive GI studies. In this section, we analyze the productivity of the world's most prolific countries and regions from 2000 to 2019. **Table 2** presents the results of the top ten countries and regions publishing in GI research. The ranking is based on the number of publications.

Table 2 shows that China is the most productive country with 173 publications. It shows that the Chinese academicians are paying more attention to GI as a tool of business strategy.

Table 2.
The most productive
countries and regions

Rank	Country/region	Total publications
1	China	173
2	The USA	61
3	Taiwan	56
4	The United Kingdom	49
5	Italy	39
6	Malaysia	34
7	Australia	27
8	Japan	25
9	Spain	23
10	Germany	21

The USA is ranked second with 61 publications, followed by Taiwan with 56 publications. The United Kingdom (UK) appears at number four with 49 publications, while Italy comes at number five with 39 publications.

We create a bibliographic coupling to better understand the networking of the countries publishing in GI. Bibliographic coupling among countries happens when two different documents from two countries commonly cite a third document.

Figure 2 represents the results of the BC; China is the most productive country (Table 2). It is evident that China has the most significant BC with other countries and regions.

Another interesting issue is to see how the authors from different countries/regions have networked with other countries' authors. For this, we run a coauthorship analysis.

Figure 3 represents the coauthorship structure in the case of countries/regions. Recall that with coauthorship, we can see the volume of publications of a country and the critical connections it has with other countries/regions. Figure 3 represents the networking of coauthorship with a different color. China has strong coauthorship with several countries/regions such as the USA and Taiwan, while the UK has a strong coauthorship connection with Italy, India, Brazil and Hong Kong. Similarly, Germany, Switzerland and Sweden have a

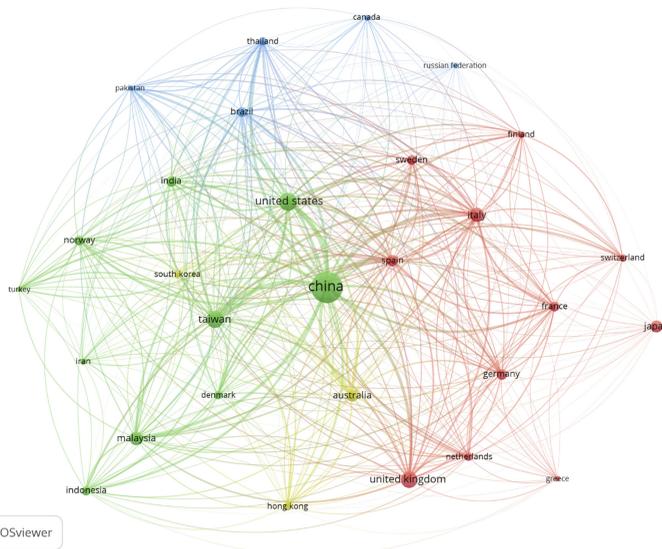


Figure 2.
BC of countries/regions

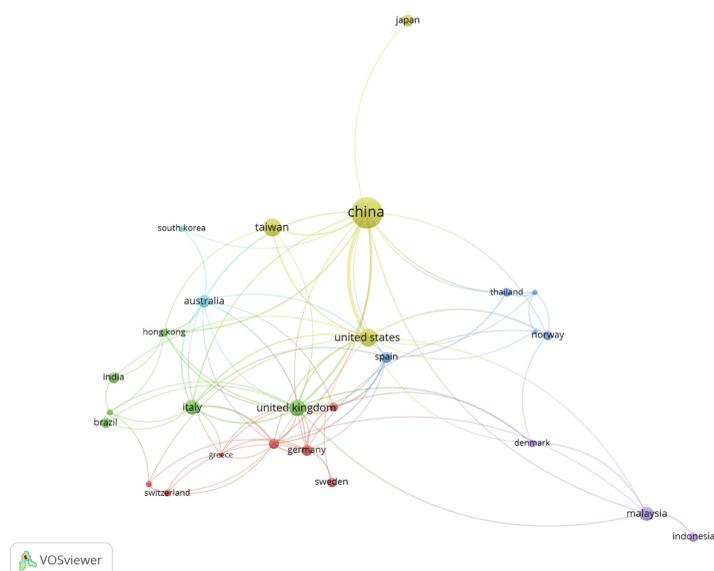


Figure 3.
Coauthorship among
countries/regions

strong coauthorship connection. Malaysia has coauthorship with Indonesia and Denmark. These results are based on five minimum documents of a country/region and the top 15 countries with frequent coauthorship connections.

4.3 The most productive universities

Another significant aspect of the bibliometric analysis is to see which are the most productive institutes or universities. Results in Table 3 show that Harbin Engineering University is the most productive institute in terms of publications. Universiti Sains Malaysia, ranked second, while the Chalmers University of Technology, Northwestern Polytechnical University,

Rank	Name of institute	The number of documents
1	Harbin Engineering University	13
2	Universiti Sains Malaysia	10
3	The Chalmers University of Technology	8
4	Northwestern Polytechnical University	8
5	National Taipei University	8
6	Tamkang University	8
7	The University of East Anglia	7
8	Central South University	7
9	Xi'an Jiaotong University	7
10	The Harbin University of Science and Technology	7
11	The University of Seville	7
12	Handelshøyskolen BI	6
13	Nankai University	6
14	Chinese Academy of Sciences	6
15	Tianjin University	6
16	Shanghai Jiao Tong University	6
17	Xidian University	6

Table 3.
The most productive
universities

National Taipei University and Tamkang University are ranked third with eight publications each. It is astounding to see that the top five universities belong to the Asian countries, i.e. China and Malaysia. These results are based on a minimum of six documents contributions from the institutes.

4.4 *Leading journals*

Another critical aspect of the bibliometric analysis is to consider the top productive journals which publish more research on GI as compared to other journals. Table 4 represents the top ten journals that published papers in the field of GI. *Journal of Cleaner Production* is the top journal with 45 publications with 2,237 citations, followed by *Sustainability* with 24 publications on GI between 2000 and 2019 and got 583 citations. *Business Strategy and Environment* has published 24 documents and received 890 citations.

4.5 *The most productive authors in GI research*

In order to see who publishes most frequently in GI, we present results in Table 5. Chen, Y.S., tops the list with ten publications and 1,439 citations, followed by Chang, C.H Albort with eight publications and 466 citations. While Li, D. from Central South University, Changsha, China, published six papers and received 203 citations (see Table 6).

An exciting aspect of the bibliometric analysis is the co-citation analysis of these top authors. Co-citation occurs when two documents from two different authors are cited together by a third document. Figure 4 shows the cluster of co-citations of the authors in three different colors. The red color cluster’s author has a co-citation connection with each other, and the same is the case for the other clusters.

4.6 *The most cited publications*

Another significant aspect to consider when assessing the output of authors or journals is the most cited source or reference. We listed the most cited publications in this section. We used information from the Scopus database to accomplish this. As stated in the Methods section, we typed “Green Innovation” in the search option of the Scopus database and selected the option “Article title, Abstract, Keywords.” This gave us a list of all the publications with the word "green innovation" in the title, abstract or keywords. All publications with 100 or more citations were included.

The influence of green innovation performance on corporate advantage in Taiwan by Chen, Y.-S., Lai, S.-B., Wen, C.-T, published in 2006 in the *Journal of Business Ethics*, received the most number of citations: 517. This publication aimed to draw insights from diverse literature to develop a perspective of GI. This publication focuses on the GI impact on the business

Rank	Title	NP	TC
1	<i>Journal of Cleaner Production</i>	45	2,237
2	<i>Sustainability</i>	37	583
3	<i>Business Strategy and the Environment</i>	24	890
4	<i>Journal of Business Ethics</i>	9	1,517
5	<i>Technological Forecasting and Social Change</i>	9	324
6	<i>IOP Conference Series Earth and Environmental Science</i>	9	5
7	<i>International Journal of Environmental Research and Public Health</i>	8	49
8	<i>European Journal of Innovation Management</i>	7	213
9	<i>IEEJ Transactions on Electronics Information and Systems</i>	5	3
10	<i>Strategic Direction</i>	5	1

Table 4.
Top productive
journals that publish
GI research

Table 5.
The most productive
authors in GI

Rank	Authors	Affiliation	The number of papers	Citations
1	Chen, Y.S.	National Taipei University, Department of Business Administration, Taipei, Taiwan	10	1,439
2	Chang, C.H.	National Taiwan Normal University, Taipei, Taiwan	8	466
3	Li, D.	Central South University, Changsha, China	6	203
4	Albort-Morant, G.	The University of Seville, Sevilla, Spain	6	189
5	Cooke, P.	The Western Norway University of Applied Sciences, Mohn Center for Innovation and Regional Development, Bergen, Norway	6	105
6	Dangelico, R.M.	Università degli Studi di Roma La Sapienza, Department of Computer, Control and Management Engineering, Rome, Italy	5	331
7	Zailani, S.	The University of Malaya, Kuala Lumpur, Malaysia	5	268
8	Stucki, T.	Berner Fachhochschule, Department of Business, Bern, Switzerland University of Jyvaskyla, School of Business and Economics, Jyvaskyla, Finland	5	75
9	Sun, J.	The University of Texas Rio Grande Valley, Brownsville, the USA	5	18
10	Yang, Z.	Xidian University, School of Economics and Management, Xi'an, China	5	18

outcome. Next, the hallmark in GI research is “*Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective*” by Geels, F.W. published in 2014 in *Theory, Culture, and Society* received 432 citations.

5. Conclusions

In this study, we aimed to identify the publication trends of GI between 2000 and 2019 to characterize and provide valuable information in order to assist all the stakeholders of the GI research field. The data were collected from the Scopus database.

Regarding authors, institutions and countries, this paper shows that Chen, Y.S. and Chang, C.H. are among the most productive authors; each of them published ten and eight articles, respectively. In the analysis of institutions, it is seen that the most productive universities in GI research are Harbin Engineering University, followed by Universiti Sains Malaysia. There is a great diversity of countries/regions that research GI; their detailed analysis enabled us to see that China, the USA and Taiwan are the top three contributing countries and regions. Another exciting aspect is to see those journals which publish GI research; a large proportion of documents come from the *Journal of Cleaner Production, Sustainability and Business Strategy and the Environment*.

Like any other study, this study also suffers some limitations. Such as the data were collected from the Scopus database, and the limitations of this database may also affect our analysis; therefore, we suggest future analysis should be conducted by combining the data from other databases. Another limitation is concerning to the country analysis, many countries conduct research in non-English language, and most of these publications are not included in the Scopus database and publications are not usually cited; thus, this issue may produce a nonconformity in the results. Third, in terms of visual analysis, the study conducted a cumulative analysis from 2000 to 2019; therefore, we suggest future studies should do some temporal analysis to see how the trends in GI literature unfold during different decades; furthermore, a content analysis may also provide a better understanding of

Rank	Authors	Title	Year	Source title	Cited by
1	Chen, Y.-S., Lai, S.-B., Wen, C.-T.	The influence of green innovation performance on corporate advantage in Taiwan	2006	<i>Journal of Business Ethics</i>	517
2	Geels, F.W.	Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective	2014	<i>Theory, Culture and Society</i>	432
3	Chen, Y.-S.	The driver of green innovation and green image – Green core competence	2008	<i>Journal of Business Ethics</i>	391
4	Chiou, T.-Y., Chan, H.K., Lettice, F., Chung, S.H.	The influence of greening the suppliers and green innovation on environmental performance and competitive advantage in Taiwan	2011	<i>Transportation Research Part E: Logistics and Transportation Review</i>	338
5	Ozaki, R., Sevastyanova, K.	Going hybrid: An analysis of consumer purchase motivations	2011	<i>Energy Policy</i>	227
6	Schiederig, T., Tietze, F., Herstatt, C.	Green innovation in technology and innovation management – an exploratory literature review	2012	<i>R and D Management</i>	222
7	Chang, C.-H.	The Influence of Corporate Environmental Ethics on Competitive Advantage: The Mediation Role of Green Innovation	2011	<i>Journal of Business Ethics</i>	194
8	Qi, G.Y., Shen, L.Y., Zeng, S.X., Jorge, O.J.	The drivers for contractors' green innovation: An industry perspective	2010	<i>Journal of Cleaner Production</i>	193
9	Tseng, M.-L., Chiu, A.S.F., Tan, R.R., Siriban-Manalang, A.B.	Sustainable consumption and production for Asia: Sustainability through green design and practice	2013	<i>Journal of Cleaner Production</i>	174
10	Gerrard, J., Kandlikar, M.	Is European end-of-life vehicle legislation living up to expectations? Assessing the impact of the ELV Directive on 'green' innovation and vehicle recovery	2007	<i>Journal of Cleaner Production</i>	166
11	Chen, Y.-S.	The positive effect of green intellectual capital on competitive advantages of firms	2008	<i>Journal of Business Ethics</i>	165
12	Lin, C.-Y., Ho, Y.-H.	An empirical study on logistics service providers' intention to adopt green innovations	2008	<i>Journal of Technology Management and Innovation</i>	147

Table 6.
The most cited publication

(continued)

Rank	Authors	Title	Year	Source title	Cited by
13	Cheng, C.C.J., Yang, C.-L., Sheu, C.	The link between eco-innovation and business performance: A Taiwanese industry context	2014	<i>Journal of Cleaner Production</i>	146
14	Cuerva, M.C., Triguero-Cano, A., Córcoles, D.	Drivers of green and non-green innovation: Empirical evidence in Low-Tech SMEs	2014	<i>Journal of Cleaner Production</i>	140
15	Rubashkina, Y., Galeotti, M., Verdolini, E.	Environmental regulation and competitiveness: Empirical evidence on the Porter Hypothesis from European manufacturing sectors	2015	<i>Energy Policy</i>	129
16	Lee, K.-H., Kim, J.-W.	Integrating suppliers into green product innovation development: An empirical case study in the semiconductor industry	2011	<i>Business Strategy and the Environment</i>	126
17	Tseng, M.-L., Wang, R., Chiu, A.S.F., Geng, Y., Lin, Y.H.	Improving performance of green innovation practices under uncertainty	2013	<i>Journal of Cleaner Production</i>	121
18	Gupta, H., Barua, M.K.	Supplier selection among SMEs on the basis of their green innovation ability using BWM and fuzzy TOPSIS	2017	<i>Journal of Cleaner Production</i>	116
19	Guoyou, Q., Saixing, Z., Chiming, T., Haitao, Y., Hailiang, Z.	Stakeholders' Influences on Corporate Green Innovation Strategy: A case Study of Manufacturing Firms in China	2013	<i>Corporate Social Responsibility and Environmental Management</i>	114
20	Dangelico, R.M.	Green Product Innovation: Where we are and Where we are Going	2016	<i>Business Strategy and the Environment</i>	111
21	Nesta, L., Vona, F., Nicoli, F.	Environmental policies, competition and innovation in renewable energy	2014	<i>Journal of Environmental Economics and Management</i>	111
22	Zailani, S., Govindan, K., Iranmanesh, M., Shaharudin, M.R., Sia Chong, Y.	Green innovation adoption in automotive supply chain: The Malaysian case	2015	<i>Journal of Cleaner Production</i>	107
23	Chou, C.-J., Chen, K.-S., Wang, Y.-Y.	Green practices in the restaurant industry from an innovation adoption perspective: Evidence from Taiwan	2012	<i>International Journal of Hospitality Management</i>	101
24	Olsen, M.C., Slotegraaf, R.J., Chandukala, S.R.	Green claims and message frames: How green new products change brand attitude	2014	<i>Journal of Marketing</i>	100

Table 6.

the trends and trajectories. Despite these limitations, our study offers a trend of GI and a trajectory for future research, which may be considered a general assumption to identify the important information regarding GI research.

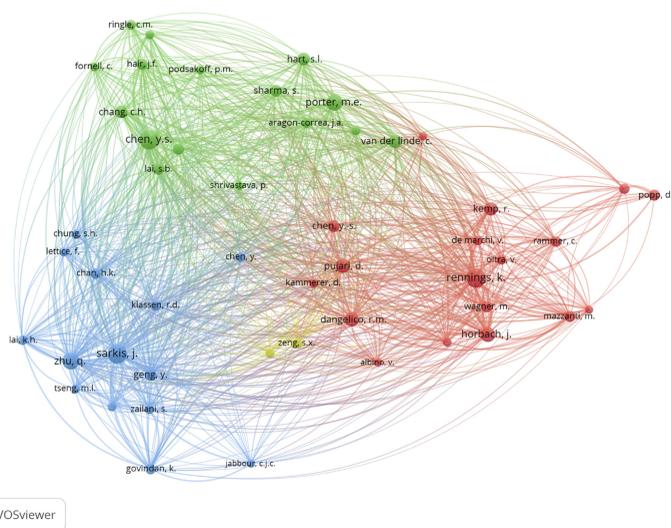


Figure 4.
Co-citations of authors

6. Future research directions

GI as a subject has attracted a lot of scholars and researchers and gained momentum in the last few years (Albort-Morant *et al.*, 2017). On the same lines, GI, as a field, has recently developed. It has great relevance for the practitioners and academicians because of its substantial and noteworthy impact on the literature. However, a review of the literature shows that its theoretical underpinning is still under construction, and yet, there is heterogeneity concerning its drivers and antecedents. So, future studies should address these issues.

According to the stakeholder's theory, for any organization to be successful, it must meet the demands of its stakeholder and incorporate their concern in business operations. Contemporary studies heed more attention to the GI technology considering the sustainable development issues; nevertheless, how this incorporation of the GI affects the corporate image, reputation, stakeholders' reactions and characterizes still in an innate stage. So, future studies should attempt to bridge different disciplines (economics, psychology, education, etc.) as new issues need new theories to comprehend them.

This study attempted to unleash the latest research trends and newly developing topics in the field of GI. The conclusions of subject, geographic areas, journals and institutional distribution of the publications might aid scholars and the institutions to not only identify but justify their position in the international context. For instance, publications perfectness in the journal of this category, i.e. GI for different countries, can help scholars and practitioners to identify more specific targets when undertaking their work. Consequently, this activity would promote more valuable ideas and emerging hotspots for the researchers.

Lastly, scholars should conduct the bibliometric analysis using the Web of Sciences and other databases as this study only incorporated the Scopus database. The incorporation of other databases would result in gathering more information and reaching a better comprehension of the topic.

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