



Knowledge mapping of platform research: a visual analysis using VOSviewer and CiteSpace

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Abstract

This study offers a systematic review of academic research on platforms in management, business and economics. By using two visualization tools named VOSviewer and CiteSpace, we analyzed 619 articles on platform research with associated 23,093 references from the Web of Science database. We have discerned the most impact publications, authors, journals, institutions and countries in the platform research. In addition, we have explored the structures of the cited references, cited authors and cited journals to further understand the theoretical basis of the platform research. Moreover, by evolution analysis through CiteSpace and co-occurrence analysis through VOSviewer, we explored the evolution process of platform research and predicted the future development trends. The results conjunctively achieved by VOSviewer and CiteSpace will enhance understanding of platform research and enable future developments for both theorists and practitioners.

Keywords Platform · Bibliometric analysis · CiteSpace · VOSviewer · Future tendencies

1 Introduction

Past few decades witnessed the rapid development of the platform in the business world. The various platforms greatly facilitated people's daily life. Social platform, for example, Twitter in the US, Wechat in China, provided people with a medium for timely communicating and became an access to obtain real time information [1]. Electronic shopping platform, for example, Amazon in the US, Taobao in China, helped retailers to reach massive customers and effectively reduced the retailers' cost [2].

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A series of data displayed by eMarketer¹ demonstrated the importance of platform for changing the way of life and promoting enterprise development. Reports about the digital video platform shows that, the users of the digital video platform in the US will reach 235 million (represents 71.2% of the country's population) in 2019 [3], while the number of users in China will be 654.7 million (equates to 47.1% of the population) in 2019 [4]. The boom of the digital video platform like YouTube attacked the tradition TV channels. Another report on E-shopping platform predicts that worldwide retail ecommerce sales will increase from \$2.290 trillion in 2017 to \$4.479 trillion by the end of 2021, equating to 16.1% of total retail sales [5]. Platform also stimulated the rapid development of enterprises. A report from Sina Finance² indicates that as a largest platform company, Alibaba's net profit reached 725.40 billion yuan till the second quarter of 2019, which increased 262% compared with the last year [6].

With the great success of eBay, Alibaba, Twitter, Tencent and other enterprises, platform has gradually become a hot topic and achieved a rapid growth in the past few decades [7]. However, there is a lack of comprehensive, quantitative reviews exclusively focused on platform. Our work in this study provided a thorough and in-depth picture on the status quo and evolution of the platform research, and also predicted the future tendency in this field. We analyzed 619 publications on platform from the Web of Science database (WoS) from 1978 to the end of 2018. By analyzing bibliometric indicators achieved on WoS, we illustrated the distribution of publications, most influential journals, most cited publications, most important authors, most outstanding institutions and countries. Furthermore, by analyzing data with VOSviewer, we presented the co-citation of cited references, cited authors and cited journals. We also explored the evolution of the platform research by using CiteSpace, and on this basis, we predicted the future tendencies in the platform research field.

This study has three contributions. First, it reflects the status quo and the content of platform research more directly, which makes it clear and easy to trace the origin in this field. Second, it shows the development trace in the platform research, which assists scholars deeply understand the evolution in this field and then recognize new directions. Third, it shows the most influential institutions, journals and references in the platform research, which helps scholars accurately search for journals, authors and papers.

The following section is a literature review on platform research. Next section is the description of the bibliometric methods and the data for analysis in this study. Then we present the results of the bibliometric analysis. Finally, we explain the conclusions, contributions and limitations of this research.

¹ eMarketer is a research enterprise that specially provides data, reports and insights in a digital world.

² Sina Finance is a Chinese largest financial network media, which focus on in-depth mining industry information and reporting important industrial conferences and events.

2 Literature review on platform research

What is a platform? An early definition is that a platform is a common structure including a set of subsystems and interfaces from which a stream of products can be developed [8]. Bresnahan and Greenstein emphasized the role of a platform in promoting cooperation, and considered it as a bundle of standard components around which buyers and sellers coordinate efforts [9]. Hereafter, a more general and straightaway definition was brought forward, platform is the products and services that integrate groups of users in two-sided networks [10]. A platform may encompass physical components, tools and rules to facilitate development, a collection of technical standards to support interoperability, or any combination of these things [11]. Gawer and Cusumano classified platform into two categories: internal and external platform [12]. Internal platform is a set of assets organized in a common structure from which a company can efficiently develop and produce a stream of derivative products, which is a firm level definition [8, 13]; while external platform is products, services, or technologies that act as a foundation upon which external innovators, organized as an innovative business ecosystem, can develop their own complementary products, technologies, or services [14].

As platform can be used in different contexts, thus, there are several applications which result in different kinds of platforms in practice. According to the arguments of Rochet and Tirole, applications of platform can be divided into four types (see Table 1).

Among the last couple of decades, numerous studies in the platform research field used “network effects” as the theoretical basis [15]. The “network effects” argues that the utility of users on one side of the platform is not related to the number of users on the same side, but to the number of users on the other side [16]. Therefore, it can explain the different value of different platforms: the more users who choose the platform, the more valuable the platform becomes to the suppliers, users and owners because of growing access to the network of users and often to a growing set of complementary innovations [17]. According to the “network effect” theory, the existing studies in the platform research field are mainly conducted from two perspectives: one-side perspective and two-sides perspective. From one-side perspective, studies focus on the effect of actions of one side on themselves. For example, Chen and Xie studied on the effect of user recommendations on consumer purchase decisions and product sales [18]. They argued that product reviews which were posted by users on the e-commerce platforms, offering product information to help other consumers evaluate the quality of products and services, ultimately influence their purchasing decisions. From two-sides perspective, studies focus on the effect of actions of one side on the other side. For example, Rochet and Tirole established a platform competition model within two-sided markets on the basis of network externality, and revealed that the price allocation between the two sides of the market is influenced by a series of factors, like platform governance, the multihoming cost of end users, ipsilateral externality and platform compatibility [19].

The divergent research themes in platform research field make the existing research in chaotic, and then make the current platform research remain

Table 1 Applications and examples of platform

Platform	Two sides	Rules ^a	Examples
B2B or B2C	Sellers versus buyers	Design of auctions, information flows	Amazon, Taobao
Internet backbone services	Websites versus consumers	Termination (settlement) charges	Google, Baidu
Pools and standards	Standards amateurs versus standards users	Level of royalties, inclusiveness of pools	4G, 5G
Software as a service	Applications developers versus consumers	Development tools and other efforts to create an applications development environment, backward compatibility, pricing	iOS, Android

^aRules of a platform refer to instruments of cost allocation or cross-subsidization of a platform

fragmented [20]. Therefore, in order to improve the status quo of fragmentation in the platform research field, we conduct an integrative review through bibliometric analysis, which aims at drawing a holistic and systematic picture in this field.

3 Methodology

3.1 Bibliometric analysis

Bibliometric analysis is a quantitative method to retrospect and describe published papers, which is helpful for researchers to evaluate academic studies in a focal field [21, 22]. By using secondary data, bibliometric analysis examines secondary data acquired on digital database from a quantitative and objective perspective [23]; therefore, it is able to introduce a systematic, transparent, and reproducible review process, and then enhance the reliability and quality of review [24].

According to Noyons and his co-authors' view, performance analysis and science mapping are two prime procedures [25]. Performance analysis is used to evaluate the publication performance of various levels, which uses techniques like citation analysis, counting publications by authors, institutions, universities or countries [26]. A unique feature used in performance analysis in this study is citation counts, which provided by WoS and represents the relative importance and influence of publications, authors, journals, institutions and countries. We also calculated the average citations per articles and displayed in tables.

Science mapping is used to explore the structure and evolution of a focal research area [27, 28]. In this research, we used co-citation analysis and evolution analysis. Co-citation analysis of cited authors aims to identify eminent authors by analyzing citation records [29]. Co-citation analysis of cited journals contributes to understanding related scientific journals in a focal area [30]. Co-citation analysis reflects the importance that researchers attach to a cited article. As a consequence, the more often a publication is referred, the more predominant it will turn out to be for developing a focal area [31]. In this study, we used VOSviewer software as a tool to perform the co-citation analysis, and then to realize the visualization of intellectual structure. On the basis of understanding the structure of the platform research, we also conducted an evolution analysis through CiteSpace software to explore the development process in this field.

3.2 Data

The WoS is a high-quality digital database that has been broadly accepted among researchers all over the world and has become a common tool for both retrieving and evaluating different types of publications [26]. The WoS covers a wide range of publications from different fields, which includes over 15,000 journals and 50,000,000 classified publications in 251 categories and 150 research areas [32]. In addition, the WoS is a proper database because it contains a set of data, such as titles, authors,

Table 2 Summary of data source and selection

Data source	Web of Science
Citation indexes	SSCI
Searching period	January 1978 to December 2018
Searching keywords	“Platform”
Subject categories	“Management” or “economics” or “business”
Document types	“Articles” or “reviews”
Language	“English”
Sample size	619

institutions, countries, abstracts, keywords, references, citation counts, impact factors and others [33, 34]. In order to understand business research on platform, we collected publication information from the WoS Social Science Citation Index (SSCI), and limited to management, business and economics areas.

Our study analyzed publications from 1978 to 2018, as the first publication on platform that contains complete information was in 1978 (here we expurgate three anonymous documents in early years). By using “platform” in both topic and title field, we obtained a total of 3170 publications. After filtered by the field “categories=Management or Economics or Business”, yielded 749 results. Then the database was filtered by “document types=articles or reviews” and “Languages=English”, finally generating a unique database which includes 619 publications. The database is a text file which includes the variables of title, author, publish year, language, abstract, keywords, references. The summary of data source and selection is displayed in Table 2.

4 Results

This section presents the following results of descriptive statistics, map and analysis on publications, authors, journals, institutions and countries in the platform research field. In addition, this section also provides the results of co-citation analysis on cited references, cited authors and cited journals. In order to gain an overall perspective of developments in research on platform, we conduct an evolution analysis by using timezone view function of CiteSpace and co-occurrence analysis on keywords.

4.1 Descriptive statistics

Through searching and screening, we finally obtained 604 articles and 15 reviews (as we focused on exploring on the intellectual framework of platform research, we limited publications in “article” and “review” categories). The sample in this study was comprised of a total of 619 publications by 741 authors affiliated with 713 institutions in 57 countries, which were published in 228 journals and referred 23,093 cited references (see Table 3).

Table 3 Descriptive statistics of the database

Criteria	Quantity
Publications	619
Authors	1368
Journals	228
Institutions	713
Countries	57
Cited reference	23,093

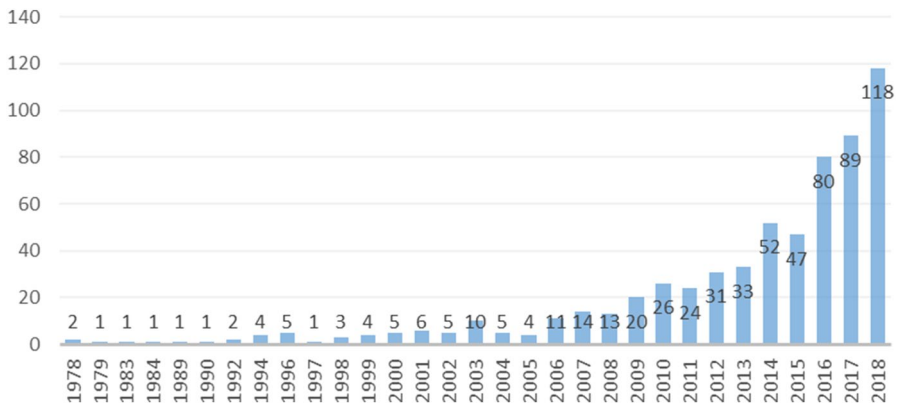
**Fig. 1** Distribution of publications

Figure 1 shows the chronological distribution of publications in the platform research field. The first traceable article was published in 1978, and from then on, the number of publications was on the rise. The growth trend can be divided into three stages. The first stage is from 1978 to 1992, when just one or two articles were published each year, which shows it is a embryonic stage. In the subsequent stage, the number of papers produced from 1994 to 2009 reaches more than quadruple of the previous stage, indicating the seedtime timeline. Within the last stage, from 2010 to 2018, publications meet a considerable increase, which represents blossom in this period.

4.2 Mapping and analysis on publications and authors

This study uncovers the most cited publications in WoS. The Top 10 most cited publications are displayed in Table 4. The first most cited article “*Platform competition in two-sided markets*” [19], accounting for 956 citations, established a platform competition model within two-sided markets, and further analyzed the determinants of price allocation and end-user surplus for the two governance structures: for-profit platforms and not-for-profit platforms. The second most cited article “*Planning for product platforms*” [35] and the fourth most cited article “*Internal*

Table 4 Top 10 most important publications in the platform research field

Rank	Title	Journal	Year	Citation count
1	Platform competition in two-sided markets	Journal of The European Economic Association	2003	956
2	Planning for product platforms	Sloan Management Review	1998	439
3	Constructing regional advantage: Platform policies based on related variety and differentiated knowledge bases	Regional Studies	2011	410
4	Internal and external integration for product development: The contingency effects of uncertainty, equivocality, and platform strategy	Decision Sciences	2005	358
5	How open is open enough? Melding proprietary and open source platform strategies	Research Policy	2003	288
6	The assimilation of knowledge platforms in organizations: An empirical investigation	Organization Science	2001	266
7	Crowd-funding: Transforming customers into investors through innovative service platforms	Journal of Service Management	2011	226
8	Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics	Information Systems Research	2010	212
9	Industry platforms and ecosystem innovation	Journal of Product Innovation Management	2014	204
10	Export-platform foreign direct investment	Journal of the European Economic Association	2007	199

Table 5 Most important authors in the platform research field

Rank	Authors	Publications	Interests
1	Hagiu, A	9	Two-sided markets; multi-sided platform; software platform
2	Gawer, A	8	Ecosystem; open innovation; platform leadership
3	Meyer, M. H	5	Modular architecture; product platform
4	Tiwana, A	5	Platform ecosystems; platform governance; platform evolution
5	Cusumano, M. A	4	Sharing economy; ecosystem
6	Evans, D. S	4	Network effects; multi-sided platform
7	Cennamo, C	4	Ecosystem; multihoming
8	Kogut, B	3	Platform investments; technological platform
9	West, J	3	Open innovation; open source platform
10	Huang, P	3	Digital platform; value co-creation

and external integration for product development: The contingency effects of uncertainty, equivocality, and platform strategy” [36] focus on a particular platform—the product platform. Robertson and Ulrich discussed the four fundamentals of product platform planning: components, processes, knowledge and people and relationships, and advocated a loosely structured platform planning process which focus on the product plan, the differentiation plan and the commonality plan [35]. Koufteros and his coauthors revealed that in the context of product development, both internal integration (indicated by concurrent engineering practices) and external integration (includes customer integration, supplier product integration, and supplier process integration) have positive effect on the profitability that mediated by product innovation and quality [36]. Moreover, the main effect is moderated by the environment equivocality. The third most cited article “Constructing regional advantage: Platform policies based on related variety and differentiated knowledge bases” [37] introduces a platform approach into the regional advantage constructing issue. By bringing together three notions (related variety, knowledge bases and policy platforms), this study constructed a regional innovation policy model, and implied that the three notions can jointly facilitate economic development within and between regions.

The Top 10 publications reflect the most classic papers about the platform research. While the Top 10 authors show the most influential scholars in this field. Table 5 shows the names, publications and interests of the Top 10 authors. Andrei Hagiu is the most productive author who published 9 articles during our searching period. He mainly focused on multi-sided platform, especially paid attention on Amazon, Google, Alibaba, Facebook and other platform companies. He was also interested in firm’s strategic challenges in two-sided markets. Annabelle Gawer published 8 articles during our searching period, and becomes the second most productive scholar. She focused on ecosystem, open innovation and platform leadership. Her seminal study on innovative ecosystems and platform leadership made it clear to understand the fundamental economic and innovative forces which shaped the dynamics platform-based high-tech industries. Marc Meyer was interested in modular architecture and product platform, and published 5 articles during our search period. As the third most productive scholar,

Table 6 Top 10 journals in the platform research field

Rank	Journal	Publications	Citations	Average citation/publication
1	Information Systems Research	23	562	24.43
2	Journal of Product Innovation Management	15	749	49.93
3	MIS Quarterly	13	365	28.08
4	International Journal of Industrial Organization	13	152	11.69
5	International Journal of Technology Management	13	110	8.46
6	Management Science	12	552	46
7	Journal of Economics & Management Strategy	12	285	23.75
8	Journal of Management Information Systems	11	884	21.56
9	Electronic Commerce Research and Applications	9	154	17.11
10	Journal of Information Technology	9	98	10.89

he mainly focused on issues around product platform, for example, he explored the necessary of organizing modular architectures across different products, and tested the effective of product platform by using LED lighting manufacturing industry data.

4.3 Mapping and analysis on journals

According to Dzikowski, a journal is more impact if the more the number of papers published on it and the more the number of citations it possesses [38]. Therefore, this study analyzed the number of publications and citations and average citation per publication of all journals. Table 6 shows the Top 10 important journals in the platform field and sorts by the amount of publications.

The top five journals with more publications are *Information Systems Research* (23 publications), the *Journal of Product Innovation Management* (15 publications), *International Journal of Industrial Organization* (13 publications), *International Journal of Technology Management* (13 publications), *MIS Quarterly* (13 publications). This reflects these five journals are more interested in studies on platform topics. While according to the “average citation per publication” indicator, the first is *Journal of Product Innovation Management* (49.93 citation per publication), followed by *MIS Quarterly* (28.08 citations per publication), *Information Systems Research* (24.43 citations per publication), *Journal of Economics & Management Strategy* (23.75 citations per publication) and *Journal of Management Information Systems* (21.56 citations per publication). This suggests that these five journals achieved more attentions in the platform fields.

4.4 Mapping and analysis on institutions and countries

The sample used in this study contains 713 institutions from 57 countries. Similarly, the number of publications and the number of average citations per

Table 7 Top 20 influential institutions in the platform research field

Rank	Institution	Country	Publications	Citations	Average citation/ publication
1	Harvard University	The United States	19	743	39.11
2	Massachusetts Institute of Technology (MIT)	The United States	14	756	54
3	Tsinghua University	China	13	76	5.85
4	National University of Singapore	Singapore	12	203	16.92
5	The University of Maryland	The United States	11	481	43.73
6	New York University	The United States	11	324	29.45
7	Boston University	The United States	10	400	40
8	Imperial College London	The United Kingdom	9	856	95.11
9	University of Pennsylvania	The United States	8	970	121.25
10	Stanford University	The United States	7	136	19.43
11	University Mannheim	Germany	7	101	14.43
12	Fudan University	China	7	91	13
13	Aalto University	Finland	7	61	8.71
14	Bocconi University	Italy	6	340	56.67
15	Northeastern University	The United States	6	271	45.17
16	University of Georgia	The United States	6	268	44.67
17	Georgia Institute of Technology	The United States	6	224	37.33
18	University of Groningen	Netherlands	6	140	23.33
19	University College London	The United Kingdom	6	108	18
20	Delft University of Technology	Netherlands	6	70	11.67

publications of each institution reflect the influence of an institution. Table 7 shows the top 10 institutions in the platform field.

Harvard University in the United States is ranked 1 in the platform area (with 19 publications and 743 citations). The subsequent institutions are Massachusetts Institute of Technology (The United States) and Tsinghua University (China), with the 14 and 13 publications, and 756 and 76 citations respectively. From Table 7 we can see, institutions in the US still occupy the leading role, while institutions in China are also improving. The amount of influential institutions located in Asia-Pacific is 3, the amount of influential institutions located in North America is 10, while the amount of influential institutions located in Europe is 7. This reflects institutions located in North America and Europe take the leading position in this field.

In order to understand which country is the most outstanding in the platform research field, we also conducted an analysis on countries. Table 8 displays the top 10 countries in this field. From the data shows in Table 8, the United States is the most impact country in the platform area (247 publications and 7742 citations). The United Kingdom and China are ranked two and three with 75 and 64 citations, respectively. Most countries in Top 10 located in North America and Europe, the only countries in the Asia-Pacific region are China and South Korea.

Table 8 Top 10 countries in the platform research field

Rank	Country	Publications	Citations	Average citation per publication
1	The United States	247	7742	31.34
2	The United Kingdom	75	2172	28.96
3	China	64	514	8.03
4	Germany	46	516	11.22
5	France	41	1788	43.61
6	Netherlands	31	986	31.81
7	Italy	31	748	24.13
8	Spain	31	353	11.39
9	South Korea	25	308	12.32
10	Sweden	24	906	37.75

4.5 Co-citation analysis on cited references

In order to clearly and deeply understand the structure of the cited references in the platform field, according to previous bibliometric analysis studies, we conducted a co-citation of the cited references [39], and then got the four clusters. This study obtained a set of 23,093 cited references. By employing threshold at 15 times, which reflects the minimum numbers of citations of a cited reference should be 15, we got a set of 75 references that are used for co-citation analysis of cited references.

The most frequently cited references are Rochet and Tirole (2003) (117 times), Armstrong (2006) (86 times), Rochet and Tirole (2006) (84 times), Caillaud and Julien (2003) (63 times), and Eisenmann et al. (2006) (59 times). On the basis of these 75 most-cited references, this study built the network within the platform research field by co-citation analysis. Result shows that the 75 references are divided into four clusters, each color stands for a cluster (Fig. 2).

The co-citation analysis of the 75 contributions contributed to construct the interconnected subnetwork, and to divide the 75 most-cited references into four clusters, in which cluster 1 illustrates the innovation and change issues on the platform, cluster 2 stands for the network effects of multi-sides markets from economic perspective, cluster 3 focuses on open thinking on the platform, cluster 4 focuses on the product platform. Each cluster includes platform's researches (bold) and other disciplines' researches which have benefited for the development of platform research (see Table 9).

The first cluster relates platform to the innovation and change issues. Adner and Kapoor identified that external innovation change will influence the firms' outcome within the platform [40]. By focusing on the technology leaders in innovation ecosystems, they concluded that greater innovation challenges from upstream will increase the performance, while greater innovation challenges from downstream will decrease the performance. Boudreau explored the relationship between different open platform strategies and the rate of innovation change, which found that granting access to independent hardware developers has a positive and significant

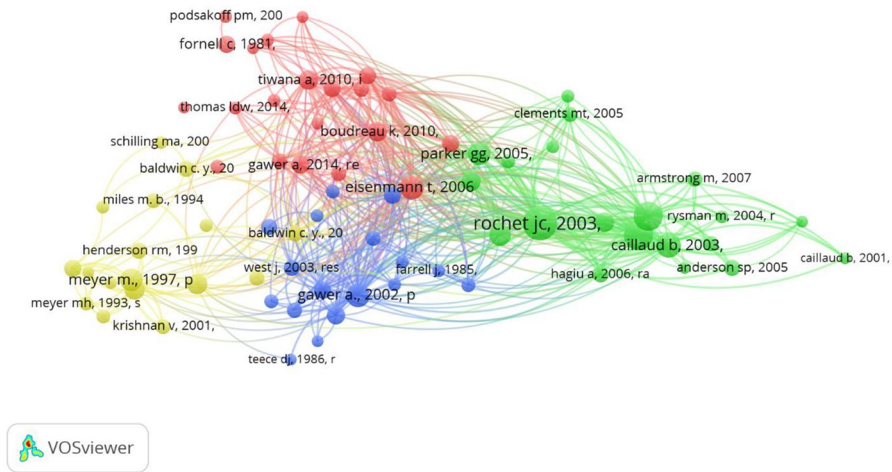


Fig. 2 Co-citation of cited references

relationship with the speed of new device development, which implied the benefit of being open in the platform [11]. On the basis of identifying and defining two prime platform: internal and external platform, Gawer and Cusumona reviewed the case of Intel (a leader in operating system) to declare the technical, strategic and business challenges that platform encounter in the process of technology and market change [12].

The second cluster seeks to explore the industry-wide platform, studies from Rochet, Armstrong and Weyl reveal network effects of multi-sided markets from economic perspective. Rochet and Tirole established a platform competition model within two-sided markets on the basis of network externality, and revealed that the price allocation between the two sides of the market is influenced by a series of factors, like platform governance, the multihoming cost of end users, ipsilateral externality and platform compatibility [19]. Similar with the study of Rochet and Tirole, Armstrong and Wright analyzed two-sided markets when competition exists between two platforms, they introduced “competitive bottlenecks” into the two-sided markets framework [41, 42]. The “competitive bottlenecks” represent the case where differentiation occurs only on one side of the market. This study indicated that “competitive bottleneck” will be weakened when platforms offer exclusive contracts to supply side. To understand the price theory of and proper policy of towards industries such as credit cards and newspapers industries, Weyl built a general theory of monopoly pricing of networks, thereby demonstrated that a monopolistic platform can internalize and counteract network effects [43].

The third part of the cluster analysis relates to open thinking on the platform. West explored the proper strategy for platform, by analyzing the hardware and software company, he found that hybrid strategies while retaining control and differentiation reflect the competing imperatives for adoption and appropriability [44]. Chesbrough, Vanhaverbeke and West defined open innovation as a paradigm which firm could and should use both internal and external ideas, and internal and external paths

Table 9 Clusters resulting from the most-cited references (parenthesis is the number of citations)

Cluster 1: Innovation and change (521)	Cluster 2: Network effects of multi-sides markets (769)
Eisenmann et al., 2006 (59)	Rochet & Tirole, 2003 (117)
Boudreau, 2010 (39)	Armstrong, 2006 (86)
Tiwana et al., 2010 (38)	Rochet & Tirole, 2006 (84)
Gawer, 2014 (33)	Caillaud & Jullien, 2003 (63)
Boudreau, 2012 (30)	Parker & Van Alstyne, 2005 (53)
Fornell & Larcker, 1981 (30)	Katz & Shapiro, 1985 (49)
Ceccagnoli et al., 2012 (29)	Katz & Shapiro, 1994 (39)
Gawer & Cusumano, 2013 (25)	Rysman, 2009 (37)
Adner & Kapoor, 2010 (24)	Anderson, 2005 (26)
Cennamo & Santalo, 2013 (22)	Hagiu, 2006 (26)
Parker et al., 2016 (22)	Clements & Ohashi, 2005 (25)
Zhu & Iansiti, 2012 (20)	Armstrong & Wright, 2007 (23)
Barney, 1991 (19)	Weyl, 2010 (22)
Ghazawneh & Henfridsson, 2013 (18)	Evans, 2003 (20)
Thomas, 2014 (18)	Corts & Lederman, 2009 (18)
Boudreau, 2009 (17)	Nair, 2004 (18)
Podsakoff et al., 2003 (17)	Rysman, 2004 (18)
Yoo et al., 2010 (16)	Caillaud & Jullien, 2001 (15)
March, 1991 (15)	Hagiu, 2009 (15)
Shapiro, 1999 (15)	Kaiser & Wright, 2006 (15)
Wareham et al., 2014 (15)	Cluster 4: Product platform (442)
Cluster 3: Different types of innovation on the platform (390)	Meyer & Lehnerd, 1997 (50)
Gawer & Cusumano, 2002 (57)	Eisenhardt, 1989 (43)
Gawer & Cusumano, 2008 (33)	Robertson & Ulrich, 1998 (42)
Eisenmann et al., 2011 (31)	Ulrich, 1995 (32)
Gawer & Henderson, 2007 (30)	Baldwin & Woodard, 2009 (28)
West, 2003 (27)	Baldwin & Clark, 2000 (27)
Bresnahan & Greenstein, 1999 (25)	Henderson & Clark, 1990 (26)
Chesbrough et al., 2006 (26)	Miles et al., 1994 (24)
Evans, 2006 (23)	Krishnan & Ulrich, 2001 (23)
Economides & Katsamakas, 2006 (21)	Cusumano & Gawer, 2002 (22)
Iansiti & Levien, 2004 (21)	Meyer, 1993 (21)
Shapiro et al., 1998 (19)	Sawhney, 1998 (21)
Von Hippel, 2005 (18)	Gawer, 2009 (17)
Eisenmann et al., 2009 (17)	Sanchez & Mahoney, 1996 (17)
Farrel & Saloner, 1985 (17)	Schilling, 2000 (17)
Katz & Shapiro, 1986 (17)	Baldwin & Clark, 1997 (16)
Teece, 1986 (16)	Meyer et al., 1997 (16)
Jacobides et al., 2006 (15)	

to market, and finally advance their technology [45]. The open innovation paradigm regards R&D as an open system. Eisenmann, Parker and Alstyne introduced open thinking into platform, and identify factors that determine the open platform decision from different types of participants [46]. Factors at provider level encompass incorporate with existing competitive platforms, license to other platform providers and expand sponsorship, while at end user level, factors entail compatibility, exclusive rights to some complements and absorptive capacity towards complements.

Cluster 4 involves studies on the product platform topic. Meyer and Lehnerd defined the product platform as a set of subsystems and interfaces that form

a common structure from which a stream of derivative products can be efficiently developed and produce [8]. The product platform can sharply decline manufacturing costs and integrate with new components which may create new opportunities in the market. Robertson and Ulrich emphasized the importance of planning the product platform for enterprise, and discussed the four fundamentals of product platform planning: components, processes, knowledge and people and relationships, and advocates a loosely structured platform planning process which focus on the product plan, the differentiation plan and the commonality plan [35]. Schilling developed an overarching model of modular systems based on the work of prominent system theory (such as economic systems and complex adaptive systems), which indicated factors that affect the increasing of interfirm product modularity, among which the characteristics of input, synergistic specificity of components, demands and urgency are included [47].

In order to understand the most cited authors in the platform research field, we achieved a sample of 15,356 cited first authors which were quoted by our 619 publications. Thenceforth, with the minimum 40 citations, the sample was declined to a new sample which contains 40 authors, and have 3078 citations in total. This study portrayed the map of the 40 authors consisting of four clusters by co-citation analysis of authors (Fig. 3). The top 3 cited authors are Gawer, A (242 citations), Rochet, J. C (220 citations) and Hagi, A (152 citations).

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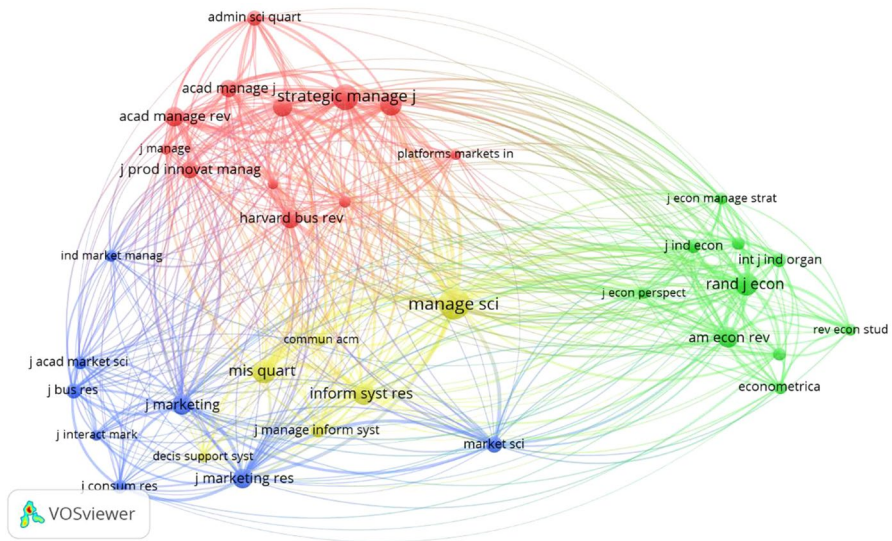


Fig. 4 Co-citation of cited journals

Cluster 2 encompasses authors from technological innovation (e.g. David Teece), open innovation (e.g. Eric von Hippel, Henry Chesbrough), strategic management (e.g. Joel West), which drew on other theory and method, such as the competitive advantage theory (e.g. Michael Porter) and case study method (e.g. Kathleen Eisenhardt).

Cluster 3 includes two-sided markets (e.g. Mark Armstrong, Jean-Charles Rochet), pricing theory (e.g. Bernard Caillaud, Andrei Hagiu), networks (e.g. Nicholas Economides), most of whom study on economic quantity relationships by constructing economic mathematical model.

Cluster 4 has the least authors with the lowest number of citations in total (469). Nevertheless, this cluster also includes studies from various fields, like modularity (e.g. Carliss Baldwin), leadership (e.g. Michael Cusumano), product platform (e.g. Marc Meyer, David Robertson).

4.7 Co-citation analysis on cited journals

This study obtained a set of 9022 cited sources that were referred by the 619 publications. By employing the threshold at 120 citations, we got a set of 36 journals that were used for co-citation analysis of cited journals, and finally gained a network consists of management, economics, marketing and information system four clusters (Fig. 4). The top 3 cited journals are *Management Science* (910 citations), *Strategic Management Journal* (636 citations) and *MIS Quarterly* (526 citations).

The management cluster contains journals concentrating on strategic management (*Strategic Management Journal*), management practice (*Harvard Business Review*) and theoretic and empirical researchers on management (*Journal of Management*, *Academy of Management Review*, *Academy of Management Journal*).

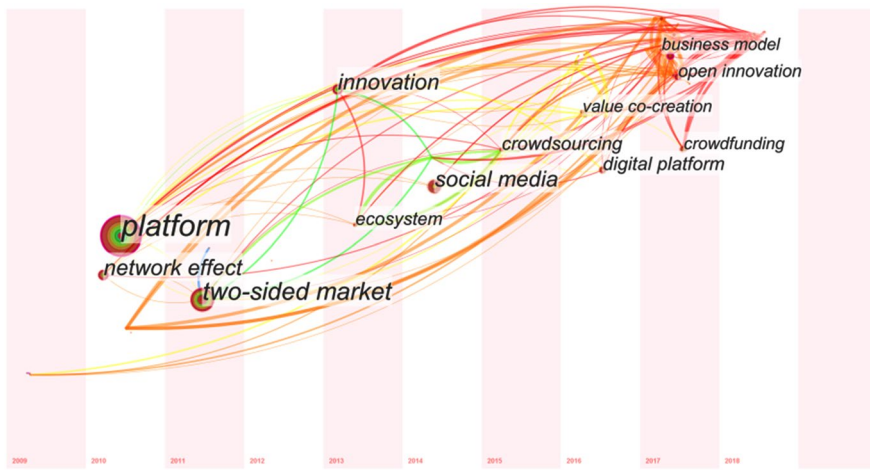


Fig. 5 Map of timezone view of recent ten years in platform research field

The economics cluster basically includes journals that accept microeconomics which focus on the organization level (*RAND Journal of Economics*, *Journal of Economics & Management Strategy*), econometrics (*Econometrica*) and industrial economics focusing on the industry level (*International Journal of Industrial Organization*).

The marketing cluster encompasses journals that focus on consumer behavior (*Journal of Consumer Research*), marketing research practice and marketing theory (*Journal of Marketing Research*) and electronic, interactive and direct marketing environments (*Journal of Interactive Marketing*).

The information system cluster is an emerging field which is more relevant with platform research than other clusters. This cluster involves journals which publish study on platform (*Information System Research*), information technology (*Decision Support Systems*) and ecosystem (*MIS Quarterly*).

4.8 Evolution analysis of recent ten years

In order to reveal the development process of platform research, we conducted an evolution analysis by using the timezone view function in CiteSpace. As there were only a few articles in early stage, more than 80% of articles published in the last decade, thus, we mainly focused on the period from 2009 to 2018.

Figure 5 illustrates that most studies emerged after 2013. Between 2010 to 2012, scholars focused on the network effects of the platform and the two-sided markets. These are classic issues in the platform research. For example, Prieger and Hu focused on exclusive contracts between software suppliers and platform providers, and found that the exclusive contracts can heighten entry barriers [48]. Since 2013, platform research comes to the stage of diversified development. By introducing difference contexts, like social media, crowdfunding, digital platform, scholars paid attentions on different kinds of platforms. For example, Schamari and Schaefer

discussed on the effect of social media platform on consumer engagement, and found that the great majority of consumers' engagement occurred on social media platform which was generated by consumers, rather than the traditional platform controlled by sellers [49]. By connecting with other topics, especially innovation, scholars found new intersecting directions, which greatly promoted and enriched the platform research.

Moreover, from Fig. 5, we can also predict the future tendencies. First, future studies will focus more on the combination of the platform and innovation topics. There are already linkages between platform and innovation, and the number of linkages increases between 2015 to 2018, but still remains low density, which means this topic is underexplored. Competitive advantage comes from the ability of managing platform-related competition and innovation [12], which makes platform and innovation significant in the platform research field. Value co-creation may be the mechanism for platform to implement innovation [50]. Second, future researches will focus on new types of platform according to the practice development of the platform. For instance, existing researches pay attention to crowdsourcing, crowdfunding and digital platform. The red color around the "crowdfunding" and "digital platform" circles reflects that, these may become the future topics in the platform research [51]. With the application of the platform in different fields, more and more types of platforms are emerging, researches on the various emerging platforms like exploring the key features and economic forces will deepen understanding of these platforms, thereby benefit for their development and improvement in the practice [52].

4.9 Co-occurrence analysis on keywords

In order to further explore the hot topics and potential future topics, we conducted a co-occurrence analysis on keywords by using VOSViewer (Fig. 6). We also listed keywords with a frequency of over 25 times in Table 10, keywords with higher frequency mains more popular in the platform research field. From Fig. 6, we can see competition, innovation, two-sided market, model and performance are the central nodes (which is also high-frequency keywords in Table 10), while video games, peer to peer lending, crowdfunding, sharing economy, consumer satisfaction and value cocreation are the fringe nodes.

By conducting co-occurrence analysis on keywords, we obtained a network consists of platform innovation, platform competition, platform strategy, platform architecture, platform technology and new types of platforms six clusters. Cluster "platform innovation" focuses on the effects of external innovation and internal innovation on platforms or firms within platforms [40]. Cluster "platform competition" is about how to established competitive advantages of the platform through ipsilateral externality, platform compatibility, exclusive contracts and others [19, 41]. Cluster "platform strategy" explores the proper strategies for different platforms, such as differentiation strategy, hybrid strategy and others [44]. Cluster "platform architecture" researches on the necessary of organizing modular architectures across different product platforms and the evolution of modular

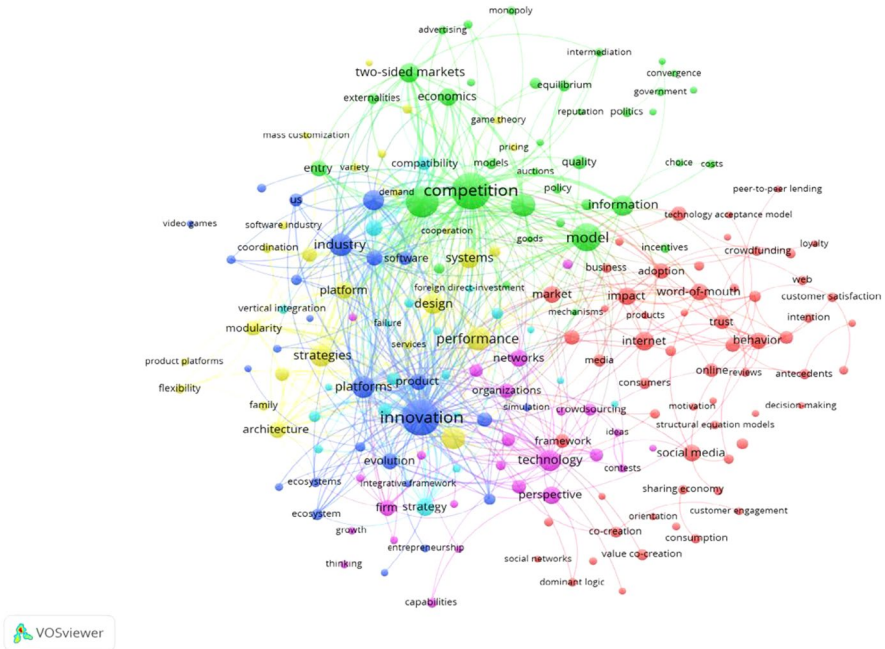


Fig. 6 Co-occurrence of keywords

Table 10 High-frequency keywords in platform research

Keywords	Frequency	Keywords	Frequency
Competition	115	Network externalities	36
Two-sided markets	113	Design	34
Innovation	111	Systems	33
Model	67	Internet	30
Markets	46	Impact	28
Performance	46	Economics	28
Industry	44	Strategy	27
Management	43	Perspective	26
Platforms	41	Market	25
Strategies	40	Word-of-mouth	25
Technology	38	Networks	25
Information	38		

architectures [53, 54]. Cluster “platform technology” relates to the outcomes of technology change, technology shock and technological collaboration among firms [12, 55]. Cluster “new types of platforms” focuses on the key features and economic forces of emerging platforms (such as social media platform, crowdfunding et al.) [49, 52].

Among the six clusters, the platform innovation, platform competition, platform strategy, platform architecture four clusters are closely inter-connected, while the platform technology and new types of platforms are the peripheral clusters because of loose connection. Topics such as innovation in platform and competition between platforms in the four inter-connected cluster will still occupied mainstream position in future research, as they have a rich theoretical base and numerous scholars. Topics such new types of platform (p2p, crowdfunding et al.), share economy, dominant logic and consumer behavior (decision-making, word-of-mouth, satisfaction et al.) will be emerging and may spawn new clusters in the platform research field.

5 Conclusions

Platform is a topic that has been shaped by numerous articles for years, but the understanding of current research still remains chaotic. This study researches and uncovers the development of platform's studies from 1978 to 2018 by bibliometric analysis. According to 619 articles achieved from WoS, we identified important publications, authors, journals, institutions and countries, and analyzed the network of the platform research field. We also predicted potential tendencies and hot topics in the future. This study achieves some insights from the literature review and summarizes the existing studies.

5.1 Contributions

This study combines VOSviewer and CiteSpace to conduct a bibliometric analysis on platform research. We clearly and holistically show the structure, evolution of the platform research, when compared with literature reviews method. The panorama will assist scholars who interested in platform research to deeply understand the development process in this field. This study can also help scholars to quickly find the target journals, authors or publications they want to refer. Moreover, this study can also be used as a guidebook when scholars are faced with the choice of journals to submit their articles. Last but not least, the predictions based on bibliometric analysis can also provide ideas for future research.

5.2 Limitations

Through bibliometric analysis, this study is helpful for portraying a comprehensive framework of platform research, and enabling future scholars to focus on their own studies effectively. However, we have to acknowledge that this study also has limitations. First, the sample in our study is captured in only one database. Although WoS encompass various journals, it could not cover the whole journals on the platform topic, such as *Journal of International Entrepreneurship*. Second, in order to ensure the high-quality of publications, data collection in this work is restricted to two types of publications (articles and reviews). Future study can extend data collection to other types of publications (e.g. conferences papers, working papers), which may

provide more insights and latest findings in the platform field. Finally, although the bibliometric analysis by employing specialized software is objective, the following interpretation of the results is somewhat subjective. Different researchers have different cognitions and interpretations on even the same content. By multiple discussions between two authors, this study tries to overcome the subjective interpretation from only one researcher.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

References

1. Geia, L., Pearson, L., & Sweet, M. (2017). Narratives of Twitter as a platform for professional development, innovation, and advocacy. *Australian Psychologist*, 52(4), 280–287.
2. Xie, K., Liu, Z., Chen, L., Zhang, W., Liu, S., & Chaudhry, S. S. (2018). Success factors and complex dynamics of crowdfunding: An empirical research on Taobao platform in China. *Electronic Markets*, 29(2), 187–199.
3. eMarketer. (2019). *US digital video 2019: OTT and mobile video flourish while TV industry undergoes disruption*. Retrieved September 19, 2019 from <https://www.emarketer.com/content/us-digital-video-2019>.
4. eMarketer. (2019). *China digital video 2019: As consumer explore new formats, traditional broadcasters shift strategy*. Retrieved September 19, 2019 from <https://www.emarketer.com/content/china-digital-video-2019>.
5. eMarketer. (2017). *Global ecommerce platforms 2017: A country-by country review of the top retail ecommerce sites*. Retrieved July 13, 2017 from <https://www.emarketer.com/Report/Global-Ecommerce-Platforms-2017-Country-by-Country-Review-of-Top-Retail-Ecommerce-Sites/2002047>.
6. Sina Finance. (2019). *Alibaba’s net profit rose 262% and Softbank gained \$2.56 billion*. Retrieve November 2, 2019 from <http://finance.sina.com.cn/roll/2019-11-02/doc-icezuev6588699.shtml>.
7. Lin, Z. J. (2014). An empirical investigation of user and system recommendations in e-commerce. *Decision Support Systems*, 68, 111–124.
8. Meyer, M. H., & Lehnerd, A. P. (1997). *The power of product platforms*. New York: The Free Press.
9. Bresnahan, T. F., & Greenstein, S. (1999). Technological competition and the structure of the computer industry. *Journal of Industrial Economics*, 47(1), 1–40.
10. Eisenmann, T., Parker, G., & Van Alstyne, M. W. (2006). Strategies for two-sided markets. *Harvard Business Review*, 84(10), 92–101.
11. Boudreau, K. (2010). Open platform strategies and innovation: Granting access vs. devolving control. *Management Science*, 56(10), 1849–1872.
12. Gawer, A., & Cusumano, M. A. (2014). Industry platforms and ecosystem innovation. *Journal of Product Innovation Management*, 31(3), 417–433.
13. Muffatto, M., & Roveda, M. (2002). Product architecture and platforms: A conceptual framework. *International Journal of Technology Management*, 24(1), 1–16.
14. Gawer, A., & Cusumano, M. A. (2002). *Platform leadership: How Intel, Microsoft, and Cisco drive industry innovation*. Boston: Harvard Business School Press.
15. Garcia-Swartz, D. D., & Garcia-Vicente, F. (2015). Network effects on the iPhone platform: An empirical examination. *Telecommunications Policy*, 39(10), 877–895.

16. Katz, M. L., & Shapiro, C. (1985). Network externalities, competition, and compatibility. *The American Economic Review*, 75(3), 424–440.
17. Parker, G. G., & Van Alstyne, M. W. (2005). Two-sided network effects: A theory of information product design. *Management Science*, 51(10), 1494–1504.
18. Chen, Yubo, & Xie, Jinhong. (2008). Online consumer review: Word-of-mouth as a new element of marketing communication mix. *Management Science*, 54(3), 477–491.
19. Rochet, J. C., & Tirole, J. (2003). Platform competition in two-sided markets. *Journal of European Economic Association*, 1(4), 990–1029.
20. Piezunka, H. (2011). Technological platforms: An assessment of the primary types of technological platforms their strategic issues and their linkages to organizational theory. *Betriebswirtschaft*, 61, 179–226.
21. Rey-Martí, A., Ribeiro-Soriano, D., & Palacios-Marqués, D. (2016). A bibliometric analysis of social entrepreneurship. *Journal Business Research*, 69(5), 1651–1655.
22. Small, H. (1973). Co-citation in the scientific literature: A new measure of the relationship between two documents. *Journal of American Society for Information Science*, 24(4), 265–269.
23. Albort-Morant, G., & Ribeiro-Soriano, D. (2016). A bibliometric analysis of international impact of business incubators. *Journal of Business Research*, 69(5), 1775–1779.
24. Bellis, N. D. (2009). *Bibliometrics and citation analysis: From the science citation index to Cybermetrics*. Lanham: Scarecrow Press.
25. Noyons, E. C., Moed, H. F., & Luwel, M. (1999). Combining mapping and citation analysis for evaluative bibliometric purposes: A bibliometric study. *Journal of the American Society for Information Science*, 50(2), 115–131.
26. Thelwall, M. (2008). Bibliometrics to webometrics. *Journal of Information Science*, 34(4), 605–621.
27. Cobo, M. J., López-Herrera, A. G., Herrera-Viedma, E., & Herrera, F. (2011). Science mapping software tools: Review, analysis, and cooperative study among tools. *Journal of the American Society for Information Science and Technology*, 62(7), 1382–1402.
28. Klavans, R., & Boyack, K. W. (2006). Identifying a better measure of relatedness for mapping science. *Journal of the American Society for Information Science and Technology*, 57(2), 251–263.
29. White, H. D., & McCain, K. W. (1998). Visualizing a discipline: An author co-citation analysis of information science, 1972–1995. *Journal of the American Society for Information Science*, 49(4), 327–355.
30. McCain, K. W. (1991). Mapping economics through the journal literature: An experiment in journal co-citation analysis. *Journal of the American Society for Information Science*, 42(4), 290–296.
31. Danvila-del-Valle, I., Estévez-Mendoza, C., & Lara, F. J. (2019). Human resources training: A bibliometric analysis. *Journal of Business Research*, 101, 627–636.
32. Merigó, J. M., & Yang, J. B. (2017). A bibliometric analysis of operations research and management science. *Omega*, 73, 37–48.
33. Carvalho, M. M., Fleury, A., & Lopes, A. P. (2013). An overview of the literature on technology road mapping (TRM): Contributions and trends. *Technology, Forecasting & Social Change*, 80, 1418–1437.
34. Gaviria-Marin, M., Merigó, J. M., & Baier-Fuentes, H. (2019). Knowledge management: A global examination based on bibliometric analysis. *Technology, Forecasting & Social Change*, 140, 194–220.
35. Robertson, D., & Ulrich, K. (1998). Planning for product platforms. *MIT Sloan Management Review*, 39(4), 19–31.
36. Koufteros, X., Vonderembse, M., & Jayaram, J. (2005). Internal and external integration for product development: The contingency effects of uncertainty, equivocality, and platform strategy. *Decision Science*, 36(1), 97–133.
37. Asheim, B. T., Boschma, R., & Cooke, P. (2011). Constructing regional advantage: Platform policies based on related variety and differentiated knowledge bases. *Regional Studies*, 45(7), 893–904.
38. Dzikowski, P. (2018). A bibliometric analysis of born global firms. *Journal of Business Research*, 85, 281–294.
39. Hsu, C. L., Westland, J. C., & Chiang, C. H. (2015). Electronic Commerce Research in seven maps. *Electronic Commerce Research*, 15(2), 147–158.
40. Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. *Strategic Management Journal*, 31(3), 306–333.

41. Armstrong, M., & Wright, J. (2007). Two-sided markets, competitive bottlenecks and exclusive contracts. *Economic Theory*, 32(2), 353–380.
42. Rochet, J. C., & Tirole, J. (2006). Two-sided markets: A progress report. *The Rand Journal of Economics*, 37(3), 645–667.
43. Weyl, E. G. (2010). A price theory of multi-sided platforms. *American Economic Review*, 100(4), 1642–1672.
44. West, J. (2003). How open is open enough? Melding proprietary and open source platform strategies. *Research Policy*, 32(7), 1259–1285.
45. Chesbrough, H., Vanhaverbeke, W., & West, J. (2006). *Open innovation: Researching a new paradigm*. New York: Oxford University Press on Demand.
46. Gawer, A. (2011). *Platforms, markets and innovation*. Cheltenham: Edward Elgar.
47. Schilling, M. A. (2000). Toward a general modular systems theory and its application to interfirm product modularity. *Academy of Management Review*, 25(2), 312–334.
48. Prieger, J. E., & Hu, W. M. (2012). Applications barrier to entry and exclusive vertical contracts in platform markets. *Economic Inquiry*, 50(2), 435–452.
49. Schamari, J., & Schaefer, T. (2015). Leaving the home turf: How brands can use webcare on consumer-generated platforms to increase positive consumer engagement. *Journal of Interactive Marketing*, 30, 20–33.
50. Maciulienė, M., & Skarzauskienė, A. (2016). Evaluation of co-creation perspective in networked collaboration platforms. *Journal of Business Research*, 69(11), 4826–4830.
51. Cui, Y., Mou, J., & Liu, Y. (2018). Knowledge mapping of social commerce research: A visual analysis using CiteSpace. *Electronic Commerce Research*, 18(4), 837–868.
52. Belleflamme, P., Omrani, N., & Peitz, M. (2015). The economics of crowdfunding platforms. *Information Economics and Policy*, 33, 11–28.
53. Tiwana, A., Konsynski, B., & Bush, A. A. (2010). Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics. *Information Systems Research*, 21(4), 675–687.
54. Meyer, Marc H., & Dhaval, D. (2002). Managing platform architectures and manufacturing processes for nonassembled products. *Journal of Product Innovation Management*, 19(4), 277–293.
55. Schilling, M. A. (2015). Technology shocks, technological collaboration, and innovation outcomes. *Organization Science*, 26(3), 668–686.

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