A Bibliometric Review and Visualization Analysis in Product Development Project Management: 2012-2021

Pingye Tian[a], Qing Yang[*][b] and Yingxin Bi[c]

School of Economics and Management, University of Science & Technology Beijing, China

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Abstract: CiteSpace is used to do the visualization analysis to all the product development project literature collected in SCI-E and SSCI, with which time and space distribution, collaborative network of authors, collaborative network of institutions, co-cited journal, co-occurrence keyword knowledge maps are made to reveal the space distribution, hot topics and development trends in the field of product development project. The study results show that: American, Germany and British scholars have led this field, some Chinese scholars also produce lots of results. Hot topics includes the performance and success factors of product development, innovation management, system modelling and knowledge management of development organization. The result can promote theoretical development of the product development, which will help scholars to determine trends and direction. This paper also provides guidance and reference for firms to achieve good practice in product development.

1 INTRODUCTION

Consumer demand is increasingly fragmented, personalized and experiential. How to efficiently and innovatively develop products to accurately meet customer requirements has become the primary problem to be solved (Kavadias and Ulrich, 2020). Experts and scholars pay more attention to it. A series of research results have been produced in product development (PD) project. Considering the richness and diversity of PD project management literature, it is urgent to conduct a state-of-the-art review to comprehensively and systematically describe the landscape and evolution of PD project research.

At present, some scholars have analysed and summarized the hot spots and frontiers of PD project. For example, Carneiro systematically summarized the development of PD project management (Carneiro et al., 2021). Marzi et al. (2021) analysed 1315 new product development (NPD) literature from 2008 to 2018. He summarized the current research focus, and looked into the future exploratory agenda. But these studies lack visual analysis process and ignore the in-depth excavation of important topics and spatial and temporal distribution.

To address the gap identified above, we conduct a bibliometric analysis to comprehensively review the landscape and evolution of the field based on a sample of 1,317 articles in SCI-E & SSCI from 2012 to June 2021. We use CiteSpace to conduct collaborative network of authors, collaborative network of institutions, co-cited journal and co-occurrence keyword knowledge maps. Such visual analysis allows us to find out the important topics and trends in PD project management.

2 RESEARCH DESIGN

2.1 Data Source

As mentioned above, the Science Citation Index Expanded (SCI-E) and Social Sciences Citation Index (SSCI) of the Web of Science core set were selected as data sources. Referring to the existing research (Marzi et al., 2021), we conduct "TS = (*Product*

[a] https://orcid.org/0000-0002-7592-4609

[b] https://orcid.org/0000-0002-7529-9065

[c] https://orcid.org/0000-0003-1753-9507

[*]Corresponding Author: Qing Yang

Development Project) OR TS = (*PD Project*)". To display and analyze the latest research results and evolution trends of PD project, the retrieval time interval is set as 2012 to June 2021, and "*articles*" and "*review*" category are selected. We select three research fields of "*Business*", "*Management*" and "*Operations Research Management Science*". Finally, 1328 literatures meeting the requirements were retrieved. To ensure the scientific results, the 1328 articles were further manually screened. Through the manual review, 11 articles irrelevant to the topic of this study (e.g., construction projects) were removed. The final sample size for bibliometric analysis was 1317. The content exported from Web of Science includes titles, authors, publications, journals, abstracts, keywords, issue numbers, DOI and all references.

2.2 Research Tool

With the development of information technology and visualization technology, bibliometrics and scientific knowledge mapping provide powerful methods and tools for clarifying the context and trend of literature. CiteSpace is a powerful literature metrology visualization analysis software. It has been favored by many scholars and widely used in many fields (Zhang et al., 2021, Guo et al., 2021). In view of this, to visualize the landscape and evolution of product PD projects management, we conduct the author co-occurrence networks, institution co-occurrence networks, keywords and cited journal co-occurrence networks knowledge maps using CiteSpace. Figure 1 is the research design of this article.
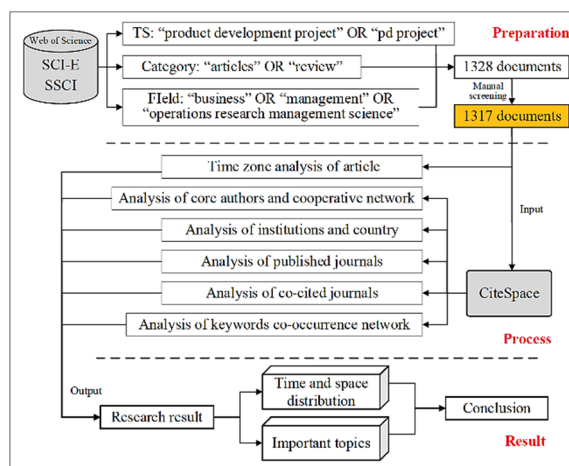

Figure 1: Article total research design.

The research design consists of three parts: 1) analysis preparation, including literature retrieval and literature screening, 2) analysis process, including visual analysis using CiteSpace, 3) analysis results refer to the time and space distribution and hot topics of PD project literature summarized according to the analysis process.

3 DISTRIBUTION OF PD PROJECT MANAGEMENT RESEARCH

3.1 Analysis of Publication Outputs

The number of annual publications can directly reflect the development status of a research field in a specific period. It is an important indicator to measure the development trend (Guo et al., 2021). Based on the statistics of literature on PD projects in SCI-E & SSCI from 2012 to June 2021, the annual distribution of the number of published papers is drawn as shown in Figure 2, which help us form a preliminary understanding of this field.
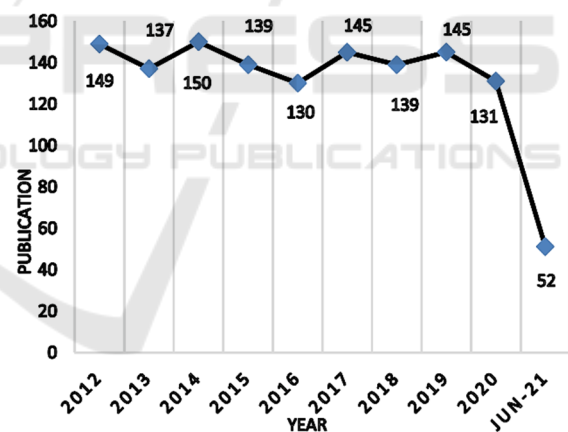
Figure 2: The annual distribution of product development projects papers published by Web of Science in the past decade.

As shown in Figure 2, international circulation of articles on PD project management has remained stable in the past decade. The annual average is 141. The highest number of publications was 150 in 2014. In conclusion, the circulation of articles in PD project management has maintained a high level in the past decade, which indicates this field continues to receive the focus of scholars, and also reflects the management and innovation of PD project is very important.

3.2 Analysis of Authors, Institutions and Countries

3.2.1 Analysis of Authors' Collaborative Network

The author collaboration network analysis of a research field helps to capture key scholars. As shown in Figure 3, the authors' collaboration network diagram in the research field of product R&D projects can be obtained by running the "Author" option of CiteSpace.
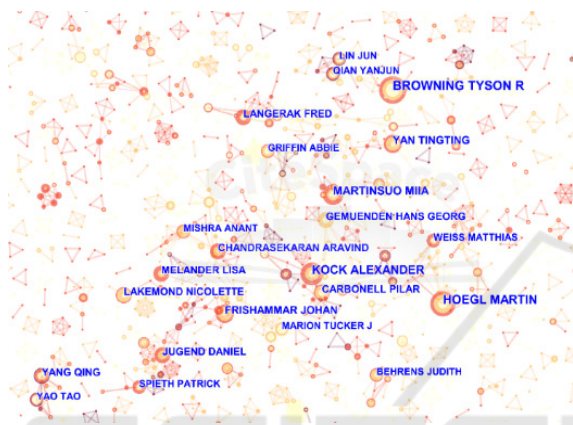

Figure 3: A collaborative network of authors in the domain of product development projects.

Table 1: Top 10 product development project scholars and their institutions.

Rank	Scholar	Counts	Institution
1	Tyson R Browning	12	Texas Christian University
2	Martin Hoegl	11	Ludwig-Maximilian's-Universität München
3	Alexander Kock	10	Technische Universität Berlin
4	Miia Martinsuo	9	Tampere University of Technology
5	Qing Yang	8	University of Science & Technology Beijing
6	Johan Frishammar	8	Lulea University of Technology
7	Tingting Yan	8	Wayne State University
8	Lisa Melander	7	Linkoping University
9	Fred Langerak	7	Erasmus University Rotterdam
10	Nicolette Lakemond	7	Linkoping University

The tree-ring nodes represent the number of articles published by scholars. The larger nodes reflect the more articles published by scholars in

recent ten years. The lines between nodes indicate that two scholars have cooperated. In this paper, the "Node Labels" Threshold in CiteSpace is set as "6". As shown in Table 1, the number of papers and institutions of the top ten authors are counted.

The top three authors of papers published in the past ten years are Professor Tyson R Browning from Texas Christian University, Professor Martin Hoegl from the University of Munich, Germany, and Professor Alexander Kock from the Technical University of Berlin, Germany.

In addition, the cooperation network shows Yang Qing and Yao Tao, Lin Jun and Qian Yanjun, Kock Alexander and Carbonell Pilar, Mishra Anant and Chandrasekaran Aravind and other authors have close cooperation relationships. Several scholars are also the core strengths of their research teams. They have made important contributions to the development of PD project management.

3.2.2 Analysis of Countries and Institutions

Analysing the countries and institutions is conducive to identifying the main research positions and the distribution of research forces. As shown in Figure 4 and Figure 5, we obtain the cooperation network of institutions and the cooperation network of countries in PD project management by running "Institutions" and "Country" in CiteSpace.
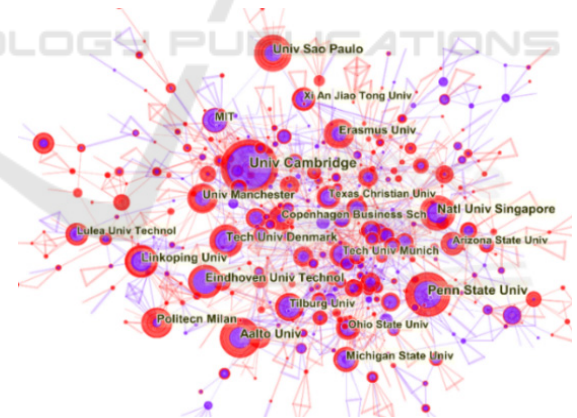

Figure 4: Network of publishing institutions in the domain of product development projects.

To display important institutions and countries, the "Threshold" of institution was set as "13", "Threshold" of country was set as "49". As shown in Table 2 and 3, we make statistics of the number of papers published by the top ten institutions and countries.
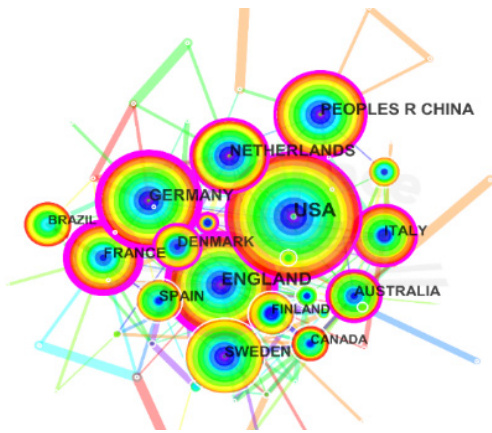
Figure 5: Network of publishing countries in the domain of product development projects.

Table 2: Top 10 the important institutions and numbers of their papers.

Rank	Institution	Counts
1	University of Cambridge	30
2	The Pennsylvania State University	24
3	Aalto University	21
4	University de São Paulo	20
5	National University of Singapore	19
6	Eindhoven University of Technology	18
7	Technical University of Denmark	18
8	Linkoping University	18
9	Politecnico di Milano	17
10	Erasmus University Rotterdam	16

Table 3: Top 10 the important countries and numbers of their papers.

Rank	Country	Publications
1	USA	391
2	ENGLAND	150
3	GERMANY	120
4	CHINA	113
5	NETHERLANDS	91
6	ITALY	82
7	SWEDEN	81
8	FRANCE	76
9	AUSTRALIA	63
10	DENMARK	59

From 2012 to 2021, the important research institution of PD project management are University of Cambridge and the University of Manchester in UK, Pennsylvania State University and Texas Christian University in USA, Technical University of

Munich in Germany, Xi'an Jiaotong University in China, and Tilburg University in the Netherlands. Among them, 29.7% were published in the US, 11.4% in the UK, 9% in Germany, 8% in China and 7% in the Netherlands. It can be seen the main countries of PD project management research is concentrated in European, American, China and Singapore.

3.3 Analysis of Published Journals and Co-Cited Journals

3.3.1 Analysis of Published Journals

The analysis of published journals helps to discover the level and number of published journals in this field. To master the distribution of journals that have published research on PD project management in the past ten years, this paper made statistics on the top 20 journals with publications, as shown in Table 4.

Table 4: Division and number of published papers of the top 20 journals.

Rank	Journal	Counts
1	Journal of Product Innovation Management	117
2	International Journal of Project Management	76
3	IEEE Transactions on Engineering Management	51
4	Project Management Journal	43
5	R & D Management	41
6	Industrial Marketing Management	37
7	Production and Operations Management	32
8	Concurrent Engineering: Research and Applications	29
9	Journal of Business & Industrial Marketing	29
10	International Journal of Managing Projects in Business	28
11	International Journal of Production Research	28
12	Technological Forecasting and Social Change	28
13	Journal of Business Research	27
14	Production Planning & Control	23
15	International Journal of Production Economics	22
16	Technovation	22
17	Journal of Engineering and Technology Management	20
18	Research Policy	20
19	International Journal of Operations & Production Management	19
20	Research-Technology Management	19

Journal of Product Innovation Management (JPIM) ranked first with 117 articles, accounting for 8% of the total sample. *International Journal of Project Management* (IJPM) ranked second with 76 papers, accounting for 6% of the total. *IEEE Transactions on Engineering Management* (IEEE-TEM) ranked third with 51 articles, accounting for 4% of the total.

3.3.2 Analysis of Co-Citation Journals

To determine the core journal, we also conduct a journal co-citation network knowledge mapping (Figure 6) by running Citespace's "Cited Journal" option.
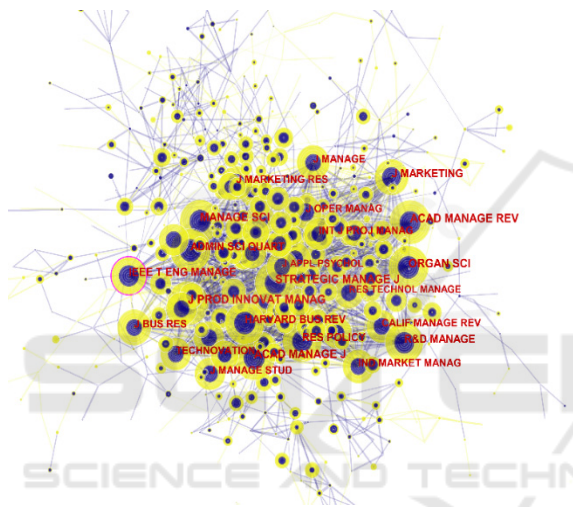

Figure 6: Network of cited journals in the domain of product development projects.

As show in Table 5, we counted the top 20 journals, citation frequency and centrality.

JPIM is not only the most published Journal, but also the most co-cited Journal, with 861 times. The journal with the highest centrality is IEEE-TEM with a score of 0.12. In addition, it also includes *Management Science* (MS), *Academy of Management Review* (AMR), *Journal of Operations Management* (JOM), and *Academy of Management Journal* (AMJ). These are the top publication in the field of management and operations research, and its published results provide the knowledge foundation of project management, organizational research, strategic management and operations research for product development.

Table 5: Division and citation volume of top 20 cited journals.

Rank	Journal	Centrality	Count
1	Journal of Product Innovation Management	0.03	861
2	Management Science	0.07	806
3	Academy of Management Review	0.04	749
4	Organization Science	0.05	715
5	Strategic Management Journal	0.07	686
6	Academy of Management Journal	0.10	685
7	Research Policy	0.05	633
8	Administrative Science Quarterly	0.03	628
9	Harvard Business Review	0.00	563
10	R & D Management	0.02	534
11	IEEE Transactions on Engineering Management	0.12	523
12	Journal of Marketing	0.02	485
13	Journal of Operations Management	0.02	449
14	Industrial Marketing Management	0.04	443
15	Journal of Marketing Research	0.05	443
16	Journal of Management	0.00	439
17	Technovation	0.02	438
18	Journal of Business Research	0.05	420
19	International Journal of Project Management	0.05	358
20	California Management Review	0.06	355

4 HOT RESEARCH TOPICS AND FUTURE RESEARCH DIRECTIONS

4.1 Hot Research Topics

To comprehensively display hot topics in PD project management, this paper makes a visual analysis of 1317 articles based on CiteSpace, referring to the research of literature (Budle et al., 2021, Khanra et al., 2018). The "Keywords" function of CiteSpace can identify and analyze the contents of "DE" (Keywords) and "ID" (Keywords Plus) in the imported documents, which is conducive to displaying the high frequency and high center keywords, thus reflecting the focus of research. The co-occurrence map of keywords of PD project from

2012 to June 2021 constructed in Figure 7, with a total of 469 nodes and 1339 links. Set "Threshold" to 13, and 104 labels are displayed.

Figure 7: Keywords co-occurrence mapping of product development projects.

As show in Table 6, we counted the top 10 keywords and counts.

Table 6: Important keywords.

Rank	Keyword	Counts
1	product development	420
2	performance	368
3	innovation	296
4	management	238
5	research and development	202
6	model	180
7	knowledge	173
8	impact	153
9	design	128
10	success	117

According to important keywords, we find four hot topics: system modelling, knowledge management, innovation management, performance & success.

(1) System Modelling. System modelling for PD project management includes the following four aspects: process architecture, organization architecture, product architecture and cross-domain integration (Yang et al., 2018). Design structure matrix (DSM), social network analysis (SNA), PageRank are the important structuring tool (Yang et al., 2018, Yang et al., 2018).

(2) Knowledge Management. Knowledge transfer, knowledge share, knowledge creation, knowledge integration, absorptive capacity and dynamic capability are the core keywords in PD project knowledge management. In recent years,

many scholars pay attention to this domain (Li et al., 2018).

(3) Innovation Management. Open innovation, technological innovation, radical innovation, product innovation, empirical analysis and competitive advantage are the important keywords in PD project innovation management (Zheng et al., 2015). Empirical research is the main research method in this field.

(4) Performance & Success. PD project performance is measured in the following ways: cost, time to market, quality, advances in technology and customer acceptance (Kleinschmidt and Cooper, 1991). PD project success factors include strategic elements, organizational elements, development process elements and market environment elements (Cooper, 2018).

4.2 Future Research Directions

We used Citespace to make burst word co-occurrence, which could better grasp the key and cutting-edge content. Burst word in PD project management capture shows 15 keywords, and the results are shown in Figure 8.

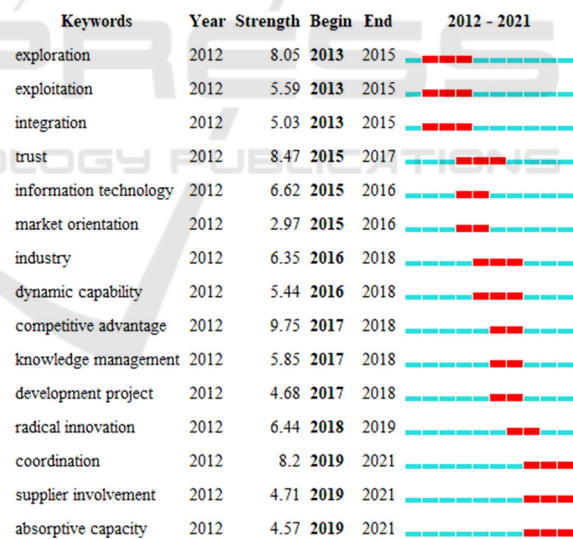| Keywords	Year	Strength	Begin	End	2012 - 2021
exploration	2012	8.05	2013	2015	
exploitation	2012	5.59	2013	2015	
integration	2012	5.03	2013	2015	
trust	2012	8.47	2015	2017	
information technology	2012	6.62	2015	2016	
market orientation	2012	2.97	2015	2016	
industry	2012	6.35	2016	2018	
dynamic capability	2012	5.44	2016	2018	
competitive advantage	2012	9.75	2017	2018	
knowledge management	2012	5.85	2017	2018	
development project	2012	4.68	2017	2018	
radical innovation	2012	6.44	2018	2019	
coordination	2012	8.2	2019	2021	
supplier involvement	2012	4.71	2019	2021	
absorptive capacity	2012	4.57	2019	2021	

Figure 8: Keywords with the strongest citation bursts of product development project.

Among them, competitive advantage burst intensity is the highest (Strength =9.75), indicating that the occurrence frequency of this word is very high in a short time. The time zone of exploration, exploitation and integration is from 2013 to 2015. The time zone of trust is 2015 to 2017. The time zone of information technology and market orientation is 2015-2016. The time zone of industry

and dynamic capability is 2016-2018. The time zone of competitive advantage, knowledge management, development project is 2017~2018. The time zone of radical innovation is 2018-2019. Coordination, supplier involvement and absorptive capacity are the breakout words of 2019~2021.

Based on the above results, we point out several issues worthy of research in PD project management in the future: (1) How to improve the knowledge absorption capacity of PD project team. (2) How to use big data technology to improve the efficiency of supplier and customer involvement in the PD project process. (3) How to launch radical innovation to improve the competitiveness of enterprises in the market.

5 CONCLUSIONS

This paper provided a visual and systematic review of the important topics on PD project management. This bibliometric research analyzed 1317 valid papers on PD project management in SCI-E & SSCI from 2012 to June 2021. The number of publications in PD project management keeps a steady trend.

According to the country and institution cooperation analysis, University of Cambridge, The Pennsylvania State University and Aalto University are the important research institution. USA, UK, China, Singapore, Germany are the core countries. According to the author cooperation analysis, Tyson R Browning from Texas Christian University, Martin Hoegl from the University of Munich, and Alexander Kock from the Technical University of Berlin are the important scholars. According to the co-citation journals network and published journals, *Journal of Product Innovation Management*, *International Journal of Project Management*, *IEEE Transactions on Engineering Management* are an influential and productive journal considering its number of articles and citations.

According to the co-occurrence keywords network, system modeling, knowledge management, innovation management, performance & success are the hot topics in PD project management in past decade. In the future, radical innovation, supplier involvement, absorptive capacity and competitive advantage are worth research agendas to be explored.

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