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Mapping the Landscape of Research on Knowledge Workers: A Bibliometric Review

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Abstract

Knowledge workers remain to be seen as one of the biggest assets for modern enterprises to maintain their competitiveness in the twenty-first century. This has led to a steady increase in academic interest in knowledge workers research, as evidenced by the rise in the number of related publications. However, there is a dearth of research on the growth and existing literary landscape of research focusing on knowledge workers, thus making it challenging for scholars to determine the current trends and future direction in this area. To address the issue, this study provided an overview of the evolution of academic research on knowledge workers over four decades (1981-2021) and identified the existing key trends. A bibliometric review of the data extracted from the Web of Science database using Biblioshiny and VOS viewer. The analysis of 1667 articles confirmed a steady growth in the literature on knowledge workers both in terms of the number of publications and citations. The study identified the evolution of knowledge research in three key dimensions: knowledge work, performance, and human capital. Moreover, “performance”, “management” and “model” have also become the most frequently occurring words. The research findings not only deepened our comprehension of the research landscape but also provided insights into potential implications.

Keywords: knowledge workers, bibliometric analysis, science mapping, VOS viewer

1. Introduction

Knowledge workers in organizations are in charge of creating original content and implementing reforms (Sheidaee et al., 2022). The rapid advancement of information technology and the knowledge-based economy has increased the global need for highly skilled knowledge workers to maintain a competitive advantage (Palvalin et al., 2017; Zhao et al., 2020).

The phrase “knowledge worker” was first proposed by Drucker (1959), who defined knowledge worker as a person who masters and applies symbols and concepts, and who works using knowledge or information. The most widely cited definition comes from T. H. Davenport, who claims that knowledge workers are those who have a high level of expertise, education, or experience, and their major function is to create, distribute, or apply knowledge (Davenport, 2005, p. 10). Horibe (1999) pointed out that knowledge workers are who use their brains more than their hands when they create wealth. Woodruffe (1999) defined knowledge workers as people who possess knowledge, and their primary purposes in work are creating, sharing, and applying knowledge. They use their knowledge to generate new knowledge or innovation, apply existing information to contemporary issues, teach knowledge, and gain knowledge through study and learning (Guthrie, 2020). Knowledge workers invest a significant amount of time and money in their intellectual capital (Drucker,

1994). Despite the growing research interest in knowledge workers, there is no consensus to precisely define the term since they do not belong to a single group (Nisula & Olander, 2021; Surawski, 2019). To summarize, the concept of knowledge workers mainly includes four perspectives, as shown in Table 1:

Table 1. Four definitions and perspectives of knowledge workers

Perspectives	Keywords
From the work content	Use symbols and create knowledge
Personal Characteristics	Education level, internal drive, etc.
Work style	Use brain more than hands
Work characteristics	Take knowledge as a career

Leveraging the definitions of knowledge workers by different scholars and the focus of the research, this article defines knowledge workers as those who are highly educated or possess relevant professional knowledge, engaged in mental processes through creating and sharing knowledge at work to achieve individual and organizational value.

Knowledge workers and their linked resources and capabilities are the ultimate, valuable, and unique internal resources and capabilities for an organization's long-term competitive advantage (Zhang-Zhang et al., 2022). As a result, organizations increasingly depend on the value generated by knowledge workers, who have emerged as a critical strategic asset for their respective organizations (Che et al., 2021; Jha et al., 2019). However, their setting increases their risk of depression more than that of other workers, and they frequently work under intense pressure (Machin et al., 2022), that's why boosting the knowledge workers' productivity has become the most pressing challenge for management in the 21st century (Heidary Dahooie et al., 2018; Spanellis et al., 2020). Several research studies in a wide range of disciplines (Surawski, 2019) have conducted research on the subject of knowledge workers in the last few decades. Scholars' research results on knowledge workers are accumulating year by year, which makes this field seem to be thriving. Nevertheless, while reviewing past research achievements, it is challenging to fully understand the literary landscape of research on knowledge workers. The primary reason for this is a scarcity of systematic literature conducted on past studies in this area.

Bibliometric literature reviews have grown in popularity in the academic world to study published knowledge (Danvila-del-Valle et al., 2019; Ellegaard, 2018; Raman et al., 2021). Scholars can identify and classify research hotspots as well as explore updated insights in a specific field through bibliometrics research (Gondivkar et al., 2018; Shareefa & Moosa, 2020). Bibliometric studies, in particular, examine and classify bibliographic material by constructing representative summaries of the existing literature (Donthu et al., 2020). Other than a traditional review, bibliometric analysis is a statistical analysis that relies on quantitative methods, and it can prevent or lessen subjective interpretation bias among

academics from various backgrounds (Donthu et al., 2021; Koseoglu, 2016). Admittedly, bibliometric studies are typically more objective and impartial than other kinds of reviews (Fan et al., 2022; Mukherjee et al., 2022).

Nevertheless, in March 2022, a pilot advanced search on the Web of Science (WoS) database was conducted using the same search parameters in this research (and the term "bibliometric") to see if there were any bibliometric studies conducted on the topic of knowledge workers. The query yielded only five results in total, only one was somewhat related to the current investigation which is the bibliometric analysis of knowledge worker's mobility and knowledge management in multinational enterprises (Ferreira et al., 2022). The other four papers were out of the scope of this paper. Based on the findings, it is argued that despite the increasing interest in knowledge workers to date, there is still a dearth of literature mapping the field. As such, the present review undertook a bibliometric analysis to explore the evolution of knowledge in this field.

First and foremost, this paper aimed to summarize and review the previous research productivity outcomes to provide some enlightenment for subsequent scholars. Second, this paper used bibliometric analysis to have an overview of the existing knowledge on the topic of knowledge workers to evaluate the essential intellectual landscape for future knowledge creation.

The scientific domain's intellectual structure encompasses its research traditions, the disciplinary composition, the topic trend covered by these, and the pattern of interrelationships (Hallinger & Kulophas, 2019; Shafique, 2012; Zupic & Čater, 2015). Given the significance of such a scientific approach, the main objective of this review was to identify the number of publications, and active years of publication, the geographic distribution, publication distribution and growth trajectory of studies, the most influential journals, papers, authors, and countries, the intellectual structure of the knowledge base and the social-interactions among authors.

2. Methodology

In this review, the purpose was to examine the research on knowledge workers by using a bibliometric mapping method. It revealed the trends in the field by analyzing the status of publications, journals, keywords, themes, and citation variables. In response to the research questions, this study employed a quantitative rigor bibliometric analysis approach investigating 1667 documents in the knowledge workers field from 1981-2021.

According to Donthu et al. (2021), there are two main sorts of bibliometric analysis in this review: performance analysis and science mapping. Performance analysis aims to present the contributions of different research constituents (journals, authors, affiliations, countries) to a certain field (Donthu et al., 2021). Science mapping uses software to identify the clusters of research, show the intellectual structure of the field, and capture the recent topics by these researchers. It can also explore and graphically display the connections among various concepts (Moosa & Shareefa, 2020) which relies on the analysis of documents drawn from digital databases (Hallinger & Kulophas, 2019). In line with these objectives, this review was structured from two aspects: performance analysis and science mapping.

The study followed the standard science mapping workflow recommended by several scholars (Aria & Cuccurullo, 2017). The five phases of detailed stages included: study design, data collection, data analysis, data visualization, and interpretation. The first phase focused on research design that included numerous steps such as database selection, search criteria formulation, and timeframe selection. Furthermore, research objectives were set, and the entire study was thoroughly structured, with several criteria determined to undertake the study in a systematic manner at this stage.

2.1 Data Collection

Based on the criteria established in the first phase, firstly database selection was done. The WoS database was selected because of its relevance to the objectives of this study, scientific rigor, and wide coverage in the area of knowledge workers' research. In line with the search criteria established previously, a search was conducted in April 2022 using the keywords "knowledge workers*" or "knowledge-worker". All papers retrieved were published in the core collection in the category of all fields. Based on the period selected (1981-2021), the search yielded results of 3069 documents. The third phase involved setting the eligibility criteria and filtering the data. The selected articles used were only journal articles given this type of document is considered to be "certified knowledge" (Ramos-Rodriguez & Ruiz-Navarro, 2004) and is more reliable due to the peer review process involved. The included criteria applied in this review have been predetermined including: (1) researchers' access to the full text; (2) written in English. The fourth phase was to filter the retrieved data and determine the final papers for analysis. After being filtered, bibliometric data of the final result of 1667 articles was extracted for further analysis in this review (see Figure 1). Figure 1 shows the procedures of the five main phases for conducting this research which followed PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Moher et al., 2009).

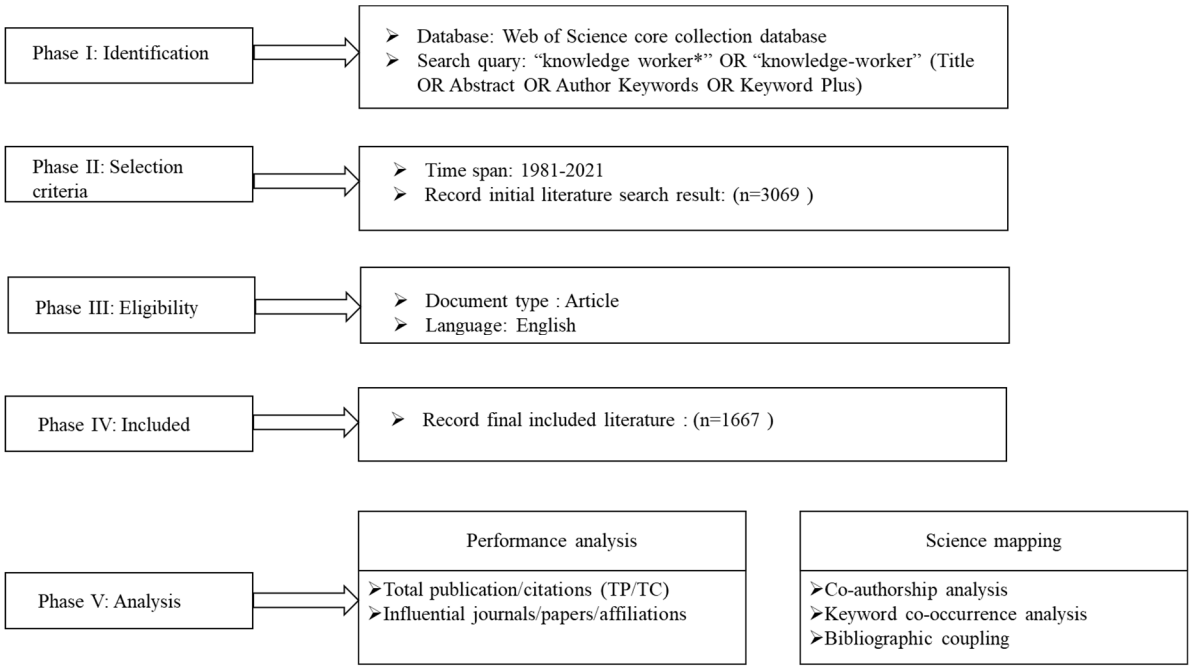

Figure 1. PRISMA flowchart

2.2 Data Analysis

Data analysis was the final phase, which was divided into two parts: performance analysis and science mapping. The performance analysis identified the most notable journals related to knowledge workers and recognized contributions made by countries, institutions, and authors. The second part of the analysis centered on science mapping, which involved creating bibliometric maps to examine the intellectual structure as well as plotting the development patterns of this field. The bibliometric approach in this paper included co-authorship analysis, keyword co-occurrence analysis, and bibliographic coupling of the document.

3. Results and Analysis

3.1 Growth in the Knowledge Workers Research

To do the performance analysis, the study began with a general overview and assessment of the publications. From 1981 to 2021, a total of 1667 papers on knowledge workers have been published maintaining a steady growth rate of 6.65% per year on average (see Table 2). The average number of citations per article was 23.75, while the average number of authors per paper and the international co-authorship were 2.54 and 21.42% respectively.

Table 2. Profile of publications

Description	Results
Timespan	1981:2021
Documents	1667
Annual Growth Rate %	6.65
Document Average Age	9.44
Average citations per doc	23.75
References	63595
Keywords Plus (ID)	2187
Author's Keywords (DE)	4100
Authors	3527
Authors of single-authored docs	386
Co-Authors per Doc	2.54
International co-authorships %	21.42

Figure 2 depicts the publications and citations of documents throughout the period 1981-2021 in chronological order. As evident from the graph, the research on knowledge workers has gone through three stages, namely: the initiation stage, the transition stage, and the rapid development stage. The period from 1981 to 1991 was the initiation stage of the research on

knowledge workers in academia. With only one article published in 1981 that received no citations, no significant changes in the growth of the literary landscape were noticed. The average per year cited 989.75 times. It was in a low circulation phase both the publications and the citations until 1990. From 1991 to 2011, the literature began to maintain a relatively steady growth, even though the number of publications and citations was still low. From 2011 to 2014, there was a sudden and sharp decline in the number of documents. Since 2015, the publications trend has maintained an alternation of rise and decline, but the citations increased substantially onwards. The most productive year was 2020, with publications reaching 155. The number of citations received in 2020 was also high, which was the second-highest number of all years reaching 4295 citations. The year 2020 and 2021 were about even, with publications and citations being 145 and 5615 respectively. At the same time, as evident from the above analysis, there was a positive correlation between the number of published literature and the number of cited literature. This upward trend indicates that knowledge worker's research is getting the attention of an increasing number of academicians. After 40 years of development, the number of publications and citations has been on a stage of steady rise.

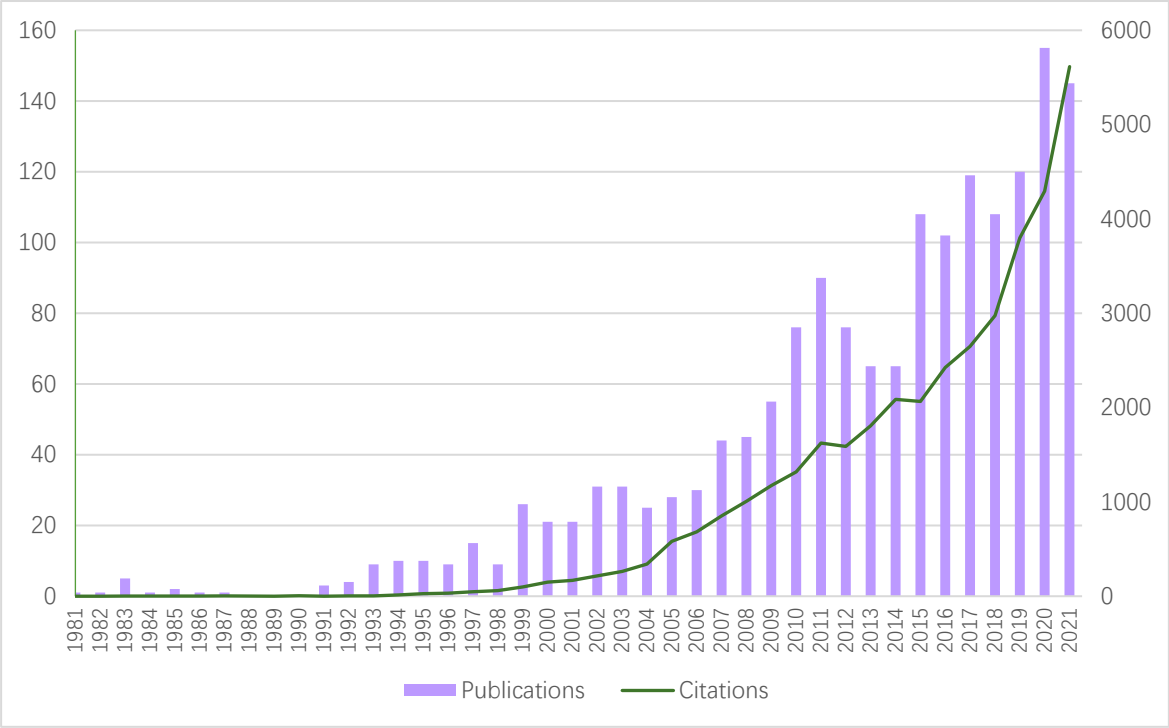

Figure 2. Distribution of publications and citations by year (1981-2021)

3.2 Main Sources of Knowledge Workers Research

3.2.1 Core Sources

Table 3 indicates the fact that the literature with the largest contribution was under the

category of "Management", accounting for 37.193 % of the total. It was followed by "Information Science Library Science" and "Business", with 256 and 219 total contributions respectively. The number of contributions from the top five journals accounted for 83.68% of the total 1667.

Table 3. Top 5 fields of publications

No	Web of Science Categories	Record Count	% of 1,667
1	Management	620	37.19
2	Information Science Library Science	256	15.36
3	Business	219	13.14
4	Computer Science Information Systems	200	12.00
5	Computer Science Artificial Intelligence	100	6.00
6	Total	1395	83.68

3.2.2 Most Relevant Journals

The number of publications reported the contributions of the journal. Figure 3 revealed the top 10 journals in terms of the number of contributions. The contribution of "Journal of Knowledge Management" was significantly higher than that of other journals, reaching 41, making it the most influential in the field. "International Journal of Human Resource Management" and "Harvard Business Review" were the second and third positions with 22 and 18 papers respectively. Whilst the contribution of other journals was not much different i.e. fewer than 20 papers ranging from 10 to 18. It was notable that the majority of these top 10 journals are about management, business, and information technology, which also reflected the focus of scholars related to the knowledge workers. As a whole, the number of journal publishing knowledge workers was relatively scattered. Even the top 10 journals published only 41 articles on knowledge workers. Presumably, more articles on the subject have been published piecemeal in various other journals. This may be caused by the discussion of scholars concerned about this issue from different perspectives, which also reflected the inclusiveness of this topic, involving many different sub-issues.

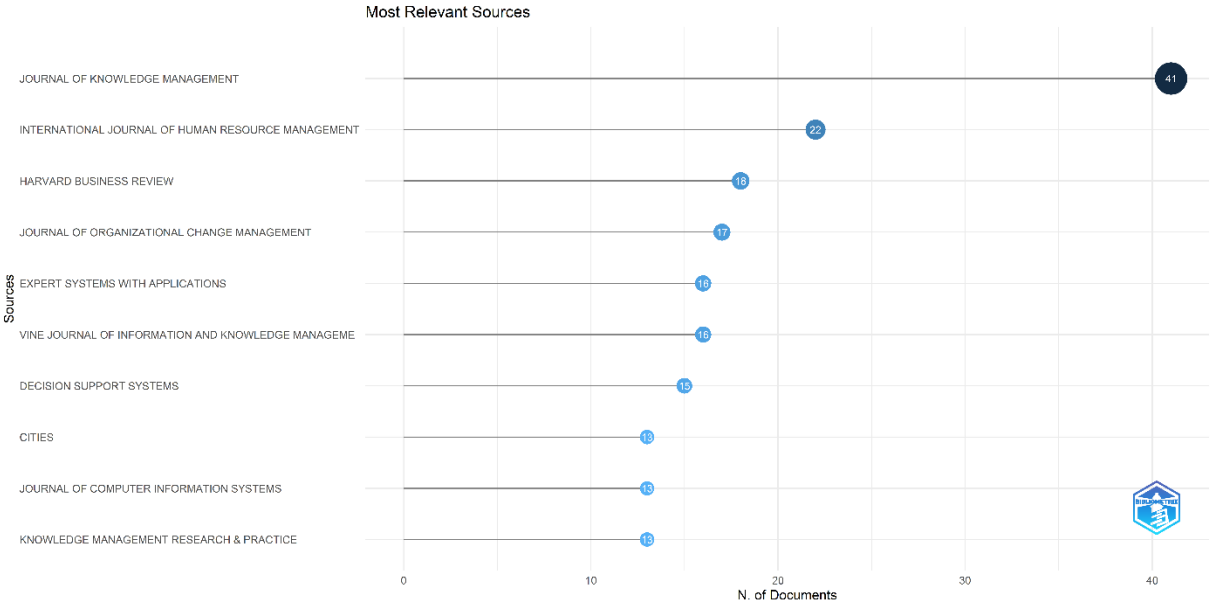

Figure 3. Top 10 most influential journals

3.3 Geography Analysis

3.3.1 Most Influential Affiliations

Table 4 reveals the contributions by the institutions in terms of the highest publications on knowledge workers. It can be observed that the top 10 institutions were unevenly distributed according to country and territory, with most of them located in Europe and the United States. The League of European Research Universities came in first place based on the number of contributions accounting for 21.25% of the total top 10. However, American research institutions still took the lead in terms of the number of affiliations (6 out of a total of 10). The United States institutions also led the top 10 in the number of publications, with 52.5% of the total. Therefore, considering the aforementioned analysis, it can be argued that despite the fact that researchers from numerous nations have engaged in research on knowledge-based work, the United States still had the most institutions in terms of the number of research institutions.

Table 4. Top 10 affiliations

Ranking	Affiliations	TP	Percentage(%)	Region/Country
1	League of European Research Universities	51	21.25	Europe
2	University of Texas System	24	10.00	USA
3	University of London	24	10.00	UK
4	University System of Georgia	23	9.58	USA
5	Tampere University	22	9.17	Finland
6	University of California System	21	8.75	USA
7	University of North Carolina	20	8.33	USA
8	Harvard University	19	7.92	USA
9	State University System of Florida	19	7.92	USA
10	Hong Kong Polytechnic University	17	7.08	China
	Total	240	100.00	

3.3.2 Co-authorship Status in the Field of Knowledge Workers

The goal of science mapping in this paper was to graphically depict the intellectual structure, the development, and the emerging trends in the field of knowledge workers research over four decades (1981-2021) from the following perspectives: subject categories and major journals, highly cited references and highly cited authors, as well as keywords analysis. The VOS viewer software was used as auxiliary software to help analyze data and visualize the results.

In scientific research, co-authorship is one of the most formal pieces of evidence of intellectual collaboration (Acedo et al., 2006). Co-authorship occurs when at least two authors co-publish a paper (Lu & Wolfram, 2012). Figure 4 shows the author's collaboration network of the core countries. To preserve effective partnerships and avoid accidental connections, a threshold of 10 was applied for the minimum number of publications by a country. It demonstrates that 36 out of the total 83 countries were grouped into 7 clusters and maintained 190 links of relationships. Though many countries around the world have published papers on knowledge workers, the United States was at the center of all the countries, as can be seen presenting 30 collaborative relationships (links). The link strength can be seen in the width of the links indicating the strength of cooperation between countries. In terms of the strength of the connection, South Korea was the most frequently associated country with the United States with a total link strength of 14. Beyond this cluster, the second

intensive cluster was the England-centric partnership. The main countries included in this group are Austria, Denmark, Ireland, Israel, New Zealand, Scotland, and Switzerland. When it came to the territorial distribution of author cooperation, Europe had more and stronger author cooperation compared to other regions. Furthermore, in Europe, Britain had the strongest cooperative relationship with other countries.

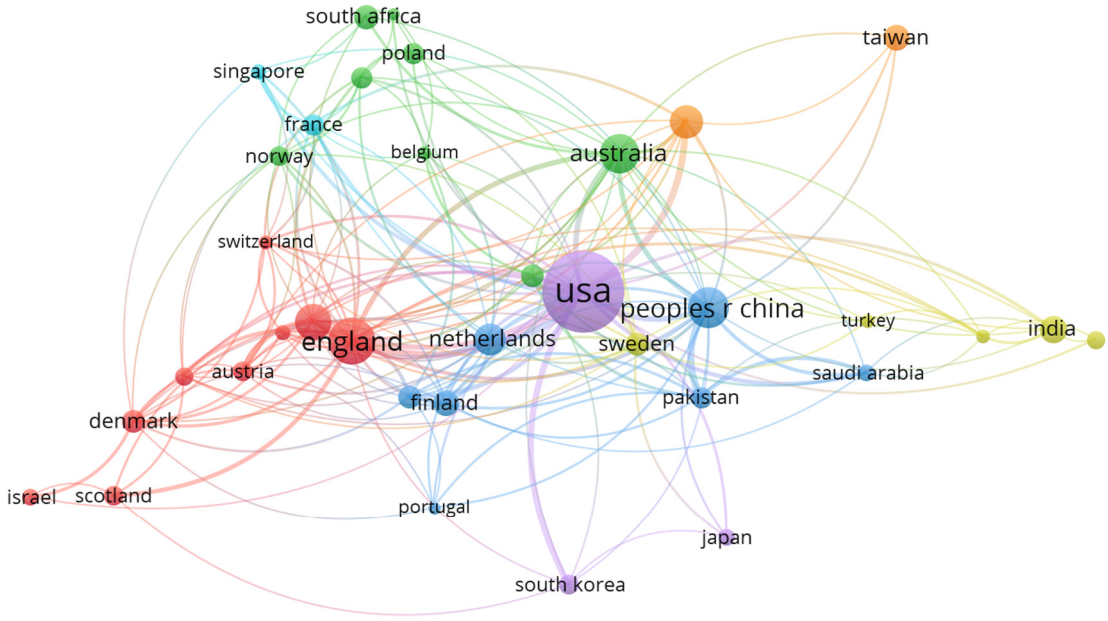

Figure 4. Collaboration network map among the countries according to the number of publications

3.4 Top Scholars and Authorship

3.4.1 The Citation Status in the Field of Knowledge Workers

Bibliographic coupling is a technique for science mapping based on the notion that two publications with comparable references will have similar content (Donthu et al., 2021). It has been used in numerous disciplines to denote subfields or study subjects (Chang et al., 2015). A bibliometric coupling analysis using VOS viewer was carried out to analyze the most cited references to find out the commonalities in the field. The full-counting method was applied meaning that regardless of the overall number of authors in a document, each document or citation has the same weight. For citations, a threshold of 100 per document was set. When conducting bibliometric coupling analysis, the minimum cluster item was set to 5. As a result, 65 connected items out of the 69 documents were selected and the analysis yielded 3 clusters. The size of the nodes indicated the frequency of occurrence.

The output generated by the software on this subject is displayed in Figure 5. As shown in the

result, the cluster in red (at the left bottom) represented those that investigated the relationship between informational technology and knowledge workers. Likewise, the cluster green denoted those that explored knowledge work in organizations. The blue cluster demonstrated the communication exchange by knowledge workers in organizations.

As suggested by the result, scholars who published on the topic of knowledge workers cited the knowledge workers' behavior in the organizational context. The findings also indicated that authors often and concurrently studied components of knowledge workers' behavior and organizational environment in the age of information technology. It was due to the focus on improving knowledge workers' productivity was the most crucial factor for excellent organizational performance (Groen et al., 2012; Palvalin et al., 2017) and the transition to a knowledge-based economy has been aided in part by advances in information and communication technologies (Seth & Lee, 2017).

Furthermore, the proximity of nodes indicated a closer link among the research. Hence, the green cluster suggested that the references cited by these scholars who published touched on the theme of knowledge work in organizations were from a wide range of sources.

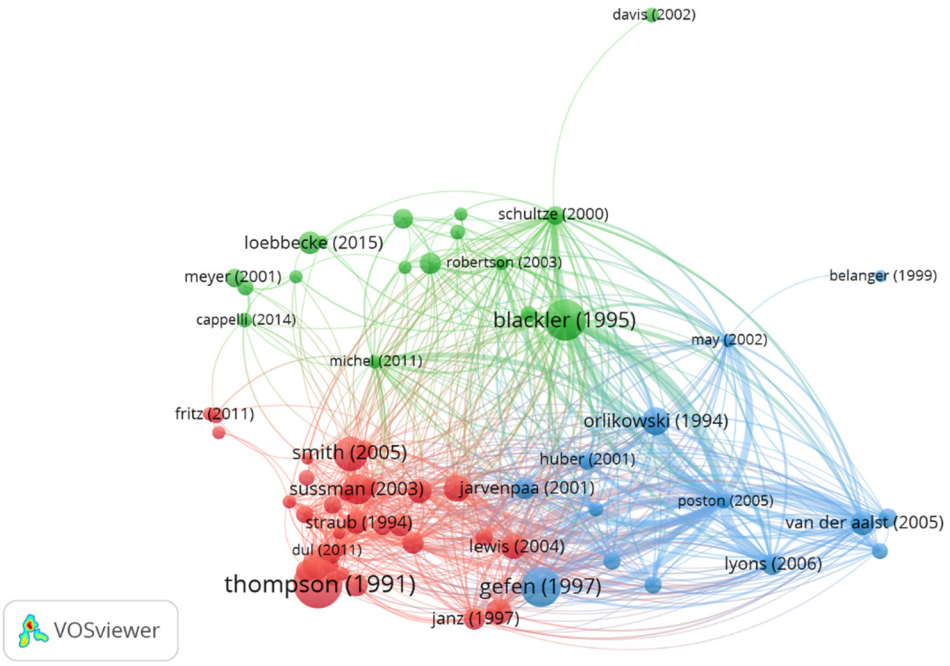

Figure 5. Bibliometric coupling of the documents

3.4.2 Authors with the Most H-index and Citations

A task that is becoming more crucial for the scientific community is measuring researchers' production of scientific knowledge (Alonsoa et al., 2009). The "h - index" is a particularly straightforward and practical method that estimates the significance, importance, and broad influence of a scientist's total research contributions (Hirsch, 2005). The top 10 authors who contributed the most to the knowledge workers community based on the h - index have been

listed in Table 6, with the top 3 being Jarrahi MH, Liu Dr, and Shujahat M.

However, relying solely on the h - index may overlook the fact that some authors have a high number of citations despite a small number of publications (Iqbal et al., 2022). To address this shortcoming, the number of citations was further analyzed as shown in Table 5.

Table 5. Most influential authors in terms of h-index or citations

Author	h_index	TC	NP	PY_start	Author	h_index	TC	NP	PY_start
JARRAHI MH	7	179	8	2013	HIGGINS CA	2	1724	2	1991
LIU DR	6	110	6	2005	STRAUB DW	4	1465	4	1994
SHUJAHAT M	6	249	7	2018	HOWELL JM	1	1444	1	1991
DUXBURY L	5	224	7	2005	THOMPSON RL	1	1444	1	1991
ESMAEILPOORARABI N	5	116	5	2016	BLACKLER F	1	1006	1	1995
GUARALDA M	5	116	5	2016	GEFEN D	1	964	1	1997
JOO BK	5	257	6	2010	COLLINS CJ	2	745	2	2005
KAPLAN S	5	150	6	2013	CLARK KD	1	709	1	2005
MONKS K	5	104	5	2011	SMITH KG	1	709	1	2005
NAWAZ F	5	231	5	2018	DRUCKER PF	2	701	2	1997

By comparison, it was found that the h - index value of the top 10 authors was not high in terms of citations, given that 87.3% of the authors had published no more than 5 articles in this field. While percentage of authors who have published more than 5 articles in this field was only 0.4%. These authors with high citation scores started publishing earlier, mostly in the 1990s, and it was possible that they were most classic articles or that the accumulation of time had led to an increasing number of citations.

3.4.3 Papers with High Citation

Citation analysis is based on the assumption that authors cite documents that are relevant to their research (Ramos-Rodriguez & Ruiz-Navarro, 2004) thus indicating the article's impact (Appio et al., 2014; Ellegaard, 2018). Therefore, the more times one document has been cited, the more influential it is in a certain research field. Table 5 showed that based on the total number of citations the highest-contributing article was “Personal computing: Toward a conceptual model of utilization” which was referred to 1444 publications. In total, there were two articles that were cited more than 1,000 times. The other one was “knowledge, knowledge work and organizations: An overview and interpretation” with 1006 citations. It was worth mentioning that the citations with the highest rankings were published many years

ago. Of these 10 most influential articles, 6 were published in the 1990s. It can be speculated that current scholars still prefer to cite some early classical literature. On the other hand, papers published in recent years require more time to demonstrate their impact. The result is presented in Table 6:

Table 6. Top 10 most cited papers

Ranking	Title	Authors	TC	YP
1	Personal computing: Toward a conceptual model of utilization	Thompson, RL; Higgins, CA; Howell, JM	1444	1991
2	Knowledge, knowledge work and organizations: An overview and interpretation	Blackler, F	1006	1995
3	Gender differences in the perception and use of E-mail: An extension to the technology acceptance model	Gefen, D; Straub, DW	964	1997
4	Existing knowledge, knowledge creation capability, and the rate of new product introduction in high-technology firms	Smith, KG; Collins, CJ; Clark, KD	709	2005
5	Knowledge-worker productivity: The biggest challenge	Drucker, PF	632	1999
6	Informational influence in organizations: An integrated approach to knowledge adoption	Sussman, SW; Siegal, WS	591	2003
7	Sources of influence on beliefs about information technology use: An empirical study of knowledge workers	Lewis, W; Agarwal, R; Sambamurthy, V	515	2003
8	Genre repertoire - The structuring of communicative practices in organizations	Orlikowski, WJ; Yates, J	491	1994
9	Measuring innovative work behavior	de Jong, Jeroen; den Hartog, Deanne	425	2010
10	Relations between work team characteristics and effectiveness: A replication and extension	Campion, MA; Papper, EM; Medsker, GJ	400	1996

3.4.5 Co-authorship Analysis

The collaboration between authors could be examined by science mapping. For this purpose, the VOS viewer co-author analysis was performed mapping the co-authorship networks. Only authors with a minimum of three documents were included, resulting in a total of 129 authors split into 4 clusters and 5069 links, which is illustrated in Figure 6. The clusters were generated using the association strength approach and reflect groups of closely related authors. The lines reflected co-occurrence between two authors and appeared when authors co-occurred at least three times.

Overall, the result suggested that collaboration among all authors on the knowledge workers topic was frequently lacking. It was notable that although there is a dense interconnection in the main cluster (red), the other smaller clusters seem isolated from each other. The scattered pattern of academics further showed a high level of author fragmentation.

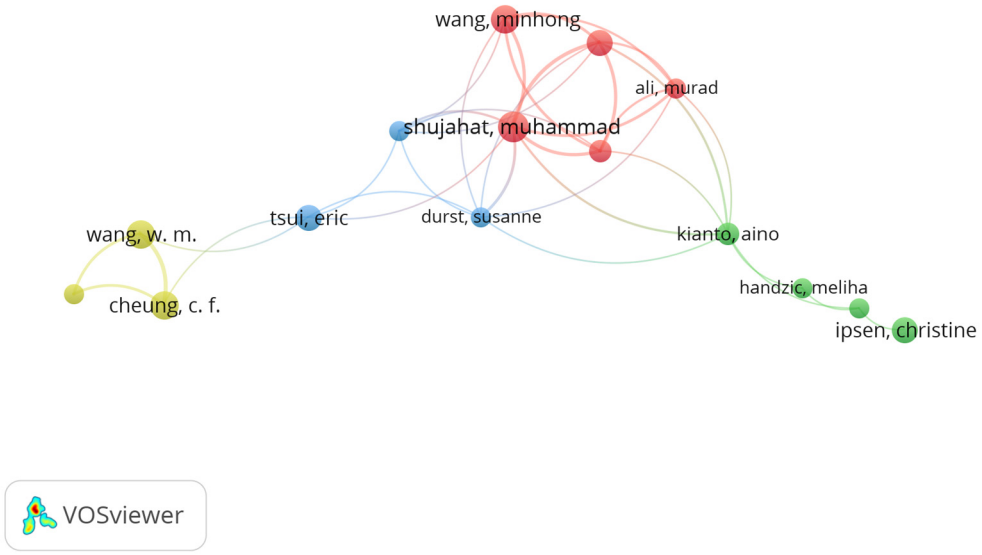

Figure 6. Co-author network for the knowledge workers

3.5 Dimensions Analysis of Knowledge Workers Research

Bibliographic coupling, in which the papers listed in reference lists serve as the unit of study, is particularly suited to determining the intellectual underpinning of a given topic. Furthermore, the theory behind keyword co-occurrence analysis is that when a certain group of words appears in different papers, it is likely that the concepts behind these words are closely related (Andersen, 2019). Thus, in order to examine the topical interests and themes in the field of knowledge workers, the bibliometric coupling in VOS viewer was chosen to carry out co-occurrence and cluster analysis which can generate a visual connection among keywords. With regard to the keywords analysis, only author keywords were considered. In this network visualization, the distance between nodes shows the relationship between phrases or concepts, whilst the nodes themselves represent the terms or concepts (Sedighi, 2016). To narrow the visualization to a manageable set of keywords, only words with a minimum of 5 occurrences were retained. Clusters were generated using the association strength method and the minimum cluster items were set to 15 to reduce the smaller clusters. It indicated in the total of 3827 author keywords 128 keywords met the threshold and were divided into 5 clusters (see Figure 7).

The figure illustrated that the circle size represented the total number of times the keywords appear in papers, while the line thickness and color represented association strength and clustering, respectively (Shareefa & Moosa, 2020). The most commonly used keyword in each cluster was chosen as the cluster name to represent the subject classification(Sedighi, 2016). According to the number of nodes, the most extensive research area was the red cluster with 38 nodes called “knowledge work” due to the term having the most frequent occurrences. This keyword had strong associations with “creativity”, “human resource management”, “knowledge work”, “motivation”, “organizational commitment”,

"productivity", "telework", "turnover intention", "well-being" and "work engagement". The second cluster (green) called "performance" was made up of 27 nodes. This theme represented the studies relating to "knowledge economy", "management", "mobility", "ontology", "performance", "social networks" and "communication". Meanwhile, the purple color represented the third cluster (26 nodes) of the articles associated with the keywords "human capital", "higher education", "education", "information management", "information retrieval" and "leadership". The fourth cluster (yellow) was made up of 20 nodes that represent "knowledge workers" and linked to other keywords such as "information technology", "tacit knowledge", "learning", "organizational learning" and "transformational leadership". The last cluster (blue) with 17 nodes called "knowledge management systems" with links to "organizational culture", "organizational performance", "information management" "information systems", "incentives" and "knowledge-based systems".

The distance between "knowledge work" and "human capital" was the shortest, which indicated the relationship between the two keywords was the strongest. The association between "knowledge work" and "performance" was the weakest, as the two keywords were the most distant from one another. In addition, the relationship between "knowledge work" and "knowledge workers" was stronger than that between "knowledge work" and "knowledge management systems".

It can be concluded that, even if the majority of the most frequent keywords showed strong connections between them, several keywords remained disconnected from the main cluster. In addition, the topic of "knowledge workers", "performance", and "human capital" has grown rapidly in the past few decades and has become critical topics in the field of knowledge workers.

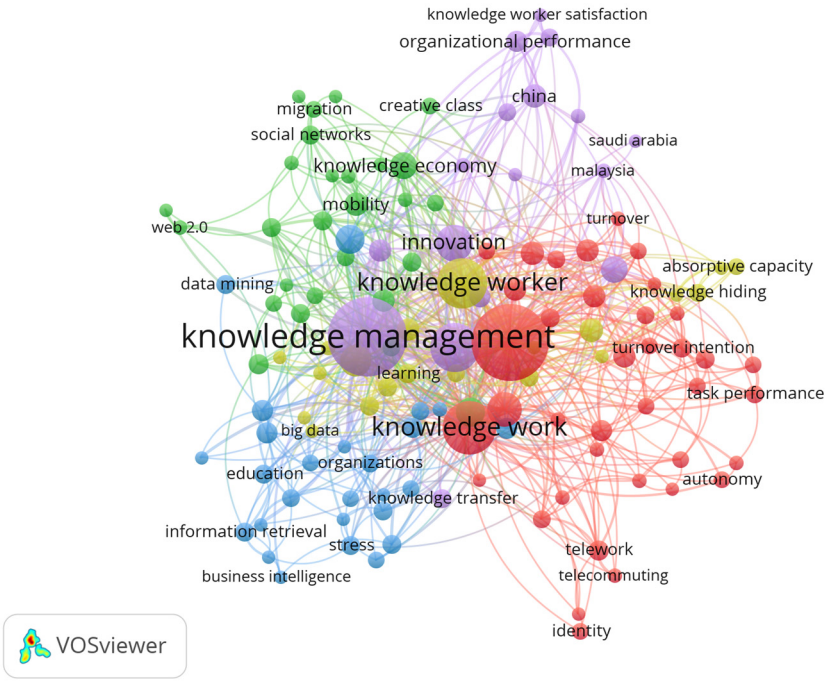

Figure 7. Co-occurrence analysis based on author keywords

To better clarify the category clusters, Table 7 lists the main keywords that represents the above clusters.

Table 7. Clusters of keywords and themes with assigned categories

Cluster	Color	Number of Items	Item category	Author Keywords
1	Red	38	Knowledge Work	creativity; human resource management; knowledge work; motivation; organizational commitment; productivity; telework; turnover intention; well-being; work engagement
2	Green	27	Performance	knowledge economy; management; mobility; ontology; performance; social networks; communication
3	Purple	26	Human Capital	higher education; education; information management; information retrieval; leadership
4	Yellow	20	Knowledge workers	information technology; tacit knowledge; learning; organizational learning; transformational leadership
5	Blue	17	Knowledge Management Systems	organizational culture; organizational performance; information management; information systems; incentives; knowledge -based systems

In order to discuss current research hotspots in-depth, we further extracted and analyzed the results of the above keyword clustering for themes that may not be fully consistent with the above five clusters, due to the fact that some keywords appear in different clusters at the same time. Our discussion focused on the scope of scholars' research on knowledge workers, and we found that they were mainly conducted in two categories, that was, at the micro level within the organization and the macro level in the social environment.

The first type was to explore knowledge workers within the organization and to manage them as an important resource in the organization. For example, Thompson and Heron (2005) investigated how perceived justice influences knowledge workers' commitment. They concluded that in the case of a psychological contract breakdown, the perceived quality of the relationship between knowledge workers and their superiors might help maintain levels of commitment necessary for knowledge generation. Horwitz et al. (2006) used the culture fit model to decide on the human resource (HR) management techniques for knowledge workers in South Africa (SA) and Singapore and discovered that while methods were divergent for luring knowledge workers, there were convergent successful HR strategies employed for motivating and retaining employees. Lee et al. (2016) suggested that the perceived psychological contract fulfillment mediated the association between organizational culture and affective commitment. Lafuente and Berbegal-Mirabent (2017) focused on how university contract employment practices—fixed-term contracts and permanent contracts—affect research productivity in terms of journal publications. Their findings implied that the excessive use of fixed-term contracts may hinder universities' ability to maximize the potential of knowledge workers by creating an unstable work environment. Wu and Yu

(2022) studied how to improve the knowledge workers' innovative behavior in digital business times. The authors confirmed that the effects of individual innovativeness were stronger when their values aligned with organizational values.

The second thread was to place knowledge workers in a macro social environment and explore the interaction between knowledge workers and the external social environment. Most of the authors emphasized the changes in the social context that brought about changes in knowledge workers' work. For example, Field and Chan (2018) highlighted that the boundaries between work and life are becoming increasingly blurred and borderless for flexible knowledge workers. They called on HR practitioners to develop new HR policies that accommodate flexible workers. Furthermore, due to the growing number of users on the technological landscape, many knowledge workers' principal outputs are intangible, analytical, creative, and frequently new digital (Jarrahi et al., 2017). Therefore, Zhang-Zhang et al. (2022) examined the importance of strategic management of knowledge workers in the current highly dynamic environment with volatility, uncertainty, complexity, and ambiguity context and proposed a holistic framework for an organization's sustainability. Although there were lots of fruitful research results in the previous literature, we found that most of the studies treated knowledge workers as passive objects of research, emphasized the influence of the external environment on them, and lacked the perspective of knowledge workers to explore how they proactively responded to external changes. Therefore, it was suggested that future scholars focus on the subjective psychological dynamics of knowledge workers and examine their adjustment experience in response to the changing times.

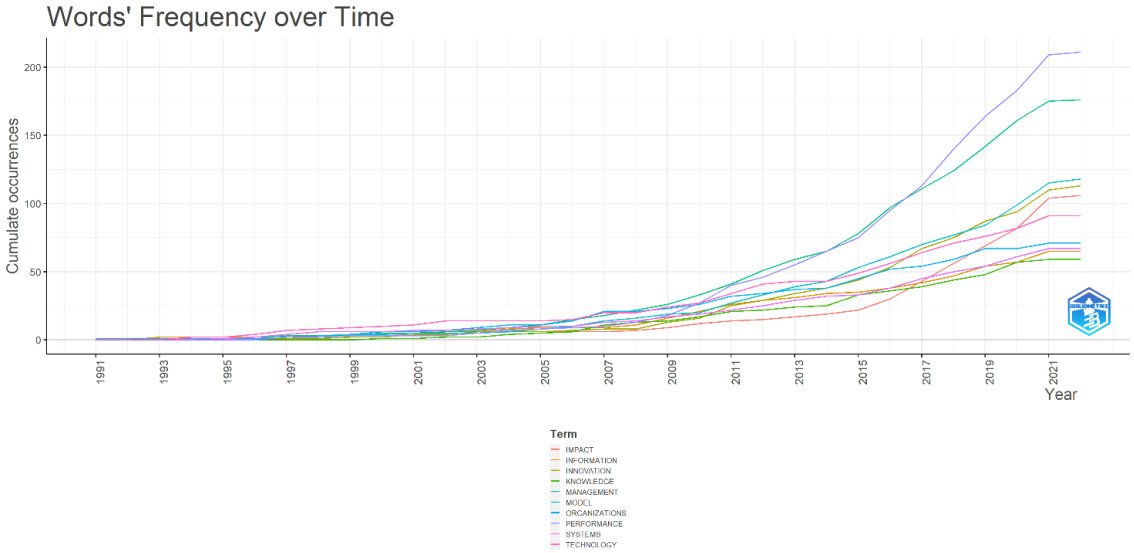

Figure 8. Evolution of popular keywords

Figure 8 illustrates a diagram showing the chronological analysis of "keywords plus" from 1981 to 2021. "keywords plus" are distinct from title and "author keywords" and provide additional descriptive terms for the article's content, aiding in obtaining more comprehensive

search results. These "keywords plus" were generated using computer algorithms that extract relevant words or phrases from the references' titles. To generate Figure 8, this study conducted time sequence analyses on the top ten supplementary keywords with the highest occurrence frequency. Interestingly, unlike author keywords, "performance" replaces "knowledge management" as the most frequent term in keywords plus, especially after 2017, when there has been a rapid increase. Followed by the highest frequency is "management", and the third is "model". In addition, the frequency of "innovation" and "impact" has also increased rapidly since 2015. Moreover, it is evident that "technology", "organizations", "systems", "information" and "knowledge" are the top ten most frequently occurring words. This suggests that scholars in recent research have focused on the performance management of knowledge workers, utilizing various models and methods to encourage employee innovation.

4. Conclusions

This paper conducted a bibliometric analysis of publications over four decades (1981-2021) on knowledge workers to evaluate the status of the knowledge in this field. It examined not only the general productivity in the last few decades, and the international collaborative networks, but also analyzed the research hotspots and trends in recent years in the knowledge base.

An initial finding of this study confirmed the notion that knowledge workers are gaining popularity as a significant concept as well as an attractive field of research. Despite scholars having focused their attention on the influence of cultural factors on knowledge workers and conducted research in various territories, there is still a lack of comparison between different countries. The main reason for this paradox was that the transnational cooperation among scholars was relatively less relevant as noted earlier. It can be seen from the aforementioned analysis that the majority of publications were completed by scholars from a single country. It is an indisputable fact there are hardly any study of cross-cultural research can be completed by authors merely from a certain country.

Another finding from the research was that the research of knowledge workers has been widely concerned by scholars in various fields and is becoming an interdisciplinary research topical interest. Scholars seem to want to study how to improve organizational effectiveness from the perspective of improving knowledge workers' productivity. Therefore, they paid close attention to the work characteristics of knowledge workers and studied the mechanism of igniting their work enthusiasm from a variety of angles. Nevertheless, the process of the knowledge workers' work is invisible and the knowledge resides in the knowledge workers' heads which is known as "tacit knowledge" (Ramamoorthy et al., 2014), thus pressing further exploration.

Thirdly, this study also recognized that at the keyword level, the majority of the study revolves around a few central issues indicating there are a lot of research issues that have not received enough attention. For example, the keywords "business intelligence", and "knowledge workers satisfaction" appear at the edge of these co-occurrence keywords clusters. Moreover, numerous keywords in the literature even do not exist in these clusters

however their significance cannot be ignored either, such as organizational climate (Bock et al., 2005), regions (Miguelez, 2019), ambiguity (Lund, 2019) and overwork (Huang et al., 2020). We encourage future scholars to pay further attention to the areas in which these keywords are found.

Last but not least, a critical issue pressing the need for research is defining the concept of "knowledge workers". Upon reviewing the previous literature, it is not difficult to find that most of the studies on knowledge workers whether at the micro-level or macro-level, started from a managerial perspective, treating knowledge workers as an important group of the labor force and aiming to improve social productivity. Nevertheless, when we go back to the original point, we can find that although research on knowledge workers has been emerging, most scholars have followed the original concept proposed by Drucker (1959) for the definition of knowledge workers. When Drucker introduced this concept, he was referring mainly to the managerial level, but in today's knowledge economy, knowledge workers have become the main force within organizations and the number of knowledge workers is unaccounted for. Although scholars recognized the huge societal transformations nowadays, especially in many emerging occupations, there was a dearth of research on clarity of who was the knowledge workers in the specific fields, which will lead to potential researchers not knowing whether knowledge workers are applicable when exploring a certain type of workers as it may generate differences of opinions and understandings. It is hoped that future scholars will keep pace with the times and make a clear distinction between knowledge workers and non-knowledge workers based on existing occupations.

In light of the above, these findings implied that there is plenty of potential for more empirical and theoretical research in this field. In this context, the analysis results help to demonstrate visually the evolution of publications, the influential research through time and indicate current research interests, capture the more recent topics in the field, and pave the way for future research.

5. Research Limitations

Like any other study, the current review was constrained by several limitations Firstly, the most significant limitation was that the present review was conducted using one database. Secondly, given that the bibliometric review only provided a fragment comprehension of the field under study based on the bibliometric information extracted. Therefore, the bibliometric approach should supplement traditional literature reviews, providing a more in-depth overview of the area while demonstrating the network among publications. In addition, to uncover specific mechanisms and assess the quality of each study, more in-depth evaluations are required.

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Competing Interests Statement

The authors declare that there are no competing or potential conflicts of interest.

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