Global Business and Management Research: An International Journal
Vol. 17, No. 1 (2025)

Innovations in the Military: A Bibliometric Analysis

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Abstract
Purpose: This research uses bibliometric citation and co-word analysis to assess military innovation's past, present, and future. This paper provides a systematic and critical analysis of military innovation literature using bibliometric analysis.
Design/methodology/approach: Scopus and Web of Science databases have been used for this review is based on 624 research papers published from 1947 to 2024. The prominence of the research is assessed by studying the publication trend, sample statistics, theoretical foundation, the highly cited research articles and journals, most used keywords, research themes of the top four recognised clusters, sub-themes within each cluster and thematic overview of military innovation corpus formed on the premise of bibliographic coupling. Additionally, thematic analysis of recently published papers revealed emerging research patterns and potential gaps.
Findings: Major findings indicate that the research area consists of five established and emerging research themes based on clusters formed as (1) Defence strategic planning, technological innovation, and public policy considerations in the defence and security domain. (2) The continuous evolution of defence capabilities and strategies in response to emerging threats, technological breakthroughs, and geopolitical challenges (3) Complex interplay between technological advancements, strategic imperatives, and geopolitical competition in shaping the future of military innovation (4) Multifaceted nature of military innovation as both a catalyst for transformational change and a response to the evolving challenges and opportunities confronting modern armed forces in an increasingly complex and contested security environment (5) The complex interplay between historical context, geopolitical competition, and operational requirements in driving military innovation agendas and shaping the trajectory of international security relations. Emerging themes identified through content analysis of recent articles include (1) Cybersecurity and cyber warfare (2) Autonomous system and AI (3) Space defence and militarization (4) Biotechnology and biosecurity (5) Electromagnetic warfare (6) Resilience against hybrid threats (7) Climate change and environmental security (8) Multi-domain operations.

Research limitations/implications: A search was conducted using the Scopus database on 4 May 2024. This database is renowned for its diverse selection of scholarly journals across various fields, including social sciences. The initial search yielded 624 literary documents, which were subsequently refined using specific inclusion and exclusion criteria, resulting in 306 papers. These papers underwent a rigorous examination for relevance based on title, abstract, and keywords, eliminating extraneous and redundant materials. The final screening focused on selecting full-text articles directly addressing the study's aims, culminating in a final corpus of 306 relevant texts.
Practical implications: Military and innovation are closely intertwined, with important theoretical implications. This study ultimately demonstrates a conceptual map of this body of knowledge, allowing us to better grasp the body of knowledge on military innovation. This research paper is the first of its kind on the subject of military innovation, as it provides a multifariousness of study fields within the military innovation corpus by using varied bibliographic mapping approaches. It also suggests viable avenues for future research.
Originality/value: Despite the abundance of journal articles on military and innovation, there hasn't been any bibliometric analysis article on military innovation until now. Although there are a few systematic reviews on innovation, there are still under-explored studies in military innovation in presenting the current issues and future directions. Nonetheless, bibliometric analysis in military technology is still in its infancy and lacks sophistication. Hence, this study explores innovation in the military context based on a bibliographic way of reviewing from the beginning until the trend of the future

Keywords: Defence R&D, military innovation, military R&D, defence innovation, armed forces innovation, defense innovation, military innovation, bibliometric analysis

Introduction

Innovation has been recognized as a key element in achieving the Sustainable Development Goals (SDGs). In this context, an innovative approach not only supports the attainment of SDGs but also facilitates the transformation process towards a more sustainable society. The blueprints outlined within the Sustainable Development Goals consist of 17 goals that seek to attain no poverty, zero hunger, good health and well-being, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, reduced inequalities, sustainable cities and communities, responsible consumption and production, climate action, life below water, life on land, peace, justice and strong institutions, and partnerships for the goals (Cuervo-Cazurra et al., 2022; D'Adamo et al., 2021;United Nations, 2015). The history of wars between countries shows the devastating effects of destruction, from which no country can rebuild well after the war.

Most of the countries take a long time and years to rebuild and some of the countries that still cannot be developed now such as countries in Europe as Russia and Ukraine, countries in Africa like Congo, Mali and in the Middle East such as Iraq, Syria, Palestine and others which have a significant impact on the lives of the people of the country. (Chol et al., 2018; Kang & Meernik, 2005). Wars affect not only conflict zones but also the rest of the world as their disruptive cascading effect runs deeper and far beyond the geographic boundaries through the globalization network (Jiang et al., 2023). Wars bring long-term adverse consequences to the global economy with weakened growth, increased inflation, and disrupted supply chains.

Innovative military approaches, such as employing advanced technology for surveillance, communication, and conflict resolution, can contribute to maintaining peace and stability within and between nations (Kahl & Larrauri, 2013). By preventing conflicts or resolving them swiftly and effectively, these approaches support SDG 16, which aims to promote peaceful and

inclusive societies for sustainable development. Military innovation can also enhance capabilities for providing humanitarian assistance during natural disasters, conflicts, and other crises (Trajano, 2021). Ultimately, a secure and stable environment is essential for achieving all SDGs. Innovative military approaches that enhance national security can create conditions conducive to economic development, social progress, and environmental sustainability, thereby indirectly supporting the entire spectrum of SDGs, such as poverty alleviation, environmental protection, and economic growth can be effectively addressed (Ministry of Defence, 2020).

For instance, the development of more advanced security technologies can help mitigate the risk of armed conflict, directly contributing to the achievement of SDG 16. Furthermore, military innovation can also positively impact other development goals, such as SDG 9 (industry, innovation, and infrastructure) through technology transfer and SDG 11 (cities and settlements) through the development of more effective security systems to maintain public order. The authority for implementing the goals is delegated to governments, which are responsible for ensuring that the goals are implemented (Cuervo-Cazurra et al., 2022;United Nations, 2022)

Literature Review

Despite the abundance of journal articles on military and innovation, there hasn't been any bibliometric analysis article on military innovation until now. Although there are a few systematic reviews on innovation, there are still under-explored studies in military innovation in presenting the current issues and future directions (Abeykoon, 2024). Nonetheless, bibliometric analysis in military technology is still in its infancy and lacks sophistication. Hence, this study explores innovation in the military context based on a bibliographic way of reviewing from the beginning until the trend of the future.

This research paper is the first of its kind on military innovation (MI) as it applies SLR-cum bibliometric analysis to provide a comprehensive and detailed analytical overview to canvass the research area holistically, intending to aid researchers, policymakers, and practitioners. The main objective of our review article is to provide the status of research on MI, with the subsequent questions describing the study's scope:

RQ1. What are the latest publication trends based on the number of years, affiliated countries, journals, and authors?

RQ2. Which popular and influential research studies are based on publication citation analysis and journal citation analysis? What are the prevalent keywords used by authors in this field?

RQ3. What are the popular themes and sub-themes in military innovation research?

An analysis of publication patterns has been conducted to examine the historical development of research in the MI domain. This analysis considers factors such as the number of years, affiliated countries, journals and authors. The aim is to provide academic researchers with a deeper understanding of the current state of research in this field. The research tools and statistical approaches commonly utilized to investigate the MI corpus are an initial effort to identify the limitations of the advancements. In this study, we will analyze the intellectual framework in the field of MI and present a comprehensive summary of significant research studies conducted over the past twenty years. Citation analysis has been used to quantify the number of citations that articles have received from other works.

We conducted a review of 306 research papers and analyzed their citation network using the VOS Viewer tool. Our goal was to identify the most pertinent articles in this particular sector. In addition, keyword analysis has been included as it is regarded as a reliable indicator of article content, reflecting the author's evaluation of the concepts and associated terms. In addition, research question 3 (RQ3) of this review has been addressed by identifying significant cluster themes obtained through thematic analysis. Finally, a thorough examination of the content of research articles published between 2017 and 2024 has been conducted to identify rising research trends and future research endeavors.

This research study contributes to the field of MI in the following ways: (1) Previous military studies did not take into account bibliometric analysis as a means to provide a thorough overview of the study topic. (2) This study utilizes a thematic analysis of the MI corpus, employing a science mapping approach to gain a comprehensive knowledge of the core principles of MI. As the subject of MI interface develops, academics have identified a range of topics and sub-themes that need to be identified. (3) This study aims to provide future research directions by analyzing the content of papers published in recent years. The subsequent sections of this work are arranged in the following manner. The second half of the paper provides a detailed explanation of the methodology section, which includes an elaboration on the search criteria, screening process, and the research methodologies utilized.

The next section presents an examination and findings, including a descriptive analysis of the chosen research publications, notable research methods, analysis techniques and theories, as well as citation and bibliographic coupling analysis. It provides a comprehensive thematic overview of the military innovation corpus based on bibliographic coupling. The fourth phase entails an in-depth examination, while the final half concentrates on the latest advancements in the field to offer valuable perspectives for future military innovation, finishing with remarks.

Research Methodology

Bibliometric analysis, a quantitative method, offers a comprehensive understanding of intellectual information within a research domain (Zupic & Čater, 2015) . strategic management (di Stefano et al., 2010) ; (Carnahan et al., 2010) ; (Ramos-Rodrígue & Ruíz-Navarro, 2004), entrepreneurship (Welter, 2008) ; (Davidsson, 2006) ; Meyer et al., 2014), innovation (Fagerberg et al., 2012, Fagerberg & Verspagen, 2018). By employing bibliographic mapping techniques, this method facilitates the identification of key research articles, countries, authors, and existing research domains. Through this analysis, one gains insights into highly cited articles globally, top contributing countries, crucial keywords, thematic clusters based on common research themes, and thematic analysis of these clusters through bibliometric coupling.

Utilizing multiple bibliometric techniques, researchers can synthesize diverse outputs to discern ongoing research trends, pinpoint research gaps, and outline future research directions in the field. VOS viewer software is utilized for constructing, visualizing, and analyzing bibliometric networks, which can be formed based on citation, bibliographic coupling, or co-citation to explore publication patterns, knowledge base, and article impact. Additionally, to track recent developments in the field of military innovation (MI), the authors have defined a based on cluster approach of sub-themes and years of articles; this analysis offers a broad overview of current research patterns within MI-related sub-areas. Figure 1 illustrates the research methodology steps and analysis tools employed to achieve the study's objectives.

Search String

The relevant keywords were identified by thoroughly examining and analyzing previous research articles on this particular topic. The specific search phrase chosen for this research

was "military innovation", rather than any other relevant keywords. Military innovation or MI is a developing term employed by researchers to remove gender biases from discussions on military advancements and promote a more comprehensive and inclusive perspective (Barry, 1984; Deborah,1994; Grissom, 2006; Suzanne, 2010). Based on our analysis of the current literature, we have determined that this word refers to military innovation.

The central focus of military innovation studies revolves around the dynamics of organizational culture, the difficulties of institutional learning, and the varying impact of internal and external factors on change. These themes have long been recognized as significant in other social science fields such as management, sociology, education, anthropology, and psychology. However, research on the factors driving military innovation has typically been considered less important in comparison to these disciplines (Griffin, 2017).

Search criteria limits

Using the Scopus database, we conducted a search for literary resources for this study on May 04, 2024, specifically targeting the given search parameters. We selected this database because of its reputation as one of the most efficient databases for academic research materials globally. It offers access to over 78 million documents, with approximately 1.7 billion citations.

However, these numbers are subject to change as the database is regularly updated (Erfanmanesh, 2017). The platform provides a diverse selection of scholarly journals in many study fields, such as the social sciences. The Scopus database has a wider coverage of international journals in the Social sciences of Humanity (Counts et al., 2014) ; (Kushniruk, 2022). Upon searching the Scopus database using specific parameters, a total of 624 literary documents were initially retrieved. Next, we narrowed down the search results by using both inclusion and exclusion criteria as referred to in Table 1.

This process resulted in a total of 306 papers. During the subsequent phase, publications underwent meticulous examination to determine their relevancy, which was assessed based on the title, abstract, and keywords. Extraneous and redundant materials were eliminated, yielding a total of 306 research publications. During the final round of screening, we specifically chose full-text articles that directly addressed the aims of our study. These articles were then filtered based on a more thorough reading. Consequently, the search procedure yielded a final corpus of 306 texts that are relevant to our study. Table 1 presents an overview of the search procedure criterion.

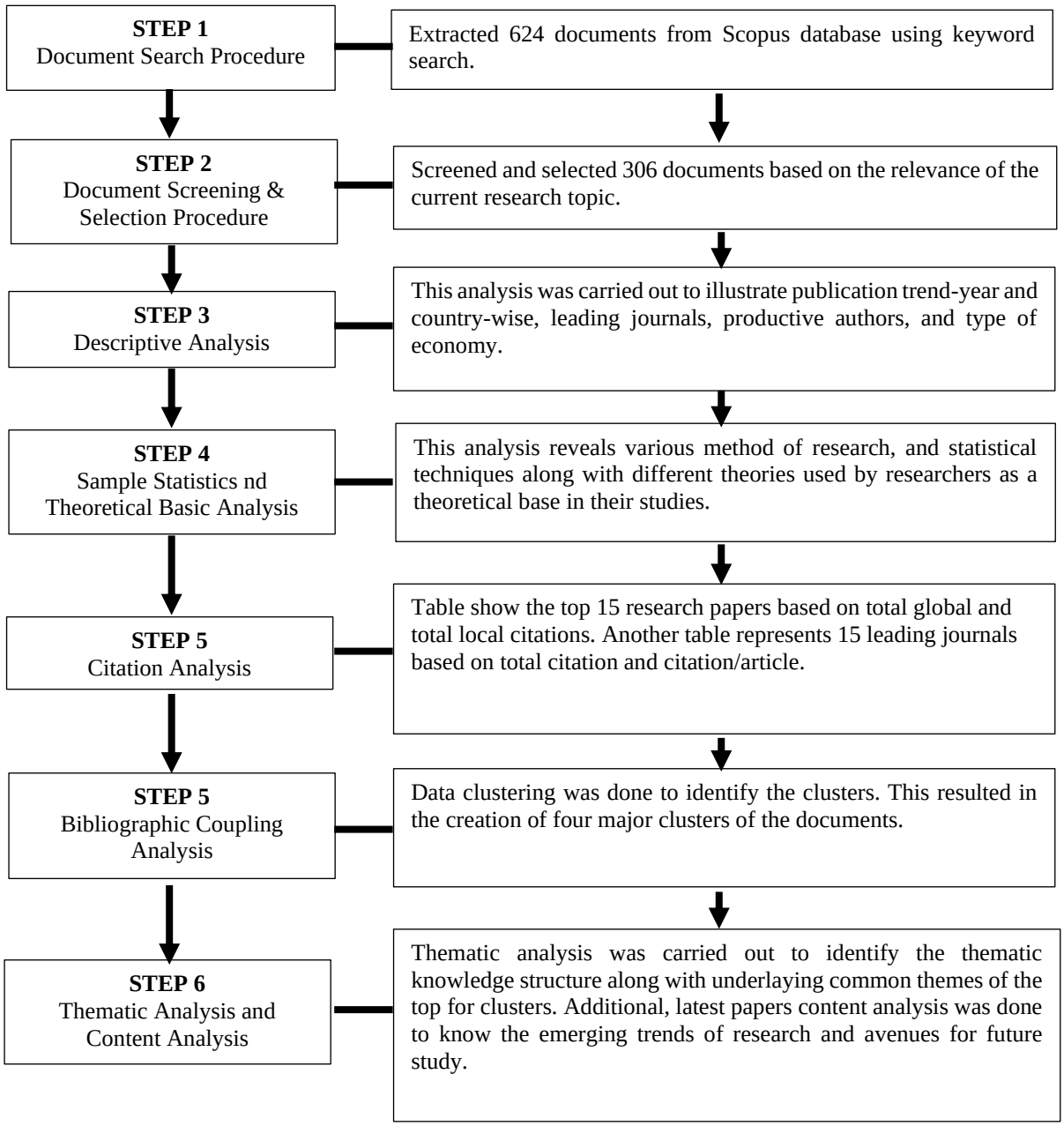

Figure 1: Structural outline representing research methodology steps and tools of analysis.

Methodology of analysis

Analysis and finding on sample statistics, keyword usage, citation patterns and bibliographic information

This phase commences with a comprehensive examination of the chosen research articles, including a study of the sample statistics, keyword usage, citation patterns, and bibliographic information. The MI corpus has undergone theme research to thoroughly and objectively analyze its unified body of information.

Descriptive analysis

To determine the ongoing trends in the chosen field of research, we conducted a descriptive analysis of 306 papers. Analyzing the publication trends based on years, countries, journals, and authors provided the answer to the first study question.

Publication frequency over a specific period

The graph below illustrates the chronological progression of studies on this subject, with a steady rise in the number of research articles produced from 1947 to 2024. This visualization trend affirms the increasing interest among research scholars due to the scarcity of literature on machine intelligence, as emphasized by multiple researchers. The efficacy and capacity of a military organization largely rely on its ability to evolve and innovate, as stated by (James D, 2020). Currently, the military is engaged in the creation of sophisticated technology, such as robots and drones, to enhance the effectiveness and accuracy of military activities (Billing et al., 2021) ; Turchin et al., 2021).

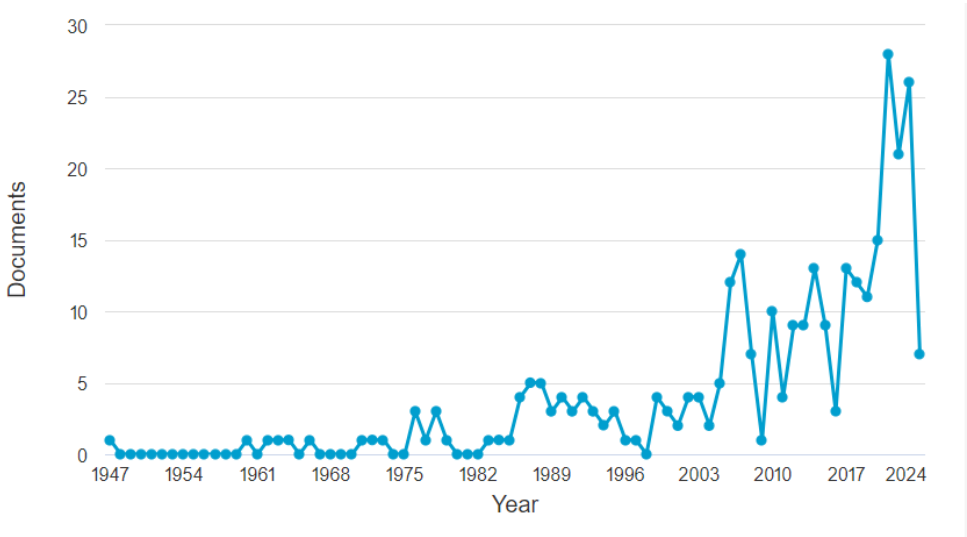

Figure 2: Annual number of research articles published in the field of military innovation
Note: This graph depicts the search of literature executed on May 04, 2024, in the Scopus database

Researchers have made significant efforts in recent years to enhance the concept of balance. Figure 2 presents a chronological representation of the progression of publications over the years. The graph above illustrates a substantial increase in the number of publications in 2018 compared to previous years. Specifically, research in this field has experienced a significant increase in activity since 2008, with more than 10 articles being published each year since that year. From 2018 to 2023, there is an annual increase in the number of publications by 18%, resulting in an extra papers being published each year. Before 2015, the annual average number of papers published fluctuated between 5 and 10.

Table 1: Search process criterion

Date	Database	Search String
04-05-2024	Scopus	("Defence R&D" OR "military innovation*" OR "military R&D" OR "defence innovation*" OR "armed forces innovation*" OR "defence innovation*") (within title, abstract and keywords)
Result **Filter: (Inclusion and exclusion criterion)**	624 papers Fields: Social sciences, engineering, business, and management, Economics, Computer science, environmental Source type: Journal Language: English	Excluded: Conference proceedings, books, editorials, non-English journals, non-peer-reviewed journals and doctoral theses
Timeline **Publication stage**	1947-2024 Final	
Result	306	

Trend of publications by country

According to Table 2, the top 15 nations contribute 255 out of 306 articles, accounting for 83.33% of the total published articles on this topic. The United States is the leading country with a score of 84, followed by the United Kingdom with a score of 49. Canada, South Korea, and Israel have scores of 16, 16, and 14, respectively, making them the next top countries. Upon reviewing the literature, we have observed that most groundbreaking research studies on MI have originated in the United States. This is because the United States was a pioneer in military enhancement.

The United States' status as a frontrunner in military innovation can be credited to historical reasons that connect the growth of the nation to progress in military technology. Across the course of history, the effectiveness of combat has been intricately linked to the level of advancement in military weaponry and tactics (Ang, 2015). Furthermore, the United States' substantial contribution to military innovation is seen in its proactive response to international emergencies, such as the Haitian earthquake, where the US government and military took charge of leading disaster relief operations (Creasy, 2012). This emphasizes the United States' proactive utilization of military resources for humanitarian and strategic objectives, demonstrating its global-scale military innovation capabilities.

Table 2: Top 15 publishing countries

No	Country	Total Publication (TP)	Percentage(%)
1.	United States	84	27.45
2.	United Kingdom	49	16.01
3.	Canada	16	5.23
4.	South Korea	16	5.23
5.	Israel	14	4.58
6.	India	13	4.25
7.	Australia	10	3.27
8.	Norway	10	3.27
9.	Germany	8	2.61
10.	Italy	8	2.61
11.	France	7	2.29
12.	China	5	1.63
13.	Netherlands	5	1.63
14.	Singapore	5	1.63
15.	Sweden	5	1.63

The continuous discussion gradually extended to other Western urbanized nations, including the United Kingdom, Canada, and several sections of Europe. Therefore, this research primarily utilized research samples from the United States (27.45%), the United Kingdom (16.01%), and Canada (5.23%) for observation purposes.

Data search strategy

A screening technique was used to choose the search keywords for obtaining articles. Various methods for developing keyword recommendation systems are discussed by multiple authors. The focus of these authors is on suggesting strategies for enhancing item descriptions by recommending keywords, typically based on the keywords that already label items belonging to the user's contacts, as Table 1. Improving the accuracy of keyword detection can be achieved by classifying keywords with similar pronunciations to others or non-keywords and then revising them for further assessment (Mori & Nagao, 1998). The inquiry began by performing an online search on the Scopus database.

This study facilitated the retrieval of documents by conducting searches for articles using the title, abstract, and keywords with a specific search string: ("Defence R&D" OR "military innovation*" OR "military R&D" OR "defence innovation*" OR "armed forces innovation*" OR "defence innovation*") (within the title, abstract, and keywords). A total of 624 publications were generated. After implementing the filtering technique, approximately 306 articles were generated. The selection criteria were refined to include only research articles written in English while eliminating article reviews, conference papers, book chapters, and novels. Table 1 provides a concise overview of the search terms used, whereas Table 1 illustrates the specific criteria used to include or exclude articles throughout the selection process.

Document publication by years

Figure 2 depicts a line trend illustrating the number of publications on military innovation in servicescape that have been indexed by Scopus from the year 1947 to 2024. There has been a

notable increase in the number of publications during this era, which suggests a growing interest in research issues. After 2010, the number of publications saw fluctuations, increasing from 10 to 13 on average each year. Nevertheless, there was a significant increase in 2021, with an annual publication rate exceeding 29 articles. This trend continued to fluctuate in the years 2022 and 2023, with 21 and 26 publications being released, respectively. The increase in research efforts can be attributed to several factors, including the growing availability of artificial intelligence technology and a greater acknowledgement of its ability to improve the service sector and military organizations. The significant increase in the number of publications in recent years suggests that this discipline has a tremendous capacity to influence the world. Figure 3 depicts publications towards MI, with the highest number being 10 articles from United States Institutions, Defence Research and Development.

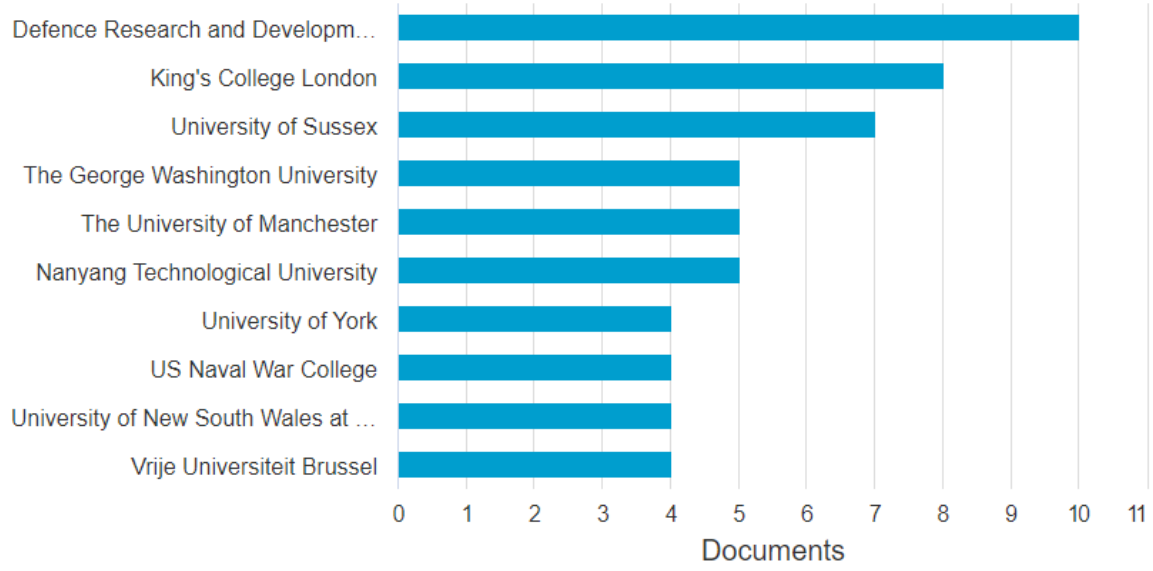

Figure 3: Publication by institutions in military innovation

Author Profile

This breakdown illustrates a hierarchical relationship between the number of papers produced by each author and their percentage contribution to the entire collection, as Figure 4. The exhibit showcases several levels of author participation, with Farrel T being the most prominent contributor. In summary, the dataset revealed a trend in document submissions from diverse authors, indicating their significance in the field.

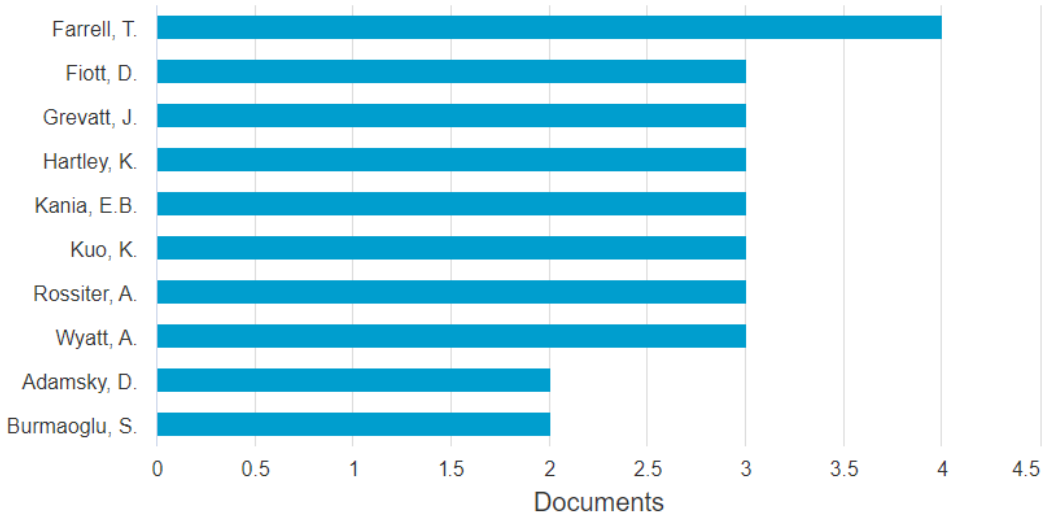

Figure 4: Author Profile depicts the distribution of articles according to authors, together with the corresponding percentages in the dataset. The authors have the most publications, namely Farrell T. 4 articles dan followed by Fiott D, Grevatt J, Hartley K, Kuo K, Rossiter A and Wyat A with 3 articles.

Type of document by subject of research

Figure 5 displays the allocation of documents among different research areas. Each colour code corresponds to a specific field, and the size of each section indicates the proportion of publications linked to that subject. The allocation of journal publications among various subjects underscores the multidisciplinary nature of research in the fields of social science, engineering, and business management. This pie chart illustrates the consistent contribution of authors in several scientific disciplines.

Approximately 40.2% of journal articles in the social science field have a follow-up, which is the second highest percentage compared to other fields. In the engineering field, about 12.6% of articles have a follow-up, while in business management, it is about 10.7%. In various other fields such as arts and humanism, economics, management, computer science, decision science, psychology, chemical engineering, and others, the percentage of articles with a follow-up is below 10%. The authors of this field mostly focus on social science, engineering, and business management. This particular region of field probability has a significant impact or influence on that specific field. As a public sector military organisation, our responsibility is to ensure a certain degree of security in the country. This will pertain to the relationship between humans, machines, and methods as tools and resources.

The defence sector will indirectly generate business with the authority responsible for defence stakeholders. The allocation of research resources in the field of military intelligence (MI) plays a pivotal role in building military organisations. Gaining knowledge about the frequency of different disciplines offers a valuable understanding of the intellectual environment in academia and helps guide decision-making in educational institutions. Based on the given statistics, social science is the most prevalent academic discipline, making up 40.20% of the overall distribution. This underscores the importance of studies such as sociology, anthropology, and political science in tackling societal concerns and comprehending human conduct. The field of engineering holds the second position, accounting for 12.60% of the total, highlighting the significance of technical advancement and the ability to solve complex problems in the modern era. The various disciplines of engineering, such as mechanical,

electrical, and civil engineering, play a crucial role in driving progress in infrastructure, technology, and industry.

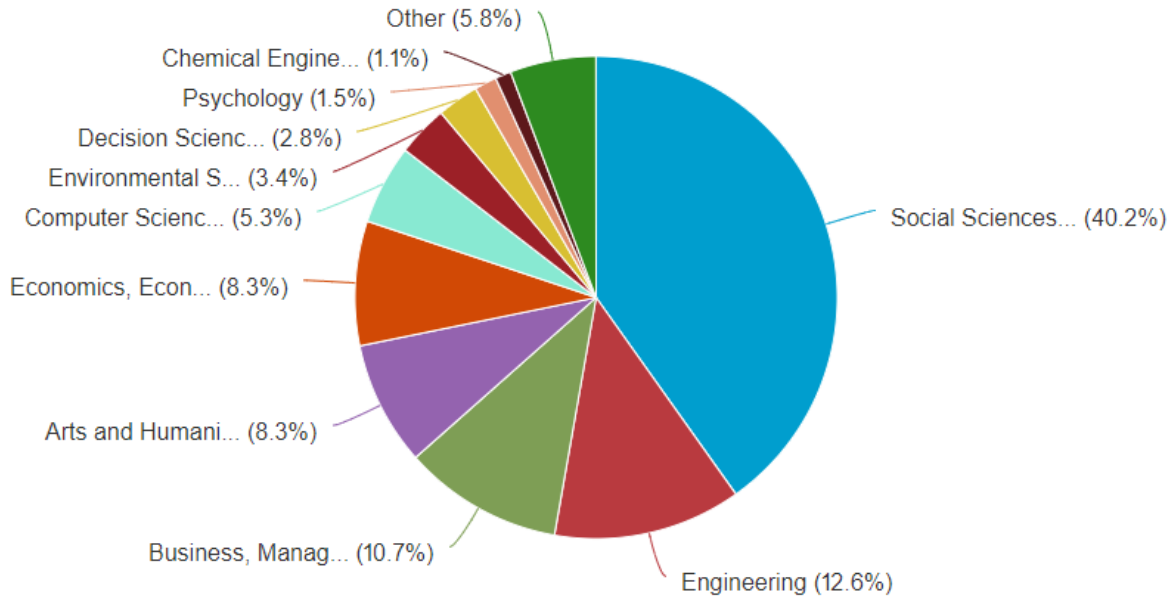

Figure 5: Various research fields by the authors

Both business & management and economics contribute equally, with a ratio of 10.70%, to the development of economic policies, organisational strategies, and decision-making processes. These fields of study offer conceptual frameworks for comprehending the dynamics of markets, the practice of entrepreneurship, and the allocation of resources. The field of art and humanism, which makes up 8.30% of the distribution, includes subjects like literature, history, and philosophy. It focuses on the importance of creativity, critical thinking, and cultural appreciation in society. The fields of computer science, environmental studies, decision science, psychology, and chemical engineering make up lesser sections of the distribution, ranging from 1.10% to 5.30%. Although some fields may have more specific areas of study, they still provide substantial contributions to scientific investigation, technological progress, and environmental preservation.

Overall, the distribution of study disciplines in the field of MI reflects the wide range of interests, goals, and challenges among researchers. Although social science, engineering, and business-related fields are prominent, other disciplines also have crucial roles in solving specific societal demands and expanding knowledge in specialised areas. Gaining a comprehensive understanding of the distribution field of research is crucial for promoting multidisciplinary collaboration, tackling intricate challenges, and guaranteeing a comprehensive and diverse research field in the domain of machine intelligence.

Top 15 authors based on citations by research

The article "Citation Versus Disruption in the Military" provides an overview of important publications in the field of military innovation research. Insights into the changing discussion on military adaptability, technology policy, and strategic viewpoints are provided by analysing citation counts, authors, and publication years. Military innovation is crucial in determining defence plans and national security policies. Comprehending the current patterns and impactful contributions in this domain is crucial for policymakers, defence analysts, and researchers. The

objective of this citation analysis is to uncover influential articles and developing topics in the field of military innovation studies as referred to in Table 3.

The approach uncovers significant patterns in the study of military innovation. Farrell's publications have gained significant attention and recognition due to their high citation rates, which highlight his valuable contributions to the field of military adaptation and transformation. Texts like "Improving in war: Military adaptation and the British in Helmand Province, Afghanistan, 2006-2009" (Farrell, 2010) and "Transnational Norms and military development: Constructing Ireland's Professional Army" (Capella & Jamieson, 1986; Farrell, 2001) emphasised the significance of studying the processes of military transformation and the establishment of institutions.

Furthermore, research conducted by Grissom, (2006) on "The future of military innovation studies" and D.C. Mowery, (2012) on "Defense-related R&D as a model for 'grand challenges' technology policies", emphasise the connection between defence policy, technical advancement, and economic expansion. These books offer valuable perspectives on the impact of research and development (R&D) in improving military capabilities and fostering innovation-driven economies.

In addition, recent scholarly articles such as "The Diffusion of Drone Warfare? Industrial, Organizational, and Infrastructural Constraints" by Gilli and Gilli (2016) and "Transformation in contact: Learning the lessons of modern war" by Foley et al. (2011) examine current obstacles and possibilities in military operations, specifically focusing on the spread of drone technology and insights gained from recent conflicts. The citation analysis highlights the interdisciplinary nature of military innovation studies, which includes topics such as history, economics, technology policy, and strategic studies. The main topics covered include the ability of the military to adjust and change, the investment in research and development, the spread of technology, and the knowledge gained from previous conflicts. This analysis provides valuable insights for ongoing research and policy conversations aimed at improving military effectiveness and national security by identifying significant works and developing trends.

Table 3: Top 15 authors by citation

Ser	Cites	Authors	Title	Year	Publication
1.	135	A. Grissom	The future of military innovation studies	2006	4
2.	111	T. Farrell	Improving in war: Military adaptation and the British in Helmand Province, Afghanistan, 2006-2009	2010	31
3.	103	T. Farrell	Transnational norms and military development: Constructing Ireland's Professional Army	2001	31
4.	84	D.C. Mowery	Defense-related R&D as a model for "grand Challenges" technology policies	2012	111
5.	68	T. Farrell	The dynamics of British military transformation	2008	31
6.	59	R.K. Goel, J.E. Payne, R. Ram	R&D expenditures and U.S. economic growth: A disaggregated approach	2008	241
7.	56	J. Stowsky	Secrets to shield or share? New dilemmas for military R&D policy in the digital age	2004	2
8.	49	T. Thayaparan, M. Daković, L. Stanković	Mutual interference and the low probability of interception capabilities of noise radar	2008	124
9.	49	S. Catignani	'Getting COIN' at the Tactical Level in Afghanistan: Reassessing Counter-Insurgency Adaptation in the British Army	2012	19
10.	49	M. Humphery-Jenner	Takeover defences, innovation, and value creation: Evidence from acquisition decisions	2014	32
11.	48	E.O. Goldman, R.B. Andres	Systemic effects of military innovation and diffusion	1999	17
12.	48	T.G. Mahnken	China's anti-access strategy from a historical and theoretical perspective	2011	37
13.	48	A. Gilli, M. Gilli	The Diffusion of Drone Warfare? Industrial, Organizational, and Infrastructural Constraints	2016	13
14.	46	R.T. Foley, S. Griffin, H. McCartney	'Transformation in contact': Learning the lessons of modern war	2022	10
15.	44	S. Chiu, M.V. Dragošević	Moving target indication via RADARSAT-2 multichannel synthetic aperture radar processing	2022	26

Co-occurrence keywords

An examination of crucial terms in the realm of military innovation studies, with a specific emphasis on how often they appear together and the strength of their connections. An analysis of the interconnections between terms such as armed forces, artificial intelligence, China, and military innovation provides a clear understanding of emerging patterns and theme associations in defence research. Keywords are essential in defining the thematic scope of academic study, as referred to in Table 4. Within the realm of military innovation studies, comprehending the interaction of fundamental ideas yields significant perspectives on the dynamics of defence

policy, technological progress, and strategic decision-making. An examination of crucial keywords unveils many significant patterns and theme groupings in the field of military innovation research.

Table 4: Top 15 keywords based on occurrence and total link strength

Ser	ID	Keyword	Co-Occurrence	Total link strength
1.	62	armed forces	12	52
2.	72	artificial intelligence	7	31
3.	131	China	9	41
4.	144	civil-military relations	5	11
5.	158	cold war	7	13
6.	231	decision making	9	32
7.	241	defence industry	7	9
8.	242	defence innovation	6	23
9.	263	defense industry	11	38
10.	265	defense innovation	6	18
11.	273	defense r&d	7	9
12.	322	drones	5	6
13.	337	economic growth	5	12
14.	356	emerging technologies	8	45
15.	392	Europe	5	15

Firstly, the armed forces are identified as a key idea, having a significant frequency of occurrence and strong connections. This highlights the importance of comprehending military organisations, capabilities, and strategies within the framework of innovation and adaptation. Artificial intelligence (AI) is a significant term that reflects the increasing interest in utilising AI technologies in defence systems and operations. The simultaneous presence of AI with other terms like defence innovation and rising technologies implies a connection between technological progress and defence capabilities. The prominence of China as a term highlights the strategic significance of China's attempts to modernise its military and the impact it has on global security dynamics. The simultaneous presence of China alongside phrases like defence industry and economic growth emphasises the complex and diverse character of China's defence stance and its influence on geopolitical and economic environments. As referred to in Figure 6.

Cluster 1 is represented by coloured red. The presence of keywords such as "military innovation," "innovation," "technological development," and "research and development" indicates a strong emphasis on technological breakthroughs and innovation in defence capabilities in the field of military.

Cluster 2 is represented by the colour green. The cluster of keywords, including "China," "United States," "Russia," "NATO," and "war," revolves around national security and strategic perspectives. This cluster highlights the geopolitical factors, military partnerships, and strategic rivalry that are influencing defence policies and tactics for innovation.

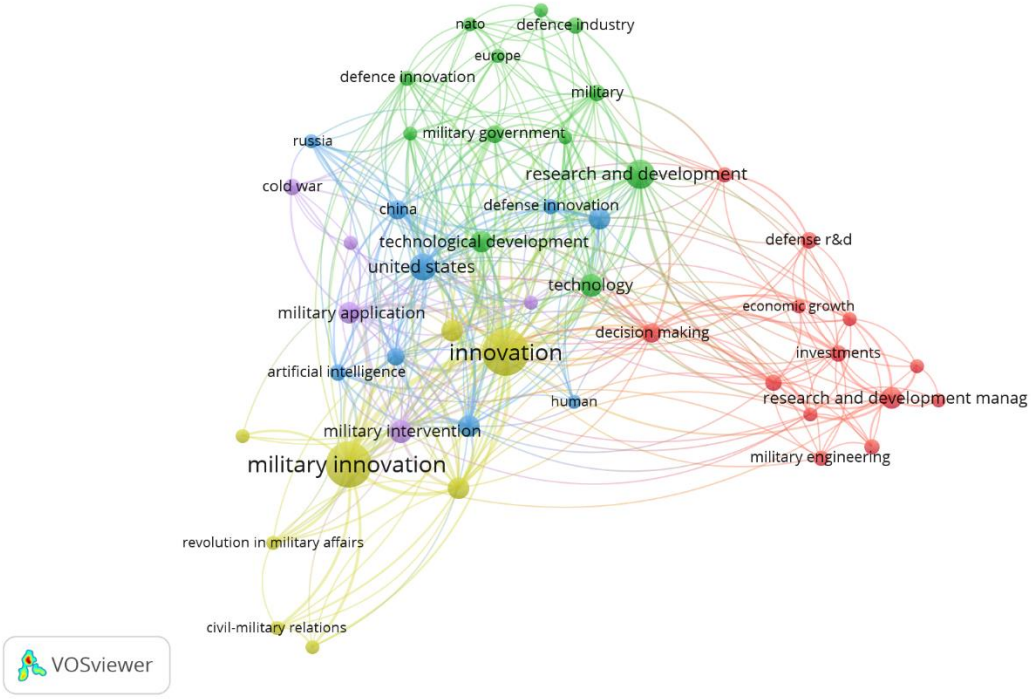

Figure 6: Co-occurrence keywords analysis of military innovation

Cluster 3 is represented by the colour blue. The cluster of keywords "armed forces," "military applications," "military operations," and "military effectiveness" focuses on the operational aspects of military innovation, encompassing tactics, strategies, and organisational effectiveness.

Cluster 4 is represented by the colour yellow. The correlation between the defence industry, economic growth, investments, and technology transfer is evident in the grouping of these keywords. This suggests a mutually beneficial relationship between defence spending, industrial capabilities, and economic development.

Cluster 5 is represented by the colour purple. The keywords "decision-making," "public policy," and "international relations" are closely associated with the governance and policy aspects of military innovation. These keywords highlight the influence of political, social, and international factors on the development of defence policies and strategies.

Keyword co-occurrence analysis uncovers clear theme clusters in the field of military innovation studies. These clusters encompass a wide range of topics, including technical advancement, national security, military operations, and policy decision-making. Through the identification of these clusters, academics and policymakers can get a more profound comprehension of the transdisciplinary relationships and emerging patterns that are driving defence research and innovation agendas.

Bibliographic coupling

Out of the 624 papers analysed in the bibliographic coupling for countries, 306 documents surpassed the 36 citations requirement. Four significant clusters were identified in the analysis. The top 3 countries in bibliographic coupling based on overall connection strength United States, the United Kingdom and Italy with link strengths of 1750, 1478, and 695, respectively. Table 5 displays the top 15 nations identified in the bibliographic coupling analysis.

Table 5: Bibliographic Coupling by Countries

Ser	ID	Country	Documents	Citations	Total link strength
1	3	Australia	10	98	287
2	8	Canada	16	211	40
3	10	China	5	28	102
4	17	France	7	66	273
5	18	Germany	8	35	242
6	21	India	13	34	155
7	24	Israel	14	81	300
8	25	Italy	8	72	695
9	33	Netherlands	5	21	245
10	34	Norway	10	94	152
11	39	Singapore	5	67	183
12	41	South Korea	16	43	66
13	49	United Kingdom	47	722	1478
14	50	United States	83	998	1750

An investigation of bibliometric coupling among countries was conducted using document co-citation patterns in the field of military innovation studies. Through the analysis of co-citation links among countries, valuable information regarding collaboration networks, research impact, and knowledge dissemination within the area can be obtained. Within the field of military innovation studies, analyzing the bibliometric coupling patterns between countries allows for a deeper understanding of how knowledge is shared, collaborative dynamics, and the impact of research. The examination of bibliometric coupling based on country of origin uncovers several significant insights. Firstly, the countries being referred to are the United States and the United Kingdom. The United States and the United Kingdom are the dominant players in the bibliometric network, with the biggest number of documents, citations, and total link strength. This highlights their prominent positions in the study of military innovation and their significant contributions to the progress of knowledge in this area.

Secondly, the United States and the United Kingdom have strong collaborations with other countries, as shown by their high overall link strength scores. The collaborative ties between these countries and others promote the sharing of knowledge, multidisciplinary research, and the spread of innovation, which in turn contributes to the worldwide progress of military innovation studies.

Other countries, including France, Israel, and Canada, demonstrate substantial research outputs and citation impact, suggesting their active involvement in military innovation research. These nations enhance the variety of viewpoints, approaches, and understandings in the discipline, enhancing the worldwide discussion on military innovation and strategy. Unlike other countries, China, India, and South Korea are showing a rise in research outputs and citation impact, which indicates their increased spending on defence research and innovation. As these nations enhance their research skills and experience in military innovation, they are expected to have a greater impact on influencing the future direction of the sector.

Bibliometric coupling study reveals the collaboration networks, research influence, and information-sharing dynamics between countries in the subject of military innovation studies. The global nature of research in this subject and the necessity of international collaboration in advancing knowledge and addressing difficult defence concerns are highlighted by the

dominance of the United States and the United Kingdom, together with the active engagement of other countries, as depicted in Table 5. Figure 6 and Table 6 display five important clusters identified in the bibliographic coupling network map. Below are the countries engaged in military innovation.

Table 6: Summary of bibliographic coupling by countries

Cluster Number and Color	Number of Countries	Representative Countries
1 (Red)	4	Canada, Germany, Norway, Netherlands
2 (Green)	4	China, France, Italy, South Korea
3 (Blue)	4	India, Singapore, Israel, United States
4 (Yellow)	2	Australia, United Kingdom

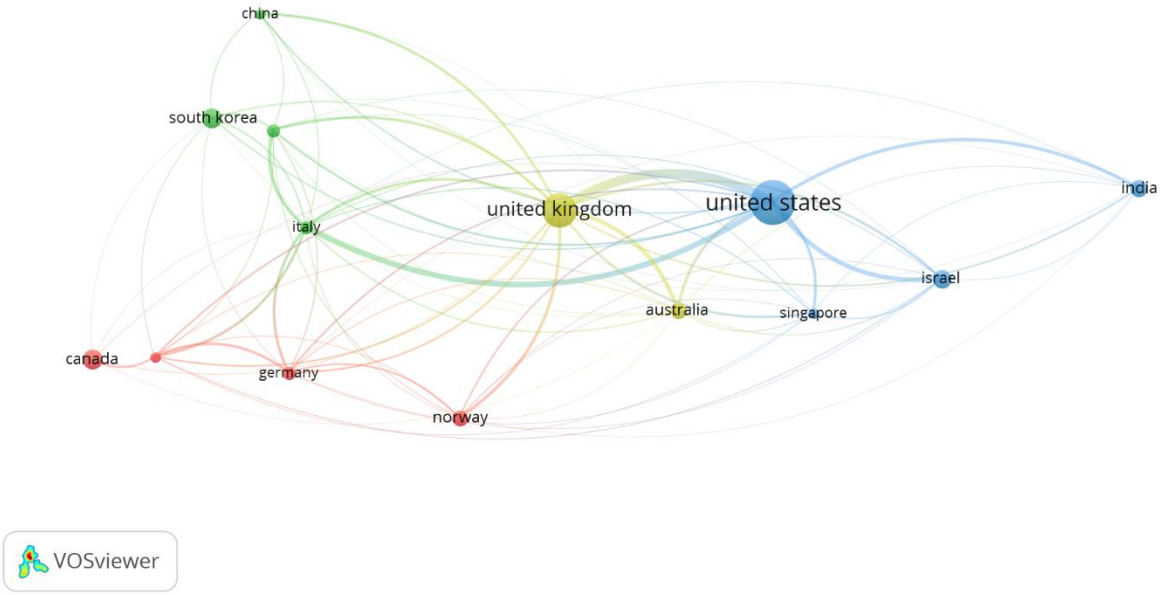

Figure 7: Bibliographic coupling for countries involved in military innovation

Discussion

The significant increase in publications from 2021 to 2024 suggests a growing interest in military innovation within the fields of social science and engineering, with an average of 10 to 13 articles being published annually after 2021. Farrell T, Fiott D, Grevatt J, Hartley K, Kuo K, Rossiter A, and Wyat A were the most prominent contributors, each of them authoring 4 and 3 pieces, respectively. The study of military innovation has seen a rise in the prominence of social science, engineering, and business management science.

These studies primarily examine significant topics such as advancements in technology, safeguarding the nation, military activities, and making policy decisions. The selection of these themes is based on how frequently these phrases are spoken. The United States was the primary contributor, with the United Kingdom, Italy, many European countries, and a few ASEAN countries following suit. The research illuminates the significance of military innovation for every nation worldwide to bolster the Sustainable Development Goals (SDGs) and align with

technological advancements. Military innovation is essential for keeping pace with technological advancements, as wars have multifaceted and far-reaching effects on all Sustainable Development Goals (SDGs).

Wars can have long-term negative consequences for the global economy, including reduced growth, heightened inflation, and interrupted supply networks. Researchers want to discover and enhance the existing innovation culture among military personnel to sustain support for Sustainable Development Goals (SDGs) across nations and reduce the likelihood of war. These studies use both theoretical frameworks and empirical research to improve understanding and provide guidance for strategic policies that promote innovative behaviour among military personnel.

Implications of Study

The implications of the study on military innovation presented in this research paper are multifaceted and significant. Firstly, the analysis of publication patterns and citation networks provides valuable insights into the historical development and current state of research in the field of military innovation. By identifying popular themes, prevalent keywords, and influential research studies, this study offers a comprehensive overview that can guide future research directions and academic endeavours. Moreover, the examination of the intellectual framework in the field of military innovation through citation and keyword analysis contributes to a deeper understanding of the core principles and emerging trends in this domain.

Secondly, the identification of leading trends and future work activities in military innovation research sheds light on the evolving landscape of this field and highlights the importance of staying abreast of technological advancements and strategic policies. The rise in publications from 2021 to 2024 indicates a growing interest in military innovation within social science and engineering disciplines, emphasizing the relevance and impact of research in this area. Furthermore, the analysis of research themes and contributors underscores the global significance of military innovation for nations worldwide, emphasizing its role in supporting Sustainable Development Goals (SDGs) and aligning with technological advancements.

Conclusion

Our review paper aims to offer significant insights into military innovation through a comprehensive analysis that combines a systematic literature review with bibliometric analysis. This research examines the historical advancements in the discipline by analysing patterns in published works. Furthermore, the study presented a concise overview of the sample statistics and the theoretical framework employed in the existing body of literature. Furthermore, the citation analysis elucidated the selected study topic by presenting the organisation of the research areas through several indicators. The assessment of highly cited research papers and journals is used to gauge the appeal and importance of articles and journals on a particular topic. It also serves to create a visual representation of the knowledge domain for novice researchers. Furthermore, a comprehensive intellectual framework in this particular domain has been investigated using bibliographic coupling analysis. In addition, a thematic analysis was conducted to identify different research themes within the clusters and sub-themes inside those clusters. Finally, the study analysed the rising research trends and future research activities by investigating the content of the most recent articles.

Despite the inclusion of 624 peer-reviewed publications obtained from the Scopus database, this study, similar to other studies, also possesses certain drawbacks. Our analysis utilised the Scopus database, which is highly active and regularly updated. Consequently, there is a possibility that the conclusions of this review paper may be modified before its publication. Our evaluation does not include a conceptual framework. As a result, future researchers can

create a comprehensive framework to gain a more insightful understanding of military innovation (MI). This article exclusively utilised VOS viewer software for doing bibliometric analysis. Although there are limits indicated earlier, this study effort can provide a fundamental foundation for comprehending research in the field of military innovation (MI), its current state, and the conceptual progression of knowledge.

In conclusion, this study not only fills a gap in previous military research by incorporating bibliometric analysis but also offers a valuable resource for academics, policymakers, and military personnel seeking to enhance their understanding of military innovation. By providing a thematic overview, identifying key contributors, and highlighting emerging trends, this research sets the stage for further exploration and collaboration in the field of military innovation. Ultimately, the implications of this study extend beyond academia to inform strategic decision-making, policy development, and innovation culture among military organizations globally, emphasizing the critical role of military innovation in shaping the future of national security and defence.

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