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GLOBAL RESEARCH TRENDS ON BAYESIAN STATISTICS IN ENGINEERING BASED ON DIMENSIONS DATABASE

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Abstract. *This study maps research trends and identifies potential avenues for novelty in the application of Bayesian statistics to engineering. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, 336 articles published between 2004 and 2023 were retrieved from the Dimensions database and examined using bibliometric techniques implemented in VOSviewer. The findings indicate a sustained growth in citations related to Bayesian Statistics in Engineering (BSE), reflecting increasing scholarly attention. SDG-based classification shows that Good Health and Well-Being is the most represented category, while Applied Mechanics and Materials contributes the largest number of publications. Furthermore, keyword co-occurrence analysis identifies eight thematic clusters, revealing the intellectual structure of the field and potential research opportunities. Overlay visualization illustrates the temporal evolution of research themes, whereas density visualization highlights comparatively underexplored topics. Co-authorship analysis further reveals 33 collaboration clusters, providing insights into the research network. Collectively, these findings offer a structured overview of the BSE research landscape and may support future research planning. Nevertheless, because the analysis relies exclusively on the Dimensions database, the results should be interpreted with caution. Future studies could incorporate additional databases, including Web of Science and Scopus, to improve the comprehensiveness of bibliometric coverage.*

Keywords: *Bayesian, Bibliometrics analysis, Engineering, PRISMA, Statistics*

1. INTRODUCTION

Bayesian statistics constitutes a branch of statistics whose applications have extended across a wide range of disciplines. In recent years, interest in Bayesian analysis has increased markedly in various fields of research (van de Schoot et al., 2017). Bayesian approaches have been applied, among others, in medicine (Stangl & Berry, 1998), psychotraumatology (van de Schoot et al., 2017), and survival analysis (Taheri Soodejani et al., 2021). In line with these developments, Bayesian topics have increasingly been incorporated into undergraduate and postgraduate statistics curricula by statistics educators (Hu, 2020). Consequently, Bayesian statistics may be regarded as a relevant and important topic in contemporary applied statistical research.

Moreover, global research interest in Bayesian statistics exhibits a fluctuating pattern with an overall upward trend over time. The number of publications related to this topic was retrieved from the Dimensions database using the keyword “Bayesian statistics”. The search, conducted on 3 February 2024 for the period 2004–2023 and limited to titles and abstracts, yielded a total of 4,237 publications. The annual distribution of publications is presented in Figure 1. The highest number of publications was recorded in 2020, with 421 publications.

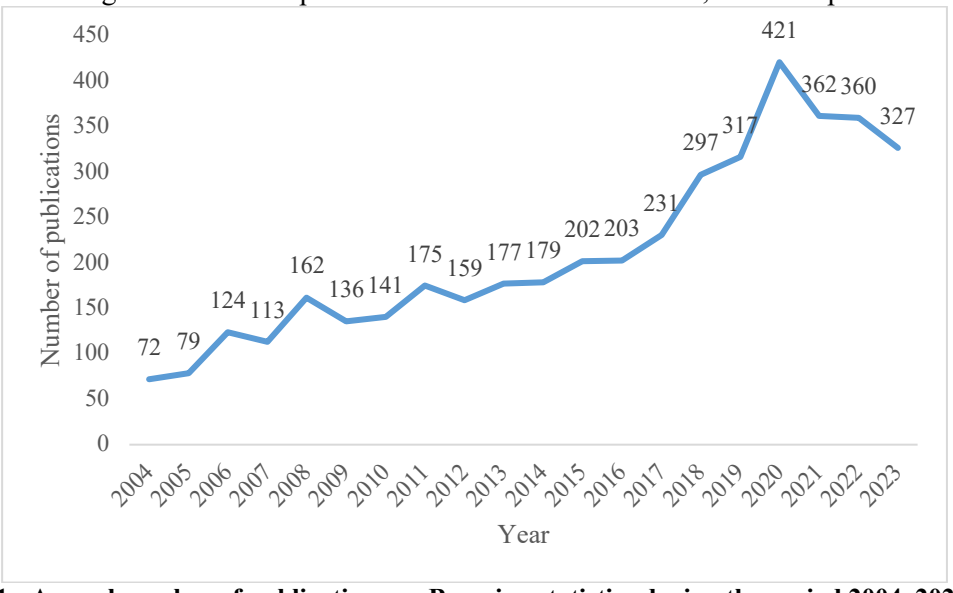


Figure 1 : Annual number of publications on Bayesian statistics during the period 2004–2023.

Furthermore, Bayesian statistics has been investigated by researchers from various countries. The distribution of publications on Bayesian statistics according to the six most productive researchers is presented in Figure 2. Based on Figure 2, Eric-Jan M. Wagenmakers from the Netherlands is identified as the most prolific researcher in the field of Bayesian statistics, with a total of 21 publications.

Figure 1 shows that interest in Bayesian statistics has increased steadily over time. In addition, Figure 2 indicates that research on Bayesian statistics has evolved into a globally scaled research topic involving scholars from various countries. This development has stimulated the emergence of diverse innovations in research. To generate relevant innovations, researchers require systematic information on research trends and potential novelty. Nevertheless, identifying research trends and novelty remains a challenge, particularly for early-career researchers.

The application of Bayesian statistics in engineering has been widely reported in the literature, including studies such as (Kammouh et al., 2020), (Chen et al., 2022), and (Taheri & Mohammadi, 2022). Study (Kammouh et al., 2020) employs a Bayesian approach to evaluate the resilience of engineering systems, while (Chen et al., 2022) applies Bayesian methods to estimate failure probabilities in complex engineering systems. Furthermore, in (Taheri & Mohammadi, 2022), Bayesian statistics is used to predict engineering demand. Previous literature reviews addressing Bayesian statistics in engineering have also been reported (see, for example, (Wang et al., 2025)). Nevertheless, bibliometric studies that specifically examine publication trends and potential novelty in Bayesian statistics within engineering remain relatively limited. This situation highlights the need for a more comprehensive analysis of publications on this topic in order to identify research trends and opportunities for novelty.

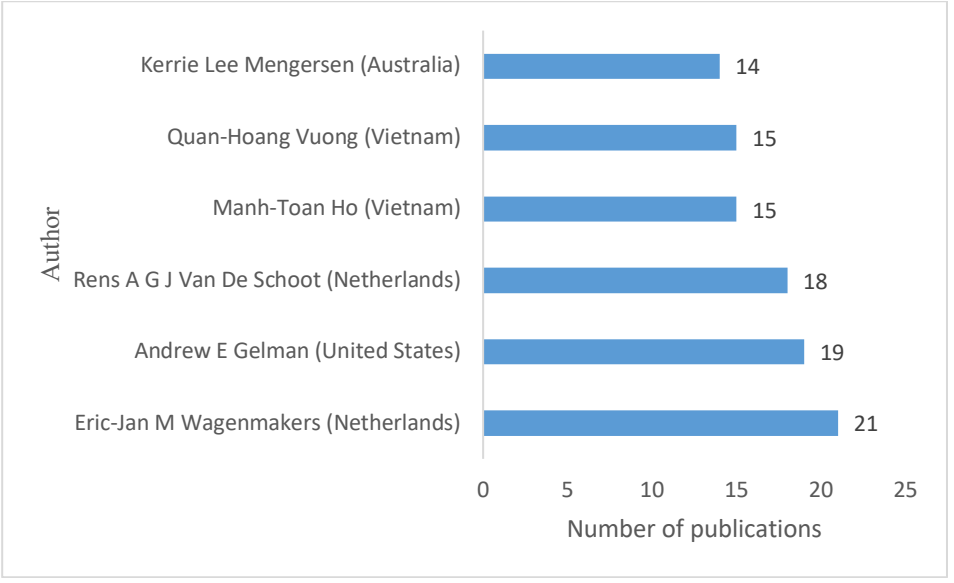


Figure 2 : Number of publications on Bayesian statistics by the six most productive authors.

From a methodological standpoint, this study differs from the work presented in (Wang et al., 2025). While the study in (Wang et al., 2025) adopts a qualitative Systematic Literature Review approach, the present study employs a quantitative bibliometric analysis. In comparison with (Wang et al., 2025), this study offers a comprehensive, data-driven mapping of global research trends in Bayesian statistics across engineering domains. By integrating The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA)-based screening with bibliometric network analysis and Sustainable Development Goals (SDGs) classification, this study not only captures the intellectual structure and temporal evolution of the Bayesian Satistics in Engineering (BSE) field but also objectively identifies underexplored research areas and potential novelty, thereby providing a strategic research roadmap. Accordingly, this study focuses on the analysis of research trends and novelty in BSE. Specifically, the study addresses the following research questions: (1) the evolution of citation counts in BSE-related research; (2) the distribution of BSE publications across SDGs categories; (3) the distribution of BSE publications by journal; (4) the characteristics of network visualizations for BSE topics and the cluster structure of publications based on co-occurrence analysis; (5) patterns and directions of topic evolution as revealed by overlay visualization; (6) the identification of relatively underexplored research areas through density visualization; and (7) the structure of author collaboration examined through network visualization and co-authorship clusters.

Bibliometric analysis is a quantitative, statistics-based approach used to evaluate scientific publications and to visualize the contributions of academic institutions as well as the dynamics of research hotspots (Fu et al., 2023). This method enables a systematic assessment of published articles, thereby assisting researchers in identifying developmental trends and major research foci within a given field, while also providing a foundation for future research directions (Soytas, 2021). Furthermore, bibliometric analysis facilitates the identification of emerging research areas and the future trajectory of a research domain through the support of scientific visualization tools (Lam et al., 2022). This approach has been applied in various studies, including the evaluation of information theory research indexed in the Scopus database (Lam et al., 2022), the analysis of immigration and environmental degradation issues (Anuar et al., 2022), and the examination of research trends in glioma radiotherapy since 2011 (Zhang et al., 2022). Therefore, bibliometric analysis is considered

an appropriate method for examining the state of the art and potential novelty in BSE, as well as for guiding future research development in this field.

To address these research questions, this study aims to provide a comprehensive overview and analysis of publication trends in BSE using a bibliometric approach. The indicators examined include citation counts, SDGs categories, journals, thematic linkages with other research topics (co-occurrence), publication clusters, the direction and evolution of research topics (overlay visualization), relatively underexplored research areas (density visualization), author linkages (co-authorship), and the structure of research collaboration groups.

2. METHODOLOGY

In general, bibliometric mapping aims to provide an overview of the structure of scientific literature within a specific domain or topic (Salemi & Koosha, 2013). Bibliometric analysis serves as a useful tool for guiding ongoing research as well as future studies at the global level (Asghar et al., 2024). In this study, a bibliometric approach is employed to analyze research directions and the potential development of studies on BSE based on publication performance. Bibliometric analysis is a widely used method in library and information science for evaluating research performance (Syros et al., 2022) and has become a popular and systematic approach for exploring and analyzing large-scale scientific data (Donthu et al., 2021). Therefore, bibliometric analysis plays a crucial role in assessing research impact, as studies can be measured according to the number of citations received (Pahwa et al., 2022).

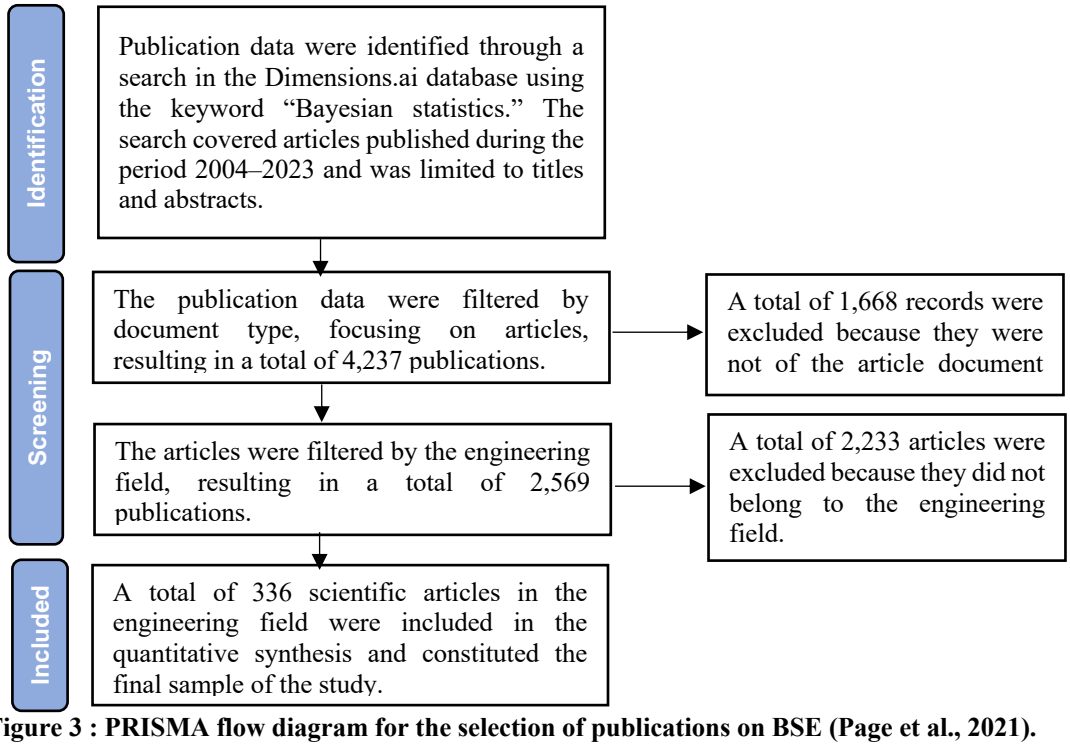


Figure 3 : PRISMA flow diagram for the selection of publications on BSE (Page et al., 2021).

Publication data for this study were extracted from the Dimensions database on 3 February 2024. The PRISMA approach (Page et al., 2021) was employed to systematically review the literature related to BSE. The PRISMA method has been applied in previous studies, including (Sun et al., 2022), (Nguyen et al., 2023), (Güzelce et al., 2024), (Nur Damayanti et al., 2024),

and (Santosa & Damayanti, 2024). The flow diagram of the PRISMA procedure is presented in Figure 3. As shown in Figure 3, the PRISMA method consists of three stages: identification, screening, and inclusion. In Stage 1 (Identification), publications were collected using the keyword "Bayesian statistics" from the Dimensions database for the period 2004–2023, with the search limited to titles and abstracts. The identification stage yielded 4,237 records. In Stage 2 (Screening), the first screening was performed by selecting the document type as articles, resulting in 2,569 records and excluding 1,668 records. Subsequently, the second screening restricted publications to the engineering field, yielding 336 articles and excluding 2,233 records. In Stage 3 (Inclusion), the analysis was conducted on the final 336 articles using VOSviewer and Microsoft Excel. VOSviewer has been applied in previous studies, including (Miao et al., 2023), (Cheng et al., 2021), and (Yu & Yu, 2023), and serves as software for constructing and visualizing bibliometric maps (van Eck & Waltman, 2010). Microsoft Excel was employed as a spreadsheet tool to analyze and present publication data.

3. RESULTS AND DISCUSSION

This section presents the results of the bibliometric analysis on BSE, based on publications collected from the Dimensions database for the period 2004–2023. The results include the growth of citation counts, the classification of publications according to SDGs categories and journals, as well as network analyses based on co-occurrence and co-authorship. In addition, the results encompass publication clustering from the perspectives of co-occurrence and co-authorship, as well as visualizations of research directions and trends (overlay visualization) and areas of research that are relatively underexplored (density visualization).

3.1 DISTRIBUTION OF THE NUMBER OF CITATIONS PER YEAR

Figure 4 shows that a total of 336 articles on BSE were published during the period 2004–2023. These 336 articles received a total of 6,186 citations. The distribution of citation counts per year is presented in Figure 4.

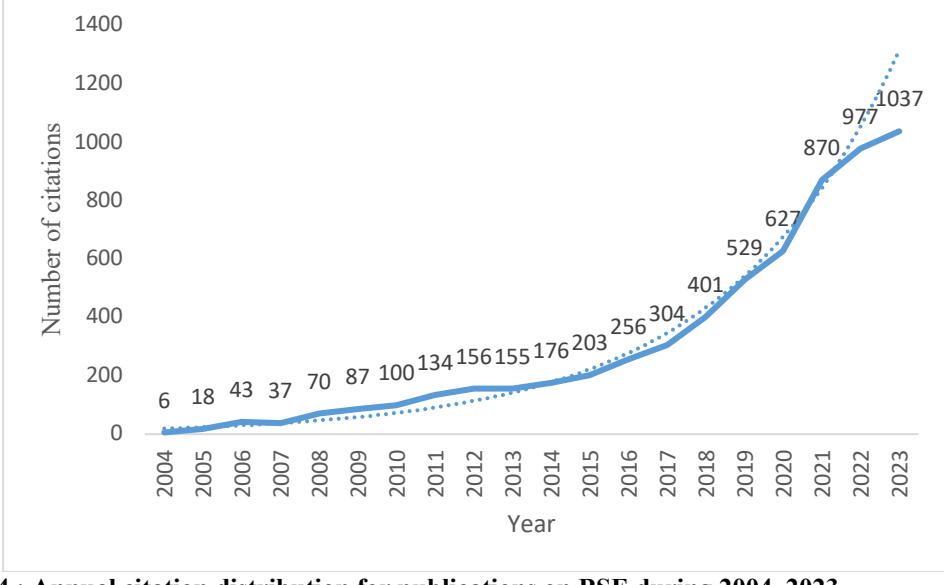


Figure 4 : Annual citation distribution for publications on BSE during 2004–2023.

Figure 4 presents the distribution of citation counts per year for BSE, showing an exponential increase. This exponential trend is indicated by the dashed curve. The rising citation pattern for works on Bayesian statistics in engineering is influenced by several factors. First, Bayesian networks are powerful and reliable probabilistic representation and inference models, widely applied in engineering structure analyses for reliability assessment (Wang et al., 2025). In addition, Bayesian inference methods offer advantages in modeling due to their ability to propagate uncertainty, handle limited data, integrate latent structures, and manage high-dimensional parameter spaces (Li et al., 2025).

The highest number of citations occurred in 2023, with 1,037 citations (16.76%), whereas the lowest number of citations was recorded in 2004, with 6 citations (0.10%). The average number of citations per year was 309, and the average citations per article was 18. Among the 336 articles, the study titled "Bayesian deep convolutional encoder–decoder networks for surrogate modeling and uncertainty quantification" (Zhu & Zabaras, 2018) received the highest number of citations, totaling 436 (7.05%). This article was authored by Yinhao Zhu and Nicholas Zabaras and published in the Journal of Computational Physics, indexed in Scopus Q1 with a 2022 SJR of 1.75. This indicates that articles published in reputable journals tend to receive more citations from other researchers. Citation analysis can serve as a measure of article quality, journal influence, and individual researcher performance (Nightingale & Marshall, 2013). Accordingly, this article has had a significant impact on the development of research in the field of BSE.

3.2 DISTRIBUTION OF THE NUMBER OF PUBLICATIONS BY SDGS CLASSIFICATION

Based on the SDGs classification, publications on BSE can be classified accordingly. Among the 336 articles, the distribution of publications across the five largest SDGs classification is presented in Figure 5.

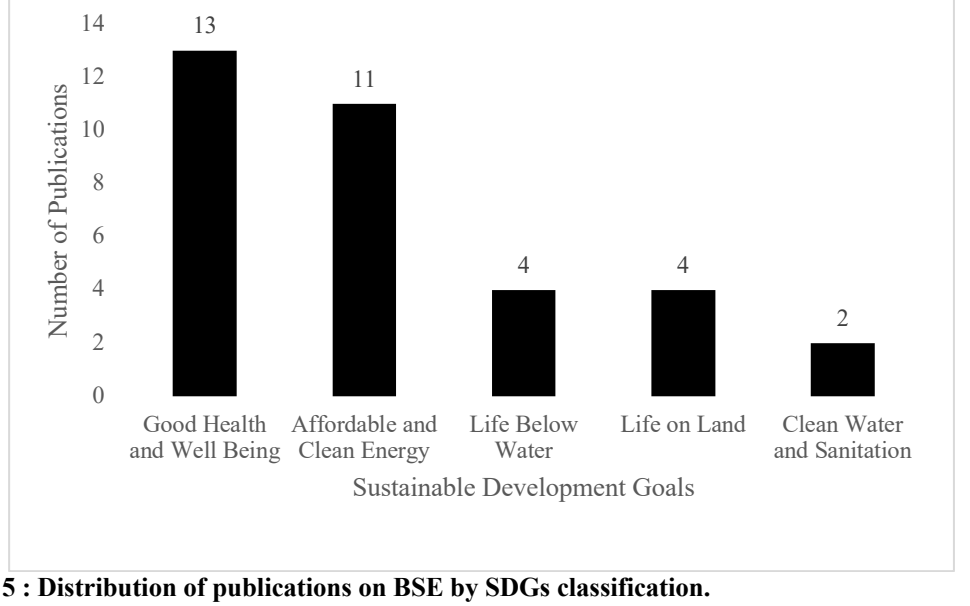


Figure 5 : Distribution of publications on BSE by SDGs classification.

Figure 5 shows that the Good Health and Well-Being category ranks first based on the SDGs classification, with 13 articles (3.87%), followed by Affordable and Clean Energy with 11 articles (3.27%). According to the SDGs classification, BSE-related research is primarily concentrated on Good Health and Well-Being (SDG 3) and Affordable and Clean Energy (SDG 7), indicating that current research efforts are largely directed toward enhancing health outcomes and promoting sustainable energy development. By comparison, the representation

of environmentally oriented SDGs, namely Life Below Water (SDG 14), Life on Land (SDG 15), and Clean Water and Sanitation (SDG 6), remains relatively limited. This imbalance suggests considerable scope for future studies to expand the contribution of BSE research to a broader spectrum of the SDGs, thereby strengthening its overall role in advancing sustainable development.

3.3 DISTRIBUTION OF NUMBER OF PUBLICATIONS BY JOURNAL

The distribution of publications on the BSE topic can be classified according to the journals in which they were published. Among the 336 articles identified, the distribution of publications across the eight leading journals is presented in Figure 6.

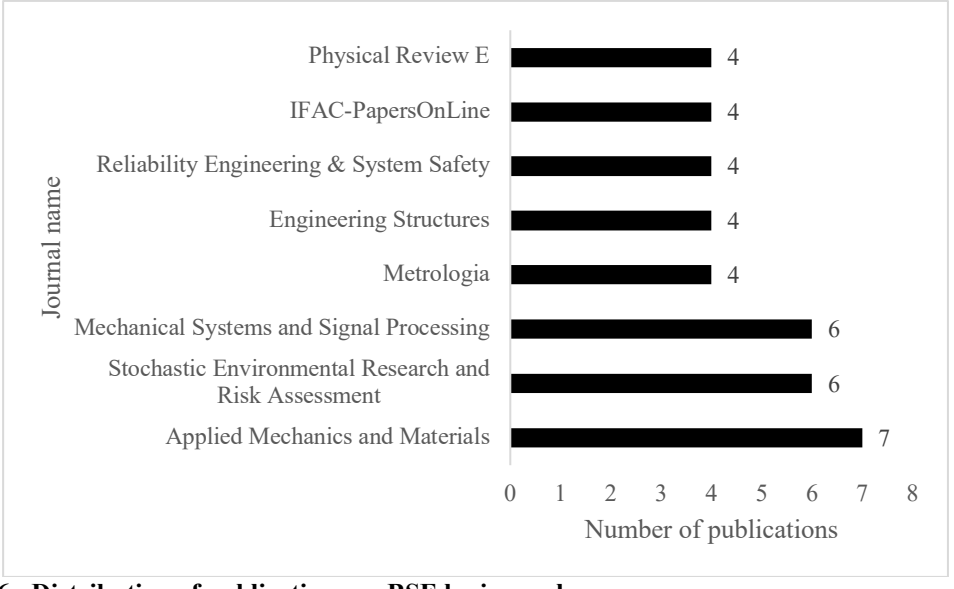


Figure 6 : Distribution of publications on BSE by journal.

Figure 6 shows that Applied Mechanics and Materials is the most productive journal with 7 articles (2.08%), followed by Stochastic Environmental Research and Risk Assessment with 6 articles (1.79%). The distribution of publications across journals indicates that research on BSE is not concentrated in a single journal. Although Applied Mechanics and Materials ranks as the most productive journal, with seven articles (2.08%), its publication output differs only marginally from that of the other leading journals. This finding highlights the multidisciplinary nature of BSE research, which is disseminated across journals covering diverse fields, including mechanics, system reliability, risk analysis, signal processing, metrology, physics, and control systems. Such a distribution demonstrates the widespread adoption of Bayesian methodologies across engineering disciplines, underscoring their methodological flexibility and broad applicability to a wide range of engineering challenges.

3.4 NETWORK VISUALIZATION BASED ON CO-OCCURRENCE

VOSviewer was used to construct the network visualization map. From the 336 articles, the co-occurrence-based network visualization yielded 98 terms, which were grouped into eight clusters: Cluster 1 (23 terms), Cluster 2 (17 terms), Cluster 3 (13 terms), Clusters 4–5 (12 terms each), Cluster 6 (9 terms), and Clusters 7–8 (6 terms each). Each cluster is represented by a different color, as shown in Figure 7.

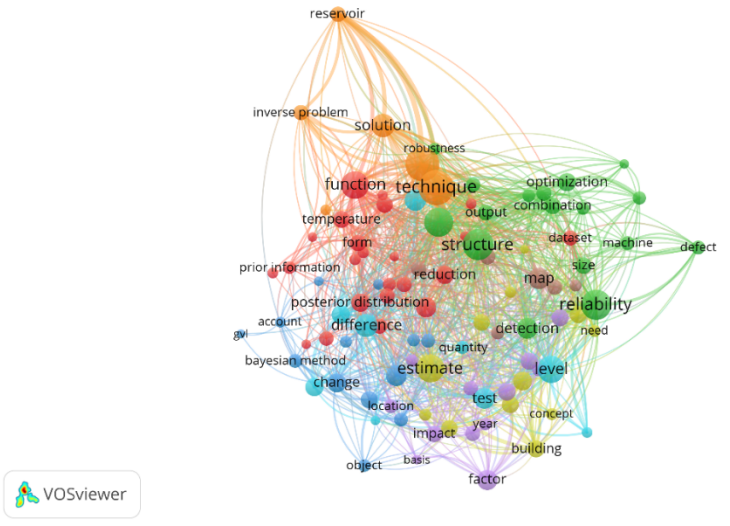


Figure 7 : Network visualization of publications on BSE.

In Figure 7, the network visualization of BSE provides an analysis based on BSE-related keywords during the period 2004–2023 to examine the relationships among topics associated with BSE. This visualization displays 98 terms grouped into eight clusters, with 2,660 links and a total link strength of 11,762. Two terms connected by a line indicate that the terms co-occurred in titles and abstracts, for example, Bayesian method and reservoir. Examples of articles containing both terms include (Li et al., 2015) and (Ma et al., 2014). In (Li et al., 2015), the researchers applied the Bayesian method through a chemical mass balance model to simulate trends in total phosphorus changes, analyze nutrient parameter uncertainty, and estimate eutrophication management thresholds. In (Ma et al., 2014), Bayesian statistical methods were used to comprehensively evaluate water quality in the Danjiangkou Reservoir.

Conversely, two terms that are not connected by a line indicate that they do not co-occur in titles and abstracts, for example, Bayesian method and inverse problem. This network visualization can be used by researchers to identify emerging research areas (Lam et al., 2022). Thus, network visualization provides guidance for discovering research novelty. For instance, the term Bayesian method is connected to reservoir, and reservoir is connected to inverse problem, yet Bayesian method is not directly connected to inverse problem. This suggests that research novelty can be achieved by linking Bayesian method with inverse problem.

Figure 7 shows that the most consolidated topics in Bayesian statistics in engineering research include Bayesian inference and estimation, reliability and risk analysis, structural engineering applications, optimization and decision-making, as well as the integration of Bayesian approaches with machine learning. The evolution of research themes in this field reflects a gradual shift from the development of classical theory and relatively simple structural applications toward more advanced computational methods and data-driven applications with higher levels of complexity.

3.5 OVERLAY VISUALIZATION BASED ON CO-OCCURRENCE

Similarly, VOSviewer was used to construct the overlay visualization map. From the 336 articles, the co-occurrence-based overlay visualization is presented in Figure 8.

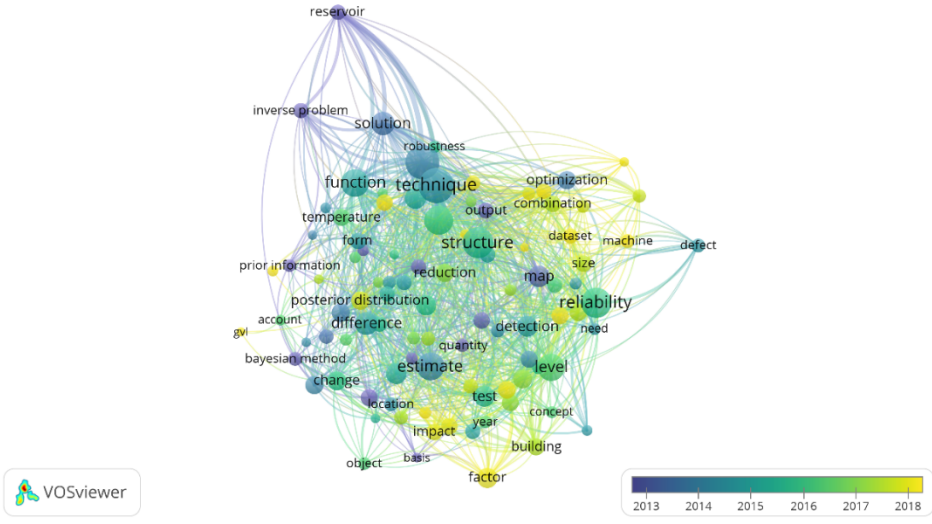


Figure 8 : Overlay visualization of publications on BSE.

Figure 8 presents the overlay visualization based on keyword co-occurrence in Bayesian statistics research in engineering, where colors indicate the average year of occurrence (blue = older, yellow = more recent) and node size reflects occurrence frequency. The visualization results show that the most frequently and relatively stably explored core themes are located at the center of the network, such as Bayesian inference, parameter estimation, uncertainty, model, and posterior distribution. These themes have dominated since the early period and serve as methodological foundations in engineering. The least explored areas appear on the network periphery with small nodes and darker colors, including reservoir, inverse problem, application-specific prior information, as well as highly contextual classical engineering topics. The connections among these peripheral topics are weak, and the number of publications is relatively limited compared to the core themes.

Conversely, the overlay visualization also indicates the emergence of promising new areas, marked by increasingly concentrated green–yellow nodes, such as machine learning, dataset, reliability, optimization, and prediction. The integration of Bayesian approaches with data-driven and modern computational methods has become a strengthening trend in recent years. Examples representing these emerging trends include Bayesian machine learning, Bayesian reliability analysis, Bayesian optimization, and the application of Bayesian methods in data-driven engineering systems. These findings reflect a shift in research from purely theoretical approaches toward data-driven applications and complex systems, opening avenues for future research.

3.6 DENSITY VISUALIZATION BASED ON CO-OCCURRENCEE

In addition, VOSviewer was used to construct the density visualization map. From the 336 articles, the co-occurrence-based density visualization is presented in Figure 9.

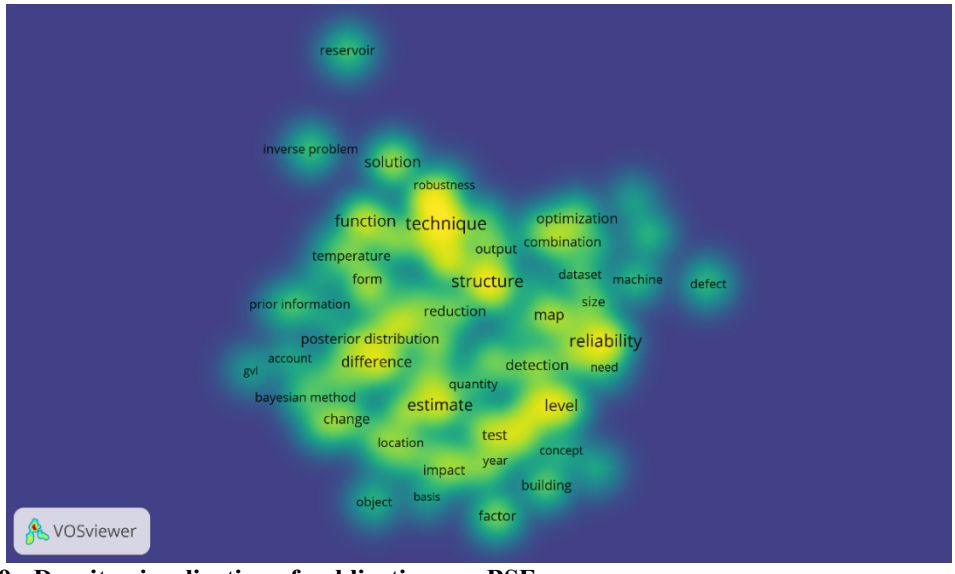


Figure 9 : Density visualization of publications on BSE.

In Figure 9, the density visualization provides an analysis based on BSE-related keywords during the period 2004–2023 to identify research topics that remain underexplored. This visualization displays term density using specific colors, where yellow indicates high density and blue indicates low density. High density signifies topics that have been extensively investigated in previous research, whereas low density highlights topics that are still relatively unexplored. Thus, density visualization can be used to identify underexplored research areas. For instance, topics linking BSE with inverse problem and surrogate model are shown in blue, indicating research areas that remain relatively underexplored.

3.7 NETWORK VISUALIZATION BASED ON CO-AUTHORSHIP

VOSviewer was also used to construct the network visualization based on co-authorship. From the 336 articles, the co-authorship network visualization identified 66 authors, grouped into 33 clusters: Cluster 1 (5 authors), Cluster 2 (4 authors), Clusters 3–10 (3 authors each), Clusters 11–20 (2 authors each), and Clusters 21–33 (1 author each). Each cluster is represented by a different color, as shown in Figure 10.

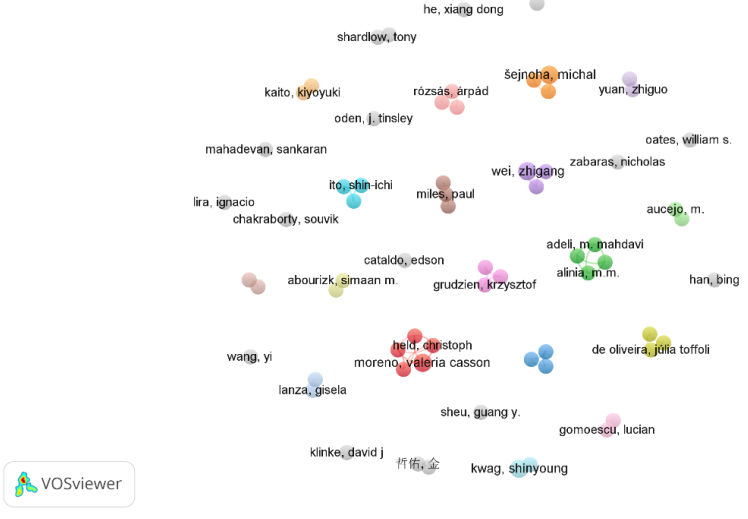


Figure 10 : Network visualization based on co-authorship for publications on BSE.

In Figure 10, the co-authorship network visualization on BSE illustrates the connections among authors. Two authors connected by a line indicate that they have co-authored an article, whereas two unconnected authors indicate that they have never collaborated on the same publication. Based on these connections, authors can be clustered, reflecting research groups. According to Figure 10, 66 authors are grouped into 33 clusters, with 49 links and a total link strength of 85. The largest cluster consists of 5 authors, while the smallest cluster comprises a single author. The co-authorship analysis indicates that the collaborative structure of Bayesian Statistics in Engineering (BSE) research remains relatively fragmented and has not yet evolved into a highly integrated research community. Although the network includes 66 authors distributed across 33 clusters, the predominance of small clusters, together with 49 collaborative links and a total link strength of 85, suggests that research collaborations are largely confined to small research groups rather than being embedded within extensive collaborative networks. This pattern reflects the decentralized development of BSE research across multiple engineering domains. Nevertheless, it also points to substantial opportunities for strengthening collaboration across institutions, disciplines, and countries, thereby enhancing knowledge exchange, stimulating methodological innovation, and further advancing the development of BSE research.

4. CONCLUSION

In this study, a bibliometric approach was employed to analyze publication data on BSE during the period 2004–2023, obtained from the Dimensions database. The study produced several key findings: the number of citations in BSE has increased over time; the most frequent SDG category is Good Health and Well-Being (researchers can develop interdisciplinary studies linking Bayesian statistics with biomedical engineering, health monitoring systems, or engineering for healthcare); the journal with the highest number of publications is Applied Mechanics and Materials; network visualization of BSE provides insights for identifying novelty in topics that are not yet interconnected, with eight clusters based on co-occurrence; overlay visualization indicates research directions and trends (researchers can use this information to align their studies with current trends, for example, by integrating Bayesian approaches into emerging engineering issues such as uncertainty modeling, data-driven engineering, or complex systems); density visualization highlights underexplored research areas (researchers can focus their studies on relatively underexplored areas, as indicated by the density visualization, thereby enhancing novelty and scientific contribution); co-authorship network visualization identifies research groups related to BSE, with 33 clusters based on co-authorship (researchers can identify active research groups and potential partners for international collaboration, improving the quality and visibility of publications). Overall, these findings provide a comprehensive overview of research trends and novelty in the field of BSE.

Although this study has contributed to understanding the state of the art in publications on BSE during the period 2004–2023, it has several limitations. First, the Dimensions database is continuously updated with new publications, so the recorded number of publications may change over time. Therefore, bibliometric analyses on BSE are recommended to be revisited in the future, considering the expansion of keywords and synonyms to ensure relevant publications are not overlooked, particularly given the diverse terminology in Bayesian statistics and engineering. Second, this study only extracted

scientific articles from the Dimensions database, focusing on articles written in English. Consequently, further research is recommended to include other international databases, such as Scopus and Web of Science, to obtain a broader and more comprehensive understanding of BSE. The integration of multiple databases can reduce bias and enhance the validity of the findings.

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