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General evaluation of studies on Poisson Processes. A Bibliometric Analysis.

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Abstract
In this analysis, 10273 Poisson articles The Web of Science database was used to access counting procedures from 2000 to 2024, and bibliometric studies were conducted using the collected data. 970 out of 22445 writers in 2039 publications contributed as a single researcher to the data set that was obtained. The journals in the data set were assessed for their publication status. Furthermore, the impact of bibliographies was examined. The years 2023, 2022, and 2021 had the most articles, according to the distribution of publications by year. Keyword analysis revealed that the most commonly used topics were "model," "models," "systems," "dynamics," "distributions," "Poisson," "design," "time," "behavior," and "simulation." Among the most prestigious journals in the subject were IEEE Access and IEEE Transactions on Wireless Communications, which published Stochastic Processes and their Applications. Wang Y, Li Y, and Dhillon HS were the authors who wrote the most papers, respectively. Research on this topic was determined to be led by the United Kingdom.
Keywords: *Bibliometrics, Poisson processes, trend*

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I. Introduction

The Poisson process is an important probabilistic process with a discrete state space and continuous parameters. Examples of phenomena that follow a Poisson process include phone calls coming from one city to another, cars arriving at a gas station, or customers arriving at a store (İnal, 1988).

Poisson processes hold a significant place in stochastic processes. They are applied in various fields such as biology, medicine, geology, seismology, meteorology, industry, finance, and insurance. Depending on their characteristics, Poisson processes are classified into homogeneous (homogeneous) Poisson processes, non-homogeneous Poisson processes, and compound Poisson processes (Özel, 2005).

In seismic risk analysis studies conducted in Turkey, the Poisson distribution and extreme value statistics were applied to earthquake data from the North Anatolian Fault between 1904 and 1992 (Altınok, 1988). According to these studies, probabilistic models that only examine earthquake occurrence in the time dimension provide different risk predictions for earthquakes with magnitudes between $5.4 \leq M \leq 5.6$, while giving approximately the same result for earthquakes with magnitudes $M \geq 5.6$. Özel and İnal (2008) examined aftershocks of destructive earthquakes with magnitudes $M \geq 5.0$ that occurred in Turkey between 1903 and 2005 using the compound Poisson process. The foreshocks and aftershocks of destructive earthquakes between 1903 and 2010 were modeled using bivariate compound Poisson processes, both without considering (Özel, 2011a) and considering (Özel, 2011b) the neotectonic regional structure of Turkey.

In a study, the non-homogeneous Poisson process model was used to test the reliability of a machine. To apply this process, the parameters of the model were estimated using the maximum likelihood function, and reliability was defined. As a result, it was determined that the non-homogeneous Poisson process is a sufficient model for time-dependent analysis in repairable failure data (Buğatekin, 2017).

The aim of this study is to examine and evaluate the bibliometric analysis of Poisson processes, which have wide applications in statistics, in studies published since the year 2000.

II. Material and Methods

Material

The research data were obtained by searching for the term "Poisson Processes" in the Web of Science database, covering a total of 10273 articles published between 2000 and 2024. The search results were used to gather data on the validity of journals in the dataset, the general citation network of the articles, the most frequently used concepts, word clouds, trending topics, keyword network maps, keyword theme maps, authors' countries, the number of articles by country, as well as collaboration data between authors, universities, and countries. Additionally, network access and scientific productivity data for each country were collected.

To generate the results related to the articles accessed during the research process, the R-Studio program was used. The "bibliometrix" package was run via R-Studio, and the "biblioshiny" command was used (Aria and Cuccurullo, 2017).

Method

In a Poisson process, events occur independently under certain axioms, and the expected number of events per unit of time remains constant over time. Let N_t, represent the number of events that occur in the time interval (0,t], the axioms provided by the Poisson process $\{N_t,\ t \geq 0\}$ are as follows (Haight, 1967):

- Any change in N_t over a time interval of length t is of size 1 unit.
- For t, s ≥ 0, $N_{t+s} - N_t$ is independent of N_t.
- For t, s ≥ 0 t, $N_{t+s} - N_t$ is independent of t and depends on s.
- $N_t = 0$, meaning that the number of events at the starting point is zero (0).

The concept of "bibliographic analysis" was first used in 1922 by E. Wyndham Hulme, who taught at the University of Cambridge, and it referred to "illuminating scientific and technological processes through the counting of documents." Pritchard (1969), one of the first figures associated with the term bibliometrics, defines it as the adaptation of statistical and mathematical aspects of books to other communication media.

The concept of bibliometrics applies mathematical and statistical methods to written communication forms in order to classify and analyze quantitative attributes. Through bibliometrics, large-scale information sources, such as scientific studies, can be examined, and processes such as the expansion of existing knowledge can be analyzed (Bozca, 2022).

Bibliometric analysis provides a visual mapping of the most cited studies related to a research topic, the most productive and influential authors, journals, institutions, countries, and the relationships/collaborations between these units (Kurutkan and Orhan, 2018).

In bibliometric analysis, publications are classified by countries, universities, research groups, journals, or authors, and analysis techniques are used for scientific domain mapping and performance-based analysis (Gaviria-Marin et al., 2019).

The scientific domain mapping technique provides an overview of the structure of a research field and its development over a specific time period. This technique involves analyzing and visualizing information derived from a research field based on relationship networks (Noyons et al., 1999).

In the scientific mapping process, there are analyses and visualizations related to co-authors, bibliographic coupling, co-words, co-occurrence, and co-citation networks (Egghe and Rousseau, 2002; van Eck and Waltman, 2022; Henriksen, 2016; Hu and Zhang, 2015; Khandelwal et al., 2022).

To generate results related to the articles accessed during the research process, the R-Studio program was used. The "bibliometrix" package was run via R-Studio, and the "biblioshiny" command was used (Aria and Cuccurullo, 2017).

III. Results

In the context of studies on Poisson processes, data obtained through the "biblioshiny" web interface of the bibliometrix package in the R programming language show that between 2000 and 2024, a total of 10273 articles were published in 2039 journals. Statistical descriptions of the data included in the study are presented in Table 1.

Table 1. Statistics of the Research Data

Timespan	2000:2024
Sources (Journals, Books, etc.)	2039
Documents	10273
Annual Growth Rate %	3.88
Document Average Age	7.91
Average citations per doc	19.96
References	263278
DOCUMENT CONTENTS	
Keywords Plus (ID)	15241
Author's Keywords (DE)	27173
AUTHORS	
Authors	22445
Authors of single-authored docs	970

AUTHORS COLLABORATION	
Single-authored docs	1190
Co-Authors per Doc	3.27
International co-authorships %	35.92
DOCUMENT TYPES	
Article	9908
Article; book	1
Article; book chapter	41
Article; data paper	6
Article; early access	94
Article; proceedings paper	220
Article; retracted publication	3

As indicated in Table 1, a total of 9908 research papers published on "Poisson Processes" were accessed from the Web of Science database and analyzed. Among the 22445 authors in the field, 970 contributed as single authors. The dataset includes 2039 journals related to the subject area. The average number of co-authors per article in these journals was found to be 3.27, with an annual growth rate of 3.88. The distribution of publications in the research field over the years is shown in Figure 1.

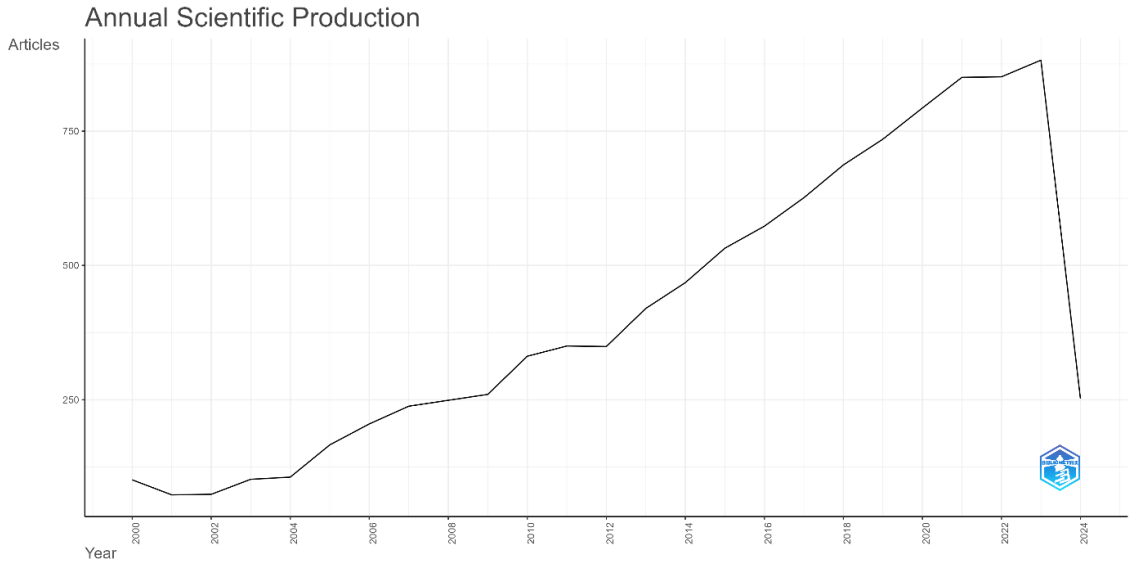

Figure 1. Distribution of Publications by Year

As shown in Figure 1, the number of articles published in the field of Poisson processes generally exhibited an upward trend from 2001 to 2023. Since 2015, the number of articles has consistently remained above 500, reaching this level until 2023. The years with the highest number of publications were 2023, 2022, and 2021, with article counts of 882, 851, and 850, respectively. Information about the journals with the highest number of publications in the dataset is provided in Table 2 and Figure 2.

Table 2. Journals in which the Articles were Published

Sources	**Articles**
Stochastic Processes and their Applications	213
IEEE Access	166
IEEE Transactions on Wireless Communications	166
Annals of Applied Probability	157
Electronic Journal of Probability	156
Physical Review E	144

Plos One	131
Advances in Applied Probability	126
Annals of Probability	112
Journal of Applied Probability	112

When Table 2 and Figure 2 are examined, the journal Stochastic Processes and their Applications is the most published journal in this field, with 213 articles. It is followed by IEEE Access and IEEE Transactions on Wireless Communications, each with 166 articles.

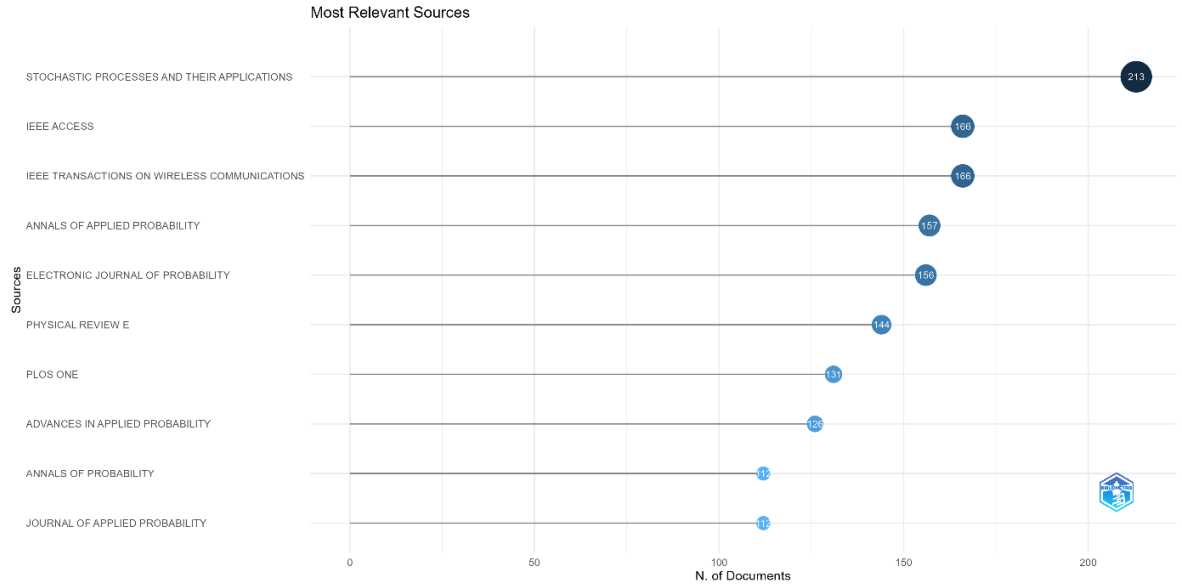

Figure 2. Journals with the Most Published Articles

It is also possible to examine the institutions with the most connections in the dataset (Figure 3).

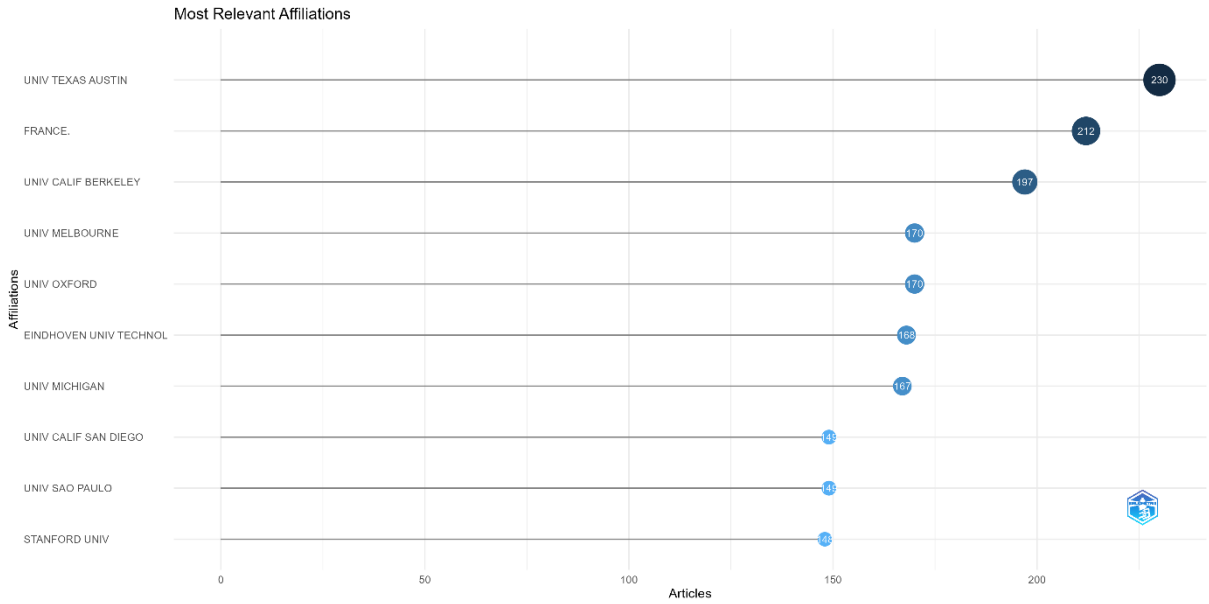

Figure 3. Most Relevant Connected Institutions

As shown in Figure 3, the University of Texas at Austin (USA), the University of France, and the University of California, Berkeley are the institutions that have conducted the most research on Poisson processes. The most frequently used keywords in studies related to Poisson processes are provided in Table 3.

Table 3. Most Frequently Used Keywords

Words	Frequency
Model	709
Models	458
Systems	288
Dynamics	273
Distributions	256
Poisson	230
Design	226
Time	212
Behavior	202
Simulation	197

The word cloud related to this is shown in Figure 4.

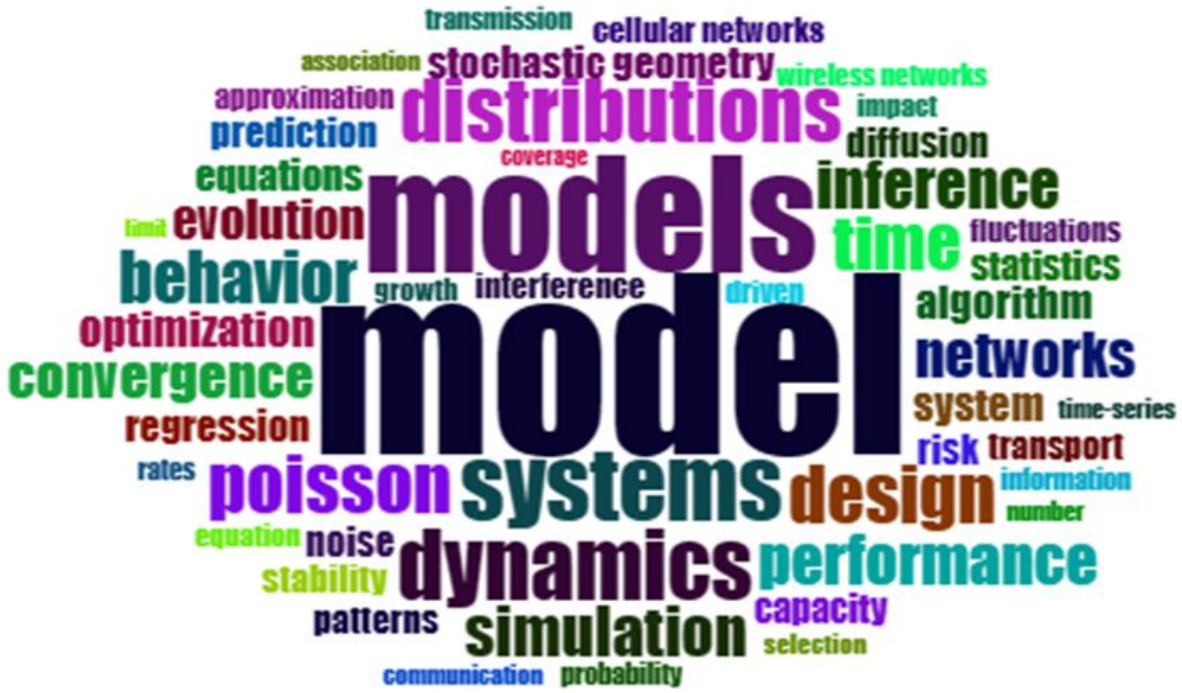

Figure 4. Word cloud

In Table 3 and Figure 4, the word cloud displays the keywords most frequently used by the authors in this study. The increase in the size of the words and their proximity to the center in the word cloud indicates a higher frequency of usage. It can be observed that the most frequently used terms specific to the field are positioned near the center. When examining the relationships between the most frequently used concepts, the terms "model," "models," "systems," "dynamics," "distributions," "poisson," "design," "time," "behavior," and "simulation" emerge. Figure 5 presents the trending topics.

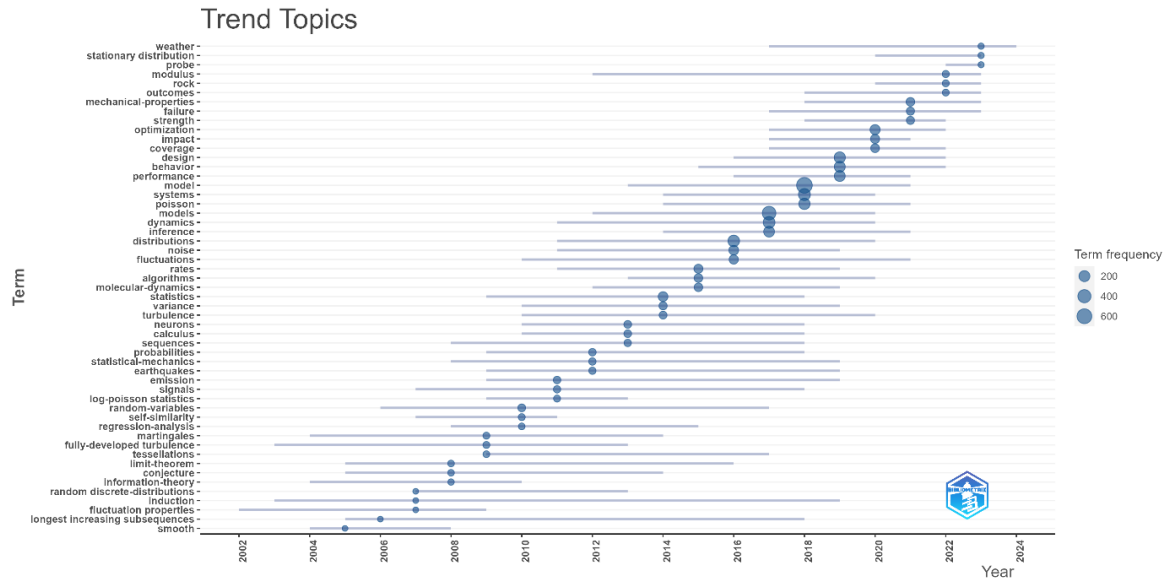

Figure 5. Trend topics

Figure 5 shows the trending topics in the relevant field. In this study, the size of the balloons and the word frequency were limited to a minimum of three words, and the annual word count was restricted to five words per year. Keywords are evaluated in this manner. The term "model" was trending between 2013 and 2021, with the peak year being 2018. The term "models" was trending between 2012 and 2020, with the peak year being 2017. The topic "systems" was trending between 2014 and 2020, with the peak year being 2018; the term "dynamics" was trending between 2011 and 2022, with the peak year being 2017; "distributions" appeared mostly between 2011 and 2020, with the peak year being 2016. The term "Poisson" was frequently used between 2014 and 2021, with the peak year being 2018; the topic "design" was popular between 2016 and 2022, with the peak year being 2019. The term "behavior" was trending between 2015 and 2022, with the peak year being 2019. The topic "performance" was trending between 2016 and 2021, with the peak year being 2019. Figure 6 examines the keyword network.

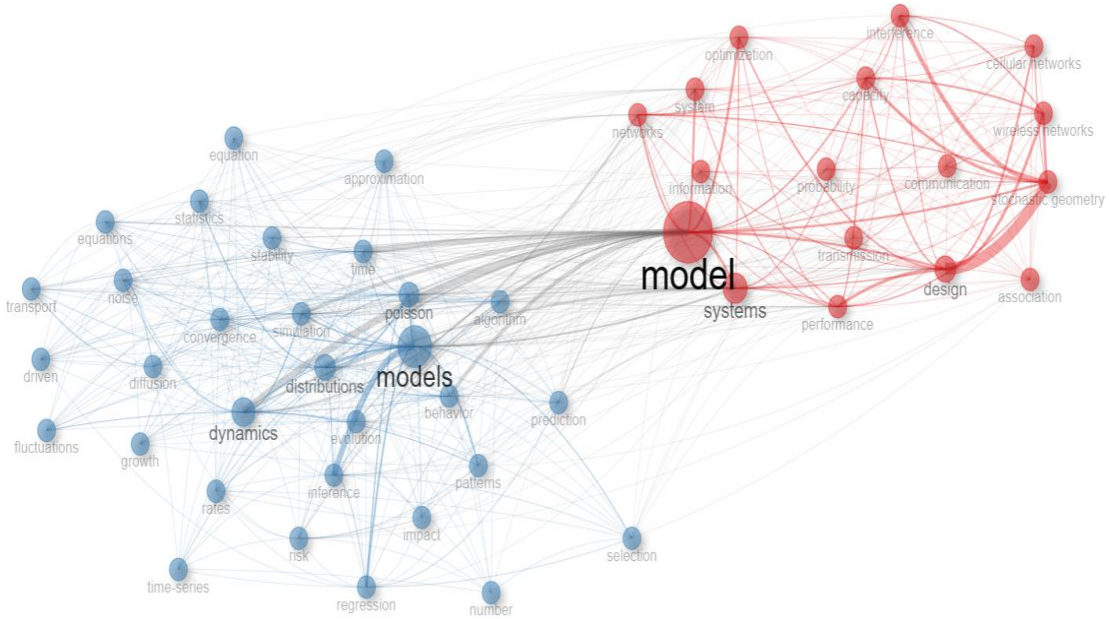

Figure 6. Word network

Figure 6 shows a keyword network map with two distinct clusters. These clusters include a red cluster containing concepts such as "model," "systems," "design," and "performance," and a blue cluster containing the keywords "models," "dynamics," "distributions," "behavior," and "poisson." The thematic map of the concepts is presented in Figure 7.

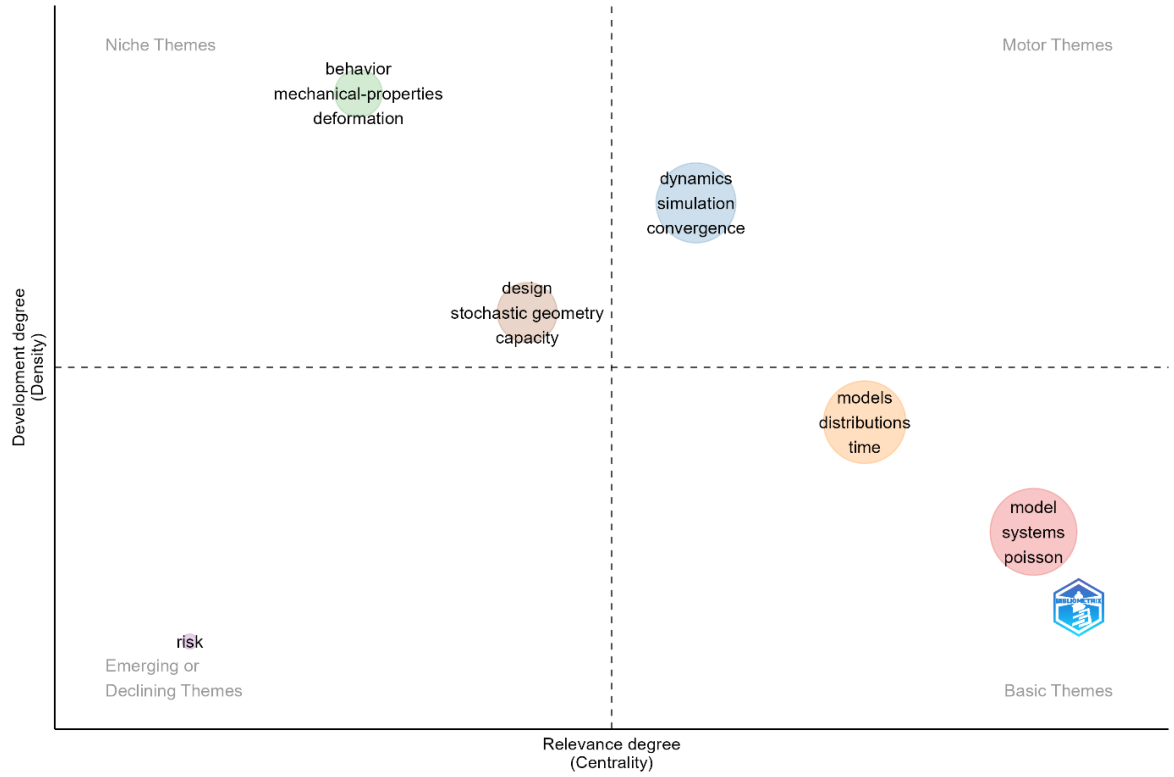

Figure 7. Thematic Mapping of the Concepts

When examining the thematic map of the words shown in Figure 7, it can be stated that the terms "dynamics," "simulation," and "convergence" are part of the core themes. These concepts are used both centrally and widely. Therefore, due to their frequent use and stronger connections with other articles, they can be considered as the most influential themes in the literature. The terms "Covid-19," "design," "stochastic geometry," and "capacity," as well as "behavior," "mechanical-properties," and "deformation," fall within niche themes. The term "risk" appears in emerging or disappearing themes. The terms "model," "systems," "Poisson," "models," "distributions," and "time" are part of the basic themes. The graph showing the rise and fall of the terms included in the study is presented in Figure 8.

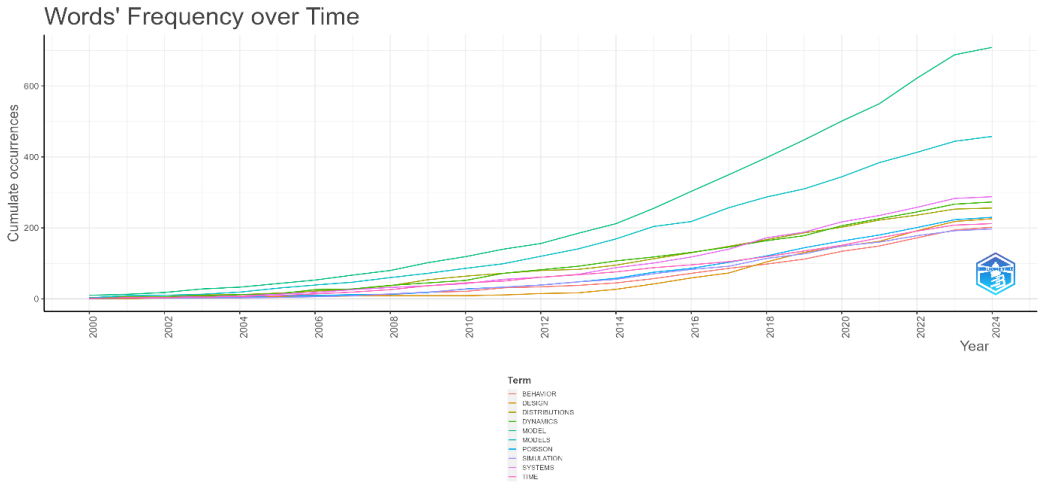

Figure 8. Cumulative Word Growth

The cumulative word dynamics graph in Figure 8 shows the rise and fall of key concepts used by authors from 2000 to 2024 in the context of Poisson processes. The most prominent term in the field of Poisson processes is "model," followed by terms such as "models," "systems," "dynamics," "distributions," "poisson," "design," "simulation," "time," and "simulation." Among the most frequently used keywords, "humans" shows a continuous upward trend, while "model," "models," and "systems" started to rise from 2001 onwards. Additionally,

"distributions" started gaining frequency in 2002, "Poisson" in 2007, "design" in 2011, "time" and "behavior" in 2003, and "simulation" began to be used more frequently and show an upward trend from 2005. The authors who published the most articles related to the topic are presented in Figure 9.

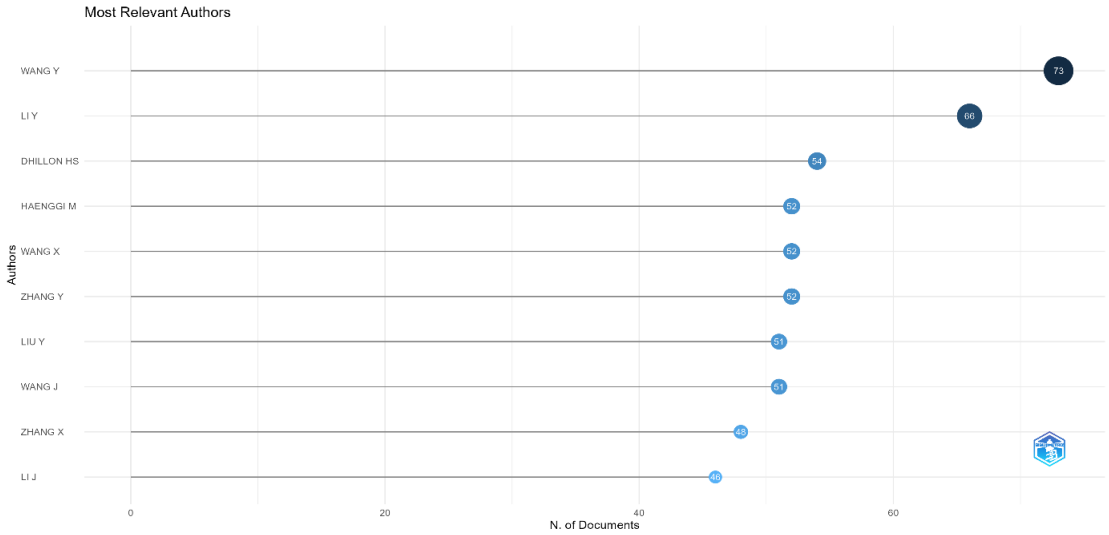

Figure 9. Authors with the Most Publications in the Topic

As seen in Figure 9, during the analyzed time period, the author with the most publications in the context of Poisson processes studies is Wang Y (F=73). Following Wang, Li Y (F=66), Dhillon HS (F=54), Haenggi M (F=52), Wang X (F=52), and Zhang Y (F=52) are identified as authors who have published the most articles. Figure 10 shows how collaboration networks were established among the authors.

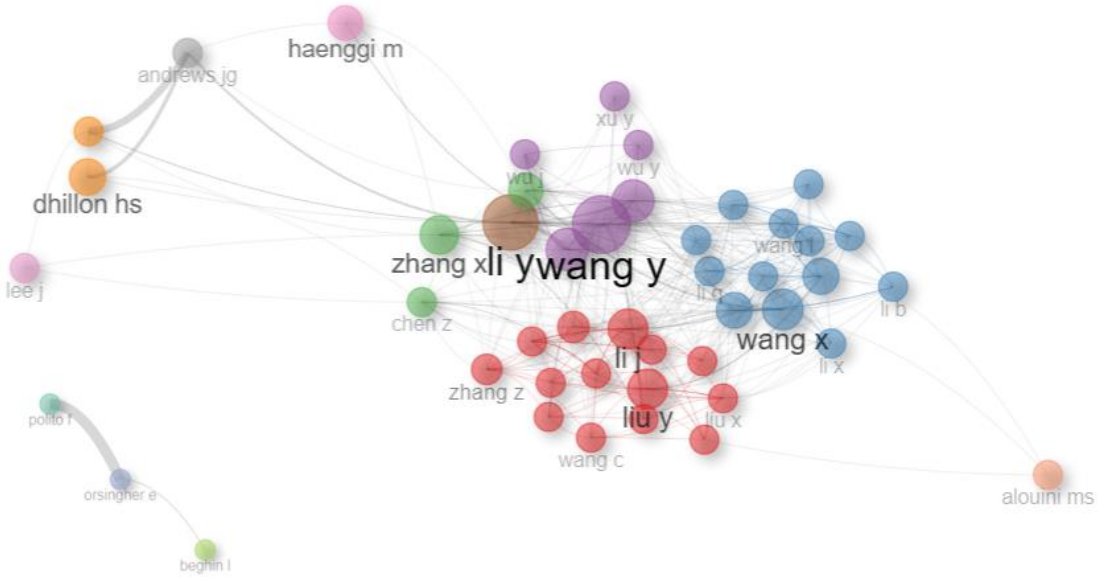

Figure 10. Authors' Collaboration Network

In Figure 10, based on the data obtained from the constraints applied with key concepts in the field of Poisson processes, a collaboration network analysis based on authors is presented. Authors working together in the same colored cluster are indicated in the figure. The size of the circle shows that the authors who collaborated the most are Wang Y, Wu Y, and Xu Y. It was observed that the author Li Y predominantly worked alone. Liu Y, Li J, Wang Z, and Zhang Z were found to be related to each other. Wang X, Li B, and Li G were found to be related to each other, as well as Zhang X and Chen Z. These authors can be considered to occupy important positions within the collaboration network. The graph showing the growth of universities in terms of publications is presented in Figure 11.

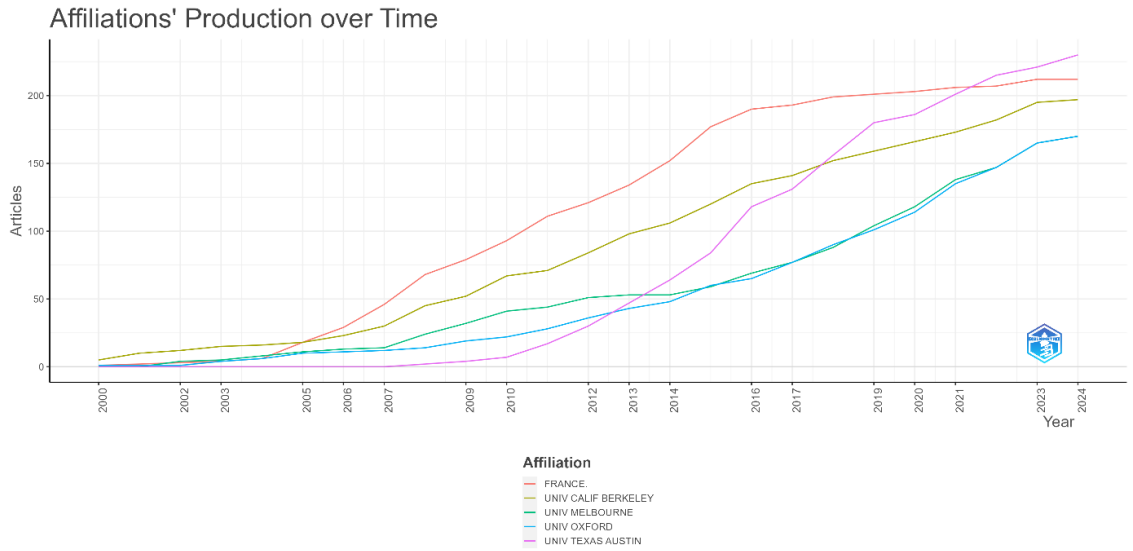

Figure 11. Publication Growth in Institutions

In Figure 11, when examining the publication growth in universities, it can be stated that the University of Texas at Austin in the USA started publishing in 2008 and reached a total of 230 publications by 2024. The University of France started publishing in 2000 and reached a total of 212 publications by 2024. The University of California, Berkeley, USA began contributing in 2000 and had 197 publications by 2024, while the University of Oxford in the UK started publishing in 2000 and reached 170 publications by 2024. The University of Melbourne in Australia began publishing in 2002 and reached 170 publications by 2024. A map showing publication collaborations between countries is presented in Figure 12, and the number of publications by country is provided in Table 5.

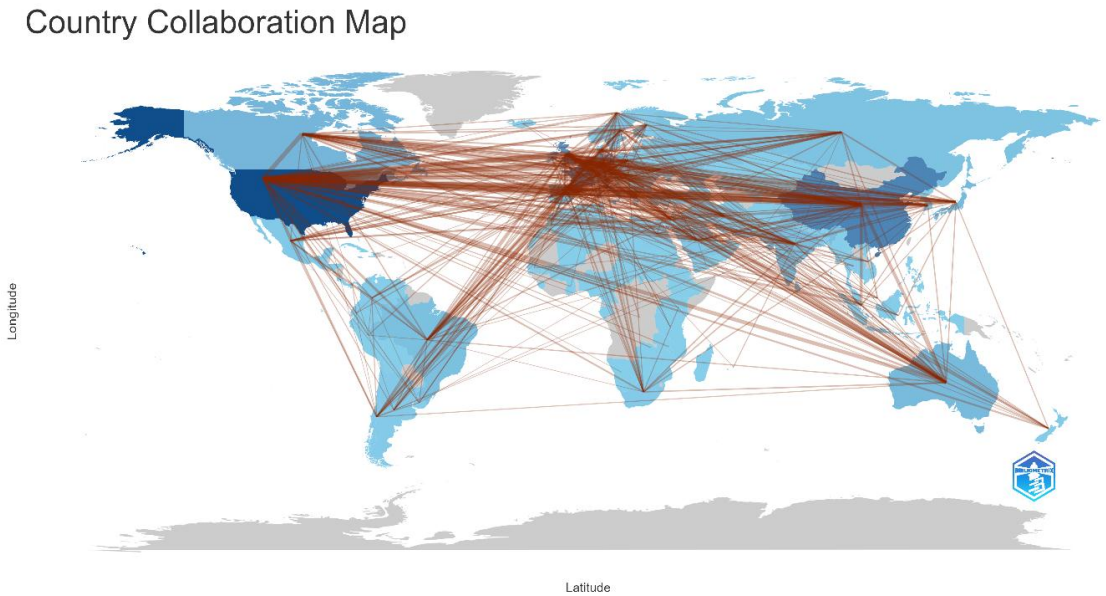

Figure 12. Publication Collaboration Map of Countries

Table 5. Countries with the Most Frequent Collaboration

Countries	Number of Publications
USA	8120
CHINA	4837
FRANCE	3450
UK	2690
GERMANY	2154

ITALY	1506
CANADA	1155
JAPAN	1043
AUSTRALIA	918
NETHERLANDS	899

Figure 12 and Table 5 show that the country with the highest collaboration frequency is the United States (N=8120). China (N=4837) is second, and France (N=3450) is third.

IV. Conclusion

A bibliometric analysis of the research data related to the topic was conducted from the Web of Science database. The relationships in the field of Poisson processes were evaluated from various perspectives.

The highest number of publications on this topic was achieved in 2023 with 882 publications. When examining the journals in which the most papers on this subject were published, it was found that Stochastic Processes and their Applications was the leading journal with 213 articles, followed by IEEE Access and IEEE Transactions on Wireless Communications with 166 articles each.

In Poisson process research, the United States is the most productive and influential country, with the widest range of collaborative partnerships. The University of Texas at Austin is the most influential institution in this area. Academic institutions worldwide are deeply collaborating to support the development of the field. The most influential authors are Wang Y, Li Y, and Dhillon HS.

Keyword analysis shows that the focal points of Poisson process research are centered on "model," "models," "systems," "dynamics," and "distributions." Based on the timeline analysis, the two clusters obtained can be considered as the core aspects of current Poisson process research.

Based on this information, bibliometric analysis can significantly contribute to the spread of studies in the field of statistics, guiding research in important areas such as Poisson processes.

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