

Meta-Analytical Review of Generalized Weibull Distributions: A Bibliometric Perspective

Manju Jose
Department of Statistics
Alphonsa College, India

Lishamol Tomy
Department of Statistics
Deva Matha College, India

Christophe Chesneau
Department of Mathematics
University of Caen, France

Arya S
Department of Mathematics
Alphonsa College, India

ABSTRACT

This paper presents a comprehensive meta-analysis and bibliometric study of research on generalized Weibull distributions, providing an in-depth examination of the intellectual structure and evolution of this emerging field in statistical modelling. The study finds prominent research issues, significant papers, and important figures influencing the subject by drawing on a broad range of scholarly sources. Research impact is measured, collaboration networks are analysed, and the global distribution of scholarly output is mapped using well-established bibliometric approaches. The results highlight important publications that have increased knowledge in this field, new research avenues, and changes in theoretical and applied focus. The paper makes significant contributions to the larger body of literature in statistics and the mathematical sciences by combining these findings to provide a holistic account of the evolution, current trends, and possible future progression of Weibull distribution generalizations.

Keywords: Generalized Weibull Distribution, Bibliometric Analysis, Web of Science, Lifetime Data, Co-Authorship Networks, Scholarly Trends.

1. Introduction

The Weibull distribution is a popular distribution in statistics because it's easy to work with and can fit different kinds of lifetime and reliability data. Since it came about, it's been used in areas like reliability engineering, survival analysis, environmental studies, and quality control (S. Nadarajah and S. Kotz, 2005). It's appreciated because it can show different hazard rate behaviours and makes it easy to estimate parameters and do simulation-based inference (Jalmar M.F. et.al. (2010).

For the last 20 years, there's been a jump in research on extended Weibull distributions, with work focusing on new distributions, better inference methods, and ways to estimate parameters and check models using computers (Almalki, S. J. and Yuan, J, 2013). Extensions like exponentiated, beta-generated, transmuted, Kumaraswamy-based, and mixture Weibull distributions have been suggested, often with simulation studies to see how well estimators perform and how well they fit (Peng, X. & Yan, Z. 2014). Because of this, there's now a big collection of theoretical work and computer-based applications out there.

Despite these advantages, numerous empirical studies have shown that the classical two-parameter Weibull distribution often lacks sufficient flexibility to adequately model complex data structures encountered in practice. Data exhibiting non-monotonic or bathtub-shaped hazard functions, heavy tails, or unobserved heterogeneity frequently led to poor model fit under the standard Weibull framework. These limitations have motivated the development of a large number of generalized Weibull distributions that extend the original model by introducing additional shape and scale parameters.

Over the past two decades, research on generalized Weibull distributions has expanded rapidly, with contributions focusing on new model formulations, improved inferential

- Received July 15, 2026, in final form August 2026.
- Lishamol Tomy (corresponding author) is affiliated with Department of Statistics, Deva Matha College, Kuravilangad, Kerala, India
Email: lishatomy@gmail.com

procedures, and computational techniques for parameter estimation and model assessment. Extensions such as exponentiated, beta-generated, transmuted, Kumaraswamy-based, and mixture Weibull distributions have been proposed, often accompanied by simulation studies to evaluate estimator performance and goodness-of-fit (Cordeiro, G. Met.al. 2010). As a result, the literature now encompasses a diverse collection of theoretical developments and computationally oriented applications.

However, the rapid proliferation of generalized Weibull distributions has led to a fragmented research landscape. Contributions are dispersed across numerous journals and application domains, making it difficult to assess the relative influence of different models, estimation techniques, and computational strategies (Lee, C. et.al. 2007). In particular, there is limited systematic understanding of how simulation-based methodologies, likelihood-based inference, and algorithmic developments have evolved within the generalized Weibull framework. A comprehensive, data-driven synthesis of this literature is therefore timely and necessary (Dan Ling et.al. 2009).

Bibliometric analysis gives us a way to handle this issue by measuring research output, citation impact, and connections between ideas in a scientific field (Aria, M., & Cuccurullo, C, 2017). By using things like co-citation analysis, bibliographic coupling, keyword co-occurrence, and collaboration network analysis, bibliometrics helps us find the main research topics, important publications, and new computer trends (Abdian S., Shahri M. H. & KhadivarA, 2023). When we add meta-analysis to this, we can get a better understanding of how statistical models have changed methodologically and in terms of simulation.

In this work, we're doing a full bibliometric and meta-analysis of research on extended Weibull distributions indexed in the Web of Science database from 2005 to 2025 (DonthuNet.al., 2021). Our goals are to look at how publications have grown, find important authors and journals, study citation and collaboration structures, and find key topic groups, especially those focused on computer and simulation-based methods. By matching bibliometric mapping with how we understand the methods, this paper gives a structured view of the extended Weibull work that's helpful for researchers working on statistical computation, simulation studies, and model-based data analysis.

2. Methodology

This study uses a bibliometric and meta-analysis approach to check out how research on extended Weibull distributions has changed, what the method trends are, and what the computer features are. Bibliographic data was pulled from the Web of Science core collection using specific searches with terms like extended Weibull distribution, extended Weibull, and changed Weibull. The search only looked at peer-reviewed articles, conference papers, and reviews released between 2005 and 2025, leaving out studies that only talked about the standard Weibull distribution. The final data set had 500 publications, covering both theory and computer work in the field.

Data was cleaned and analysed using the Bibliometrix R package in the R computing environment. Cleaning involved making author names, journal titles, and keywords standard, and getting rid of any duplicate or mixed-up records to keep the data solid.

3. Bibliometric Analysis

This part gives the bibliometric analysis of research on extended Weibull distributions, with the goal of measuring publication patterns, research impact, and the intellectual setup of the field. Bibliometric methods are used to systematically judge how things have grown, what the important sources are, how productive authors are, and how citations behave in the research, giving a data-driven view of how the field has grown over time.

The analysis is broken into two parts that work together. The first part looks at descriptive bibliometric numbers, like publication trends, citation numbers, top journals, productive authors, and research output by country. These numbers give a quantitative look at research productivity, how well it's known, and collaboration patterns. The second part uses science mapping and network analysis, like co-citation analysis, bibliographic coupling, keyword co-occurrence, and co-authorship networks, to show topic groups, method connections, and how knowledge spreads in the research.

3.1 Descriptive analysis of Bibliometric data

Descriptive analysis is basic to bibliometric studies. It gives an overview of a research area's structure, growth, and influence. It sums up and measures the features of bibliographic data, giving insight into the amount, change, and influence of research output. By looking at overall info, descriptive bibliometrics points out key things like the number of articles, writers, sources, and references. This helps in understanding the size and age of the research area.

3.1.1 General Overview of the Bibliometric Data

The data are made up of 500 articles on generalized Weibull distributions from 203 academic sources, showing the research is widely spread. The area grows yearly at about 5.65%, suggesting continuous academic interest. With articles being about 7.88 years old and having about 22.86 citations each, the literature seems solid with reliable academic Influence. The articles use 9,942 sources, meaning there's a lot of combined knowledge. Keyword analysis shows a range of topics. There are 1,758 writer keywords and 666 Keywords Plus, including model extensions, estimation ways, and uses. Authorship shows teamwork. Articles have about 3.17 writers each, and 40.4% are international collaborations, showing a global contribution.

In general, the bibliometric data show that generalized Weibull research is a developed and still growing area. It has consistent growth, good citation numbers, and more international teamwork. This gives a base for later descriptive and network analyses. Table 1 has a summary of the data's basic info.

Table 1: Overview of the Data

Main information about data	Results
Timespan	2005:2025
Sources (Journals, Books, etc)	203
Documents	500
Annual Growth Rate %	5.65
Document Average Age	7.88
Average citations per doc	22.86
References	9942
DOCUMENT CONTENTS	
Keywords Plus	666
Author's Keywords	1758
AUTHORS	
Authors	1127
Authors of single-authored docs	54
AUTHORS COLLABORATION	
Single-authored docs	60
Co-Authors per Doc	3.17
International co-authorships %	40.4
DOCUMENT TYPES	
Article	483
Article; early access	6
Article; proceedings paper	3
Article; retracted publication	2
Editorial material	1
Review	3
Review; early access	1
software review	1

3.1.2 Annual scientific production

Figure 1 shows how yearly scientific output changed in the studied area from 2005 to 2025. Each year, there were more and more papers released on generalized Weibull distributions. At first, not many papers were released, but after 2010, as people grew more interested in the methods and how to them, the quantity of released papers increased. After 2015, there was a steeper increase, with the most released papers in the most recent years, which means there was increased research activity. The small decrease in publications in the last year is probably from incomplete data. Overall, the trend shows that the field has matured into an actively developing research area.

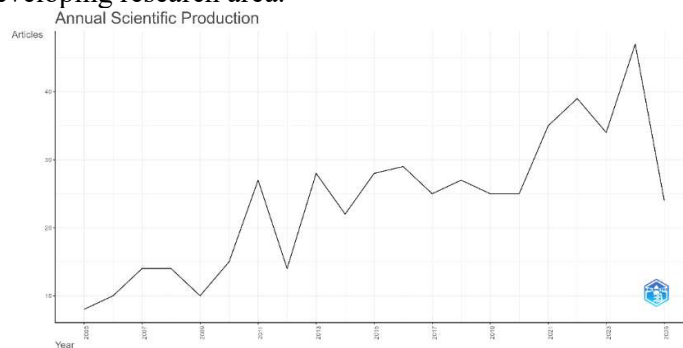


Figure 1: Annual scientific production

3.1.3 Most Relevant sources

Table 2 shows the top journals in the bibliometric data. Communications in Statistics – Theory and Methods is the leading journal with 33 articles. The Journal of Statistical Computation and Simulation (23 articles) and Communications in Statistics – Simulation and Computation (21 articles) follow, which suggests a strong focus on theory and computation in the field.

Some mathematics journals, like Mathematics, Hacettepe Journal of Mathematics and Statistics, Symmetry–Basel, and AIMS Mathematics, also have key contributions, reflecting the interdisciplinary aspect of the research. Also, journals like Reliability Engineering & System Safety point to the real-world relevance of the studies. The data suggest that output is mainly within a group of statistics and mathematics journals, which act as main places for publishing in this field.

Table 2: Most relevant sources

Most Relevant Sources	No. of Articles
Communications in Statistics-Theory and Methods	33
Journal of Statistical Computation and Simulation	23
Communications in Statistics-Simulation and Computation	21
Mathematics	14
Hacettepe Journal of Mathematics and Statistics	13
Symmetry-Basel	12
Aims Mathematics	11
Journal of Computational and Applied Mathematics	11
Reliability Engineering & System Safety	10
Statistics	10

3.1.4 Most Local Cited Sources

Table 3 indicating the most cited sources in the dataset, showing which journals have the most influence in the literature. Local citations show how often a source is cited by documents in the dataset, which points to how central and relevant it is to the research area. Communications in Statistics – Theory and Methods has the most local citations, followed by Computational Statistics & Data Analysis and IEEE Transactions on Reliability, which reveals the importance of work based on theory, computation, and reliability.

Other well-known statistical journals like the Journal of Statistical Computation and Simulation, Technometrics, Journal of the American Statistical Association, and Biometrics also have a strong local influence. The inclusion of journals related to reliability and energy shows the practical side of this field. The data suggest that this research area has strong roots in statistical theory and computation, with key uses in reliability and engineering.

Table 3: Most Local Cited sources

Sources	No. of Articles
COMMUN STAT-THEOR M	465
COMPUT STAT DATA AN	445
IEEE T RELIAB	422
J STAT COMPUT SIM	390
RELIAB ENG SYST SAFE	341
TECHNOMETRICS	341
J AM STAT ASSOC	269
J STAT PLAN INFER	256
BIOMETRIKA	180
STAT PROBABIL LETT	169
ENERG CONVERS MANAGE	163
J APPL STAT	163
COMMUN STAT-SIMUL C	147
ANN MATH STAT	145
QUAL RELIAB ENG INT	119
STAT PAP	116
RENEW ENERG	96
BIOMETRICAL J	93
J ROY STAT SOC B MET	89
COMMUN STAT THEORY	88

3.1.5 Sources' Local Impact

Table 4 shows a summary of key data for 20 journals. These data include h-index, g-index, m-index, total citations, number of articles, and the year each journal started. The Journal of Statistical Computation and Simulation comes out on top with the highest h-index (15), g-index (23), and total citations (1413), which means it's had a strong and lasting influence.

Other journals like Communications in Statistics—Theory and Methods and Computational Statistics & Data Analysis are also doing well. Journals like Hacettepe Journal of Mathematics and Statistics and Mathematics have high m-indices, meaning they have a big influence considering how long they've been around.

Newer journals, like Symmetry-Basel (2019) and AIMS Mathematics (2021), are getting cited more and more even though they don't have as many articles published. This means they're becoming important in their specific areas. Table 4 gives good info for researchers, displaying which journals have a big impact and which new ones are becoming popular.

Table 4: Sources' Local Impact

Source	h_index	G_index	m_index	TC	NP	PY
Journal of Statistical Computation and Simulation	15	23	0.714	1413	23	2005
Communications in Statistics-Theory and Methods	12	21	0.632	478	33	2007
Hacettepe Journal of Mathematics and Statistics	9	13	0.818	206	13	2015
Journal of Computational and Applied Mathematics	9	11	0.75	219	11	2014
Communications in Statistics-Simulation and Computation	8	15	0.471	242	21	2009
Computational Statistics & Data Analysis	8	8	0.381	922	8	2005
Journal of Statistical Planning and Inference	8	9	0.381	534	9	2005
Reliability Engineering & System Safety	8	10	0.444	354	10	2008
Energy Conversion and Management	6	6	0.333	376	6	2008
Statistical Papers	6	9	0.375	307	9	2010
Statistics	6	10	0.316	112	10	2007
Symmetry-Basel	6	8	0.857	75	12	2019
Journal of Applied Statistics	5	8	0.313	103	8	2010
Mathematics	5	10	0.833	119	14	2020
Mathematics and Computers in Simulation	5	7	0.313	117	7	2010
Quality and Reliability Engineering International	5	9	0.455	122	9	2015
Statistics in Medicine	5	6	0.25	420	6	2006
Aims Mathematics	4	6	0.8	40	11	2021
IEEE Transactions on Reliability	4	4	0.235	155	4	2009
Pakistan Journal of Statistics	4	8	0.222	72	9	2008

3.1.6 Sources' production over Time

Figure 2 shows the total number of articles from certain journals over time. It indicates how often each source has published in the data we looked at. Communications in Statistics—Theory and Methods (the olive line) have the most articles, with steady growth since 2007 and a big jump around 2015–2017. The Journal of Statistical Computation and Simulation (the purple line) started slower but has been consistently increasing since 2005, which means it's been publishing steadily. Communications in Statistics—Simulation and Computation (the red line) and the Hacettepe Journal of Mathematics and Statistics (the green line) are gradually increasing, which means they've been contributing at a moderate but consistent rate over the years. Mathematics (the pink line) started later than the others but has grown quickly after 2020, which suggests it's become more important recently. Generally, the figure points out that some journals have been around for a long time and are still publishing steadily, while newer journals are quickly adding more articles recently.

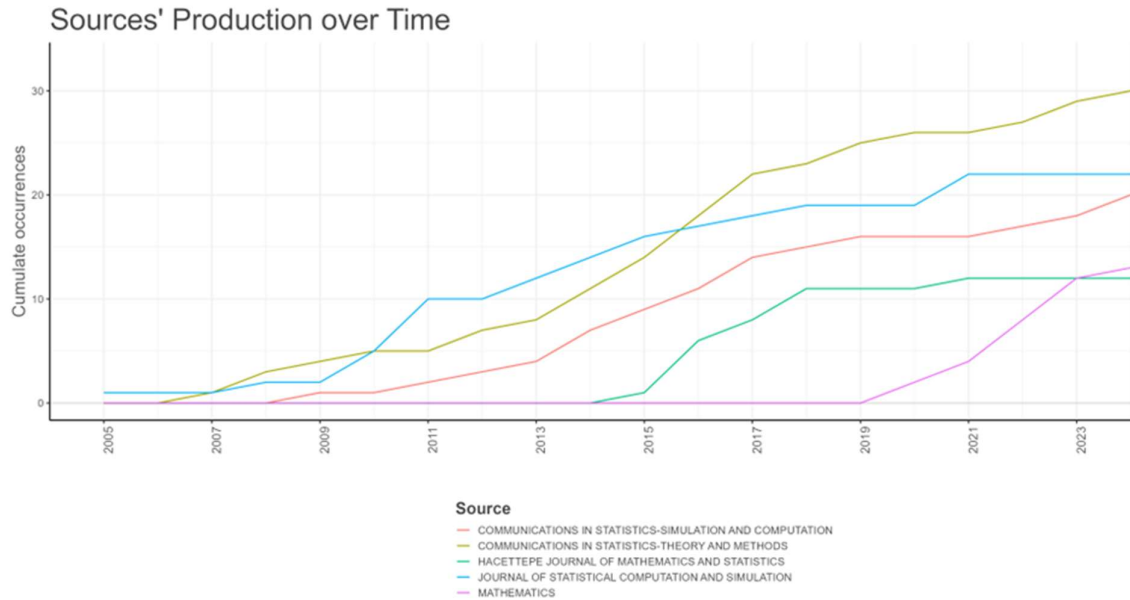


Figure 2: Sources' production over Time

3.1.7 Average Citation

Table 5 looks at the average number of citations per year from 2005 to 2025, and some interesting things popped up. From 2005 to 2007, citations went up steadily, hitting a high of 4.59 per year in 2007. This means that the work published then was getting a lot of attention. Between 2008 and 2011, the number of citations went up and down a bit, staying pretty consistent. Then, from 2012 to 2016, there was a dip, with the average going down to 1.64. Maybe newer papers weren't as influential, or maybe it just takes time for new publications to get cited. From 2017 to 2021, things picked up a bit, with citations rising to 2.83 in 2017 before going down again slowly. The period from 2022 to 2025 saw a big drop, hitting only 0.46 citations per year in 2025. This is likely because those publications are so recent.

All in all, it looks like the early years had the biggest impact, and citation rates have generally gone down over time, which is pretty normal for research papers.

Table 5: Average Citation

Year	MeanTCperArticle	MeanTCperYear
2005	60.12	2.86
2006	57.80	2.89
2007	87.14	4.59
2008	50.93	2.83
2009	58.90	3.46
2010	46.13	2.88
2011	57.07	3.80
2012	37.86	2.70
2013	23.21	1.79
2014	22.68	1.89
2015	18.07	1.64
2016	16.38	1.64
2017	25.48	2.83
2018	16.56	2.07
2019	16.08	2.30
2020	16.16	2.69
2021	11.86	2.37
2022	8.62	2.15
2023	5.38	1.79
2024	2.53	1.26
2025	0.46	0.46

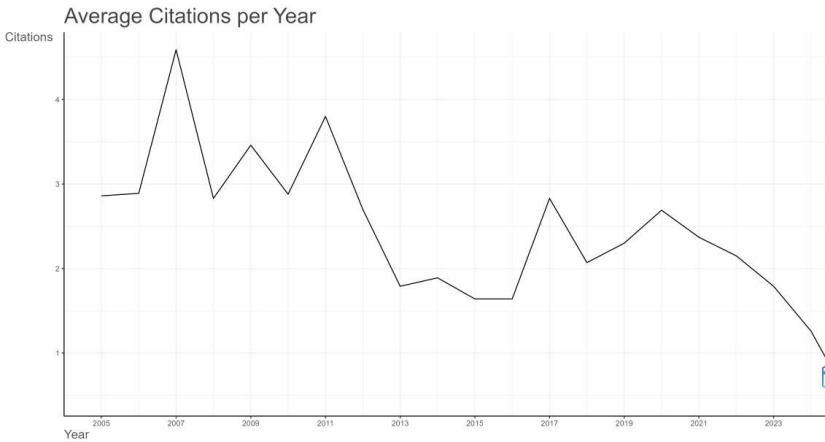


Figure 3: Average Citation

3.1.8 Life Cycle

The graph shows how many research papers have come out each year in this field. You can see that publications grew steadily since the early 2000s. The most papers were published around 2024.4, about 34 papers. That's represented by the red dashed line. The solid blue line is like an S-curve that shows the usual growth pattern. The dashed blue line guesses that the annual number of papers will slowly drop after the peak. This could mean the research area is maturing and becoming saturated.

The model fits pretty well, with an R^2 value of 0.709, which means the logistic model does a good job of showing the publication trend. Basically, the graph says that the field is almost at its peak for publications, and the number of papers will likely decrease in the next few decades. This is normal for research topics in these kinds of studies.

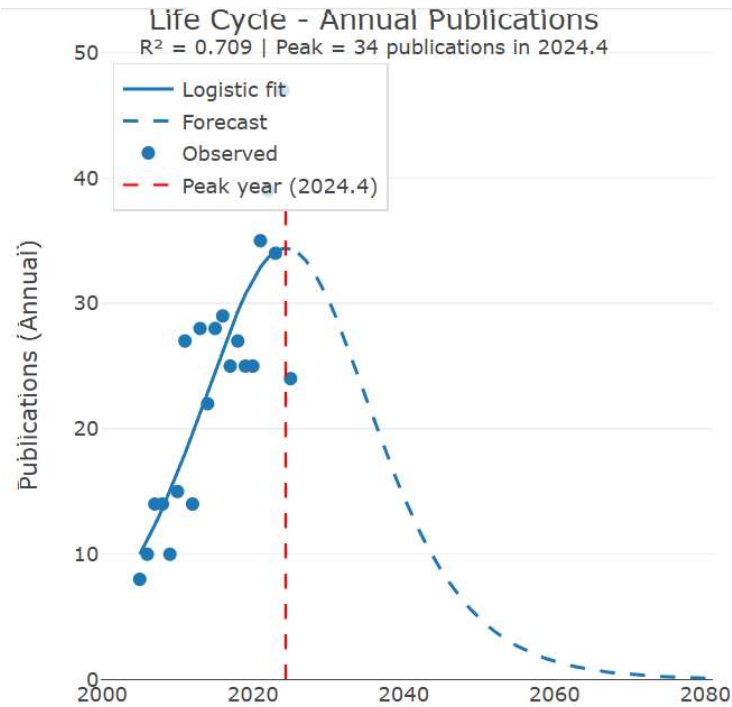


Figure 4: Life Cycle

3.1.9 Most Relevant Authors

Table 6 of most relevant authors highlights a clear concentration of research output among a few leading contributors in the field. CORDEIRO GM emerges as the most prolific author with 43 publications, significantly outperforming others and indicating a central role in shaping the research domain. This is followed by ORTEGA EMM (22 articles) and KUNDU D (17 articles), who also demonstrate sustained and influential scholarly engagement. A second tier of contributors, including SABOOR A, NADARAJAH S, ALMETWALLY EM, RAQAB MZ, and WANG L, shows moderate productivity, reflecting active and consistent participation in the literature.

Overall, the distribution suggests a core-periphery structure, where a small group of highly productive authors drives much of the research output, supported by a broader network of contributors with fewer publications. This pattern is typical of mature research areas, indicating both established leadership and a diverse set of scholars contributing to the expansion and diversification of the field.

Table 6: Most Relevant Authors

Author	No. of Articles	Author	No. of Articles
CORDEIRO GM	43	TRIPATHI YM	6
ORTEGA EMM	22	ALIZADEH M	5
KUNDU D	17	BALAKRISHNAN N	5
SABOOR A	10	COORAY K	5
NADARAJAH S	9	DEY S	5
ALMETWALLY EM	8	JAMAL F	5
RAQAB MZ	8	LEMONTE AJ	5
WANG L	8	PROVOST SB	5
AFIFY AZ	7	SARHAN AM	5
ELGARHY M	7	ALI S	4
TAHIR MH	7	ALSADAT N	4
EL-MORSHEDY M	6	ASLAM M	4
ELBATAL I	6	CHESNEAU C	4
GUPTA RD	6	HASSAN AS	4
JAFARI AA	6	HUSSAM E	4

3.1.10 Most Local Cited Authors

Table 7 and Figure 5 highlight the most locally cited authors in the bibliometric dataset, reflecting their influence within the core literature of the field. CORDEIRO GM emerges as the most locally cited author with 72 citations, followed by ORTEGA EMM (64) and KUNDU D (47), indicating their central role in shaping and advancing research themes within the dataset. Other highly influential contributors include GUPTA RD (42) and NADARAJAH S (27), whose works are frequently referenced by related studies in the same research domain.

The remaining authors show moderate yet notable local citation counts, suggesting sustained scholarly relevance and specialization in specific subareas. Authors such as SILVA GO, KRISHNAMOORTHY K, LIN Y, and KOTZ S contribute to the intellectual foundation of the field. Overall, the distribution of local citations demonstrates a concentrated impact among a few leading authors, complemented by a broader group of researchers contributing to the field's cumulative knowledge.

Table 7: Most Local Cited Authors

Author	Local Citations	Author	Local Citations
CORDEIRO GM	72	COORAY K	13
ORTEGA EMM	64	AFIFY AZ	11
KUNDU D	47	MANGLICK A	10
GUPTA RD	42	XIA Y	10
NADARAJAH S	27	ELBATAL I	9
SILVA GO	23	EL-MORSHEDY M	8
KRISHNAMOORTHY K	19	SABOOR A	8
LIN Y	19	SARHAN AM	8
DE GUSMAO FRS	18	DEY S	7
KOTZ S	16	RAQAB MZ	7

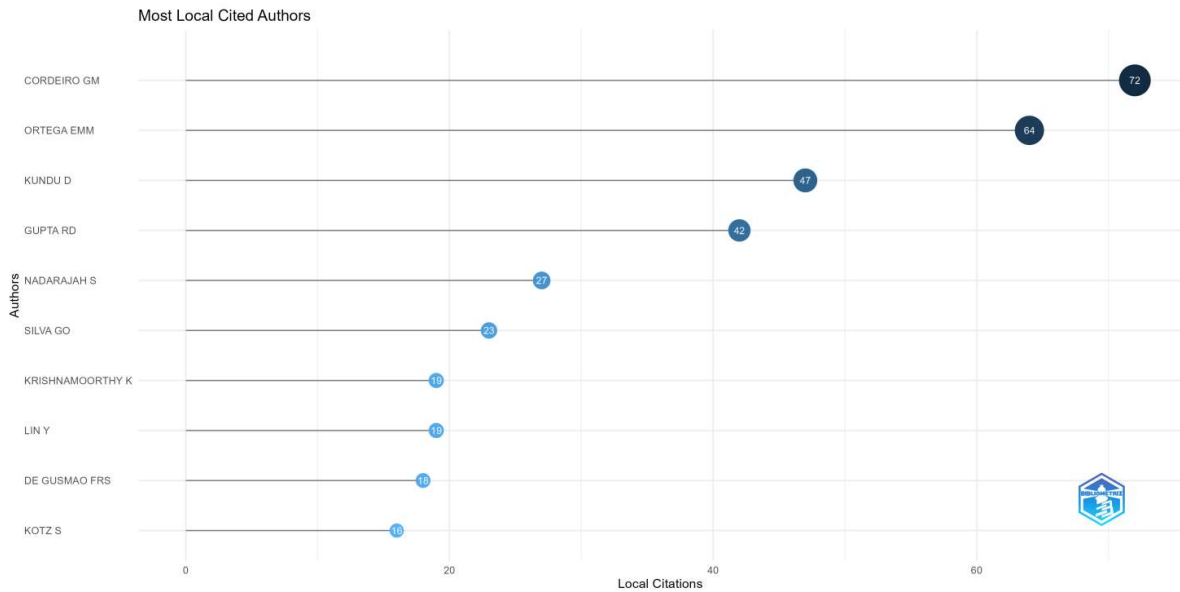


Figure 5: Most Local Cited Authors

3.1.11 Author Productivity through Lotka's Law

Table 8 and Figure 6 depict the distribution of author productivity in the dataset, aligning with Lotka's Law, where a large proportion of authors publish only a small number of documents and a very small group contributes extensively. The steep decline at the beginning of the curve indicates that the majority of authors have produced only one or two publications, accounting for the highest percentage of contributors.

As the number of documents increases, the percentage of authors drops rapidly and then levels off, forming a long tail. This pattern confirms the presence of a small group of highly productive authors who contribute a disproportionately large share of publications. The close alignment between the observed distribution and the theoretical Lotka's Law curve suggests that the author productivity in this bibliometric dataset follows a typical and well-established scientific publishing pattern.

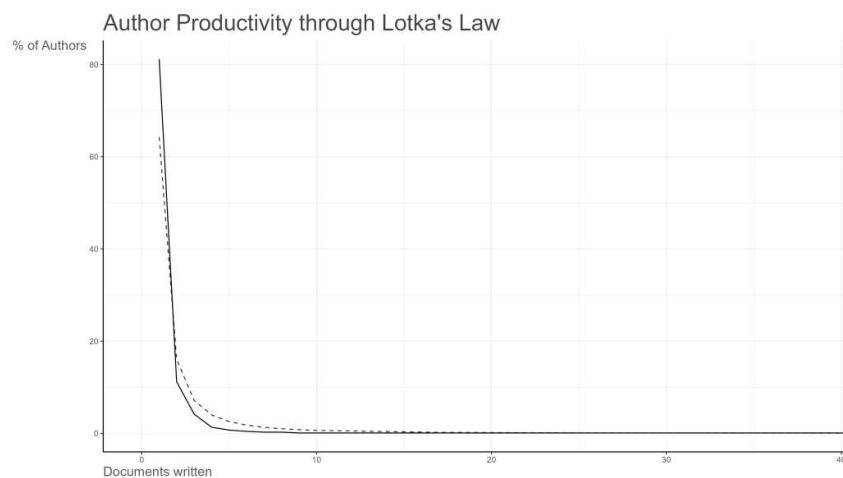


Figure 6: Author Productivity through Lotka's Law

Table 8: Author Productivity through Lotka's Law

Documents written	No. of Authors	Proportion of Authors	Theoretical
1	915	0.812	0.643
2	126	0.112	0.161
3	47	0.042	0.071
4	15	0.013	0.04
5	8	0.007	0.026
6	5	0.004	0.018
7	3	0.003	0.013
8	3	0.003	0.01
9	1	0.001	0.008
10	1	0.001	0.006

3.1.12 Authors' Local Impact

Table 9 and Figure 7 present the local impact of authors in the bibliometric dataset using indicators such as h-index, g-index, m-index, total citations (TC), and number of publications (NP). CORDEIRO GM stands out as the most influential author, leading with the highest h-index (24), g-index (43), total citations (2519), and publications (43), indicating sustained productivity and strong local influence since 2008. ORTEGA EMM and KUNDU D follow, showing high citation impact and consistent contributions, as reflected by their h-indices of 18 and 12, respectively.

The figure visually reinforces these findings by highlighting a clear concentration of local impact among a few leading authors, with a gradual decline across others. Authors such as NADARAJAH S, RAQAB MZ, and SABOOR A show moderate impact, while several recent contributors, ELGARHY M, WANG L and AFIFY AZ demonstrate promising m-index values, indicating growing influence over shorter publication periods. Overall, the analysis reveals a skewed distribution of local impact, where a small group of authors dominates citations and productivity, consistent with typical bibliometric patterns.

Table 9: Authors' Local Impact

Author	h index	G index	m index	TC	NP	PY
CORDEIRO GM	24	43	1.333	2519	43	2008
ORTEGA EMM	18	22	1	1465	22	2008
KUNDU D	12	17	0.571	1111	17	2005
NADARAJAH S	7	9	0.35	419	9	2006
RAQAB MZ	7	8	0.333	379	8	2005
SABOOR A	7	10	0.467	145	10	2011
ELGARHY M	6	7	1	196	7	2020
GUPTA RD	6	6	0.286	452	6	2005
WANG L	6	8	0.75	115	8	2018
AFIFY AZ	5	7	0.625	150	7	2018
ALIZADEH M	5	5	0.5	205	5	2016
ALMETWALLY EM	5	8	1	120	8	2021
ELBATAL I	5	6	0.5	174	6	2016
JAFARI AA	5	6	0.455	46	6	2015
LEMONTE AJ	5	5	0.333	166	5	2011
TAHIR MH	5	7	0.5	92	7	2016
TRIPATHI YM	5	6	0.833	65	6	2020
ASLAM M	4	4	0.308	50	4	2013
BALAKRISHNAN N	4	5	0.2	172	5	2006
CHESNEAU C	4	4	0.667	116	4	2020

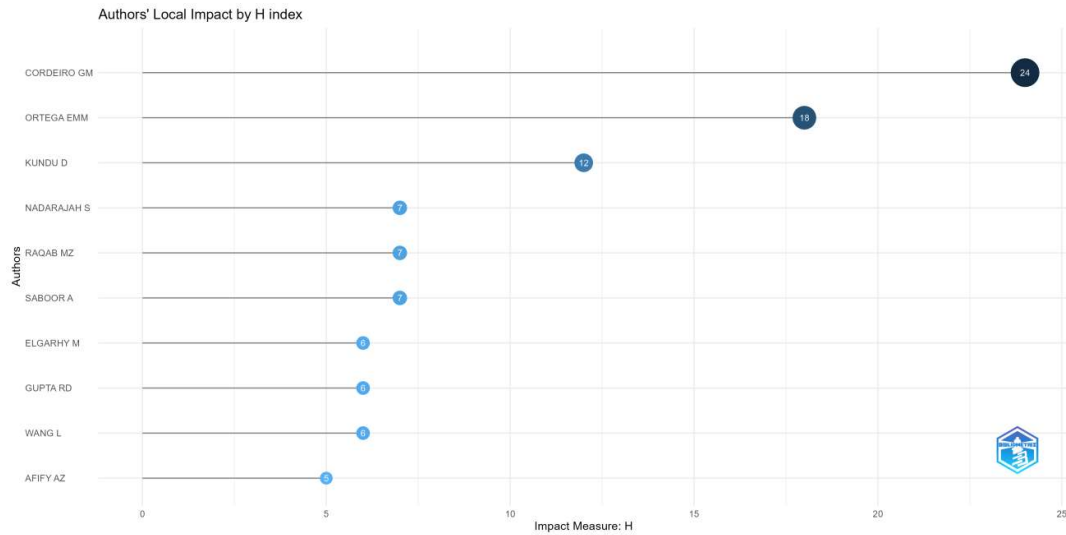


Figure 7: Authors' Local Impact

3.1.13 Corresponding Author's Countries

The analysis of corresponding authors' countries reveals the global distribution and collaborative nature of research on generalized Weibull distributions. China leads the field with 59 publications (11.8%), followed closely by India with 53 publications (10.6%) and Brazil with 45 publications (9%), indicating strong research activity across Asia and South America. These countries also show a higher proportion of single-country publications (SCP), suggesting the presence of well-established domestic research groups actively contributing to the field.

In contrast, several countries demonstrate a strong tendency toward international collaboration, as reflected by high multiple-country publication (MCP) percentages. Pakistan (86.4%), Egypt (75%), Italy (75%), Jordan (71.4%), and France (60%) exhibit particularly high MCP rates, highlighting their reliance on cross-border research partnerships. Saudi Arabia (54.3%), the United Kingdom (50%), Malaysia (50%), and Spain (44.4%) also show substantial international collaboration, underscoring the global interconnectedness of research in this domain. Overall, the findings suggest that while countries such as China, India, and Brazil dominate in terms of research volume, nations with higher MCP percentages play a crucial role in fostering international knowledge exchange. This balance between high-output countries and collaboration-oriented nations reflects the globally integrated and cooperative nature of research on generalized Weibull distributions.

Table 10: Corresponding Author's Countries

Country	Articles	Articles %	SCP	MCP	MCP %
CHINA	59	11.8	40	19	32.2
INDIA	53	10.6	36	17	32.1
BRAZIL	45	9	36	9	20
IRAN	38	7.6	30	8	21.1
USA	36	7.2	29	7	19.4
SAUDI ARABIA	35	7	16	19	54.3
EGYPT	32	6.4	8	24	75
PAKISTAN	22	4.4	3	19	86.4
TURKEY	18	3.6	13	5	27.8
UNITED KINGDOM	16	3.2	8	8	50
CANADA	15	3	9	6	40
FRANCE	10	2	4	6	60
SPAIN	9	1.8	5	4	44.4
GERMANY	7	1.4	5	2	28.6
JORDAN	7	1.4	2	5	71.4
KOREA	6	1.2	5	1	16.7
THAILAND	6	1.2	6	0	0
JAPAN	5	1	4	1	20
ITALY	4	0.8	1	3	75
MALAYSIA	4	0.8	2	2	50

3.1.14 Countries' Scientific Production

The analysis of countries' scientific production shows that research on generalized Weibull distributions is geographically diverse but concentrated in a few leading nations. China (190 publications), Brazil (172), and India (170) dominate the field, reflecting strong and sustained research activity. Saudi Arabia (153) and Egypt (149) also contribute substantially, highlighting the growing prominence of Middle Eastern research communities. The United States (123) maintains a significant presence, indicating continued engagement from established statistical research hubs. Countries such as Iran and Pakistan show moderate yet consistent output, while European nations contribute comparatively fewer publications. Overall, the pattern suggests a shift toward increased research productivity in emerging and developing research economies alongside traditional contributors.

Table 11: Countries' Scientific Production

Country	No. of Publications
CHINA	190
BRAZIL	172
INDIA	170
SAUDI ARABIA	153
EGYPT	149
USA	123
IRAN	108
PAKISTAN	85
CANADA	57
TURKEY	46
UK	42
FRANCE	30
SPAIN	30
RUSSIA	25
JORDAN	21
MALAYSIA	19
SOUTH KOREA	19
ITALY	17
GERMANY	15
PORTUGAL	15

3.1.15 Most Global Cited Documents

The most globally cited documents highlight the foundational and long-lasting contributions to generalized Weibull distribution research. The study by Cordeiro et al. (2011) dominates with 604 total citations and the highest normalized citation impact, underscoring its seminal role in advancing Weibull generalizations. Early works by Yacoub (2007), Kundu (2005), Nadarajah (2006), and Gupta (2007) also show strong citation performance, reflecting their influence on theoretical development and methodological expansion. High citations per year for relatively recent studies, such as Alexander (2012) and Jung (2019), indicate sustained relevance and growing interdisciplinary application. The presence of journals spanning statistics, engineering, medical statistics, and energy research demonstrates the broad applicability of generalized Weibull models. Overall, the citation pattern reveals a balance between early foundational works and newer contributions that continue to shape current research directions.

Table 12: Most Global Cited Documents

Paper	DOI	Total Citations	TC per Year	Normalized TC
CORDEIRO GM, 2011, J STAT COMPUT SIMUL-a	10.1080/00949650903530745	604	40.27	10.58
YACoub MD, 2007, IEEE TRANS VEH TECHNOL	10.1109/TVT.2006.883753	534	28.11	6.13
COX C, 2007, STAT MED	10.1002/sim.2836	262	13.79	3.01
KUNDU D, 2005, COMPUT STAT DATA ANAL	10.1016/j.csda.2004.05.008	230	10.95	3.83
ALEXANDER C, 2012, COMPUT STAT DATA ANAL	10.1016/j.csda.2011.11.015	227	16.21	6.00
NADARAJAH S, 2006, ACTA APPL MATH	10.1007/s10440-006-9055-0	223	11.15	3.86
CARRASCO JMF, 2008, COMPUT STAT DATA ANAL	10.1016/j.csda.2008.08.023	221	12.28	4.34
SILVA GO, 2010, LIFETIME DATA ANAL	10.1007/s10985-010-9161-1	188	11.75	4.08
BASU B, 2009, CERAM INT	10.1016/j.ceramint.2007.10.003	186	10.94	3.16
GUPTA RD, 2007, J STAT PLAN INFER	10.1016/j.jspi.2007.03.030	183	9.63	2.10
COORAY K, 2008, COMMUN STAT-THEORY METHODS	10.1080/03610920701826088	158	8.78	3.1
LI HC, 2011, IEEE J SEL TOP SIGNAL PROCESS	10.1109/JSTSP.2011.2138675	155	10.33	2.72
BARRETO-SOUZA W, 2010, J STAT COMPUT SIMUL	10.1080/00949650802552402	151	9.44	3.27
DE GUSMAO FRS, 2011, STAT PAP	10.1007/s00362-009-0271-3	139	9.27	2.44
PRADHAN B, 2009, TEST	10.1007/s11749-008-0110-1	130	7.65	2.21
JUNG C, 2019, RENEW SUST ENERG REV	10.1016/j.rser.2019.109290	119	17	7.4
CORDEIRO GM, 2017, J STAT COMPUT SIMUL	10.1080/00949655.2016.1238088	102	11.33	4
KRISHNAMOORTHY K, 2010, J STAT PLAN INFER	10.1016/j.jspi.2009.12.028	99	6.19	2.15
SOUZA WB, 2011, J STAT COMPUT SIMUL	10.1080/00949650903436554	94	6.27	1.65
KISS P, 2008, ENERGY CONV MANAG	10.1016/j.enconman.2008.02.003	89	4.94	1.75

3.1.16 Most Local Cited References

The most locally cited references highlight the foundational theoretical works that underpin research on generalized Weibull distributions. Seminal contributions by Mudholkar(1999)and Gupta(1999) dominate the list, reflecting their critical role in introducing flexible hazard models and early Weibull generalizations. The strong local citation of Weibull (1951) confirms the enduring relevance of the original distribution as the theoretical baseline for subsequent extensions. Influential works published in core statistical and reliability journals such as IEEE Transactions on Reliability, Technometrics, Biometrika, and Computational

Statistics & Data Analysis indicate the methodological rigor of the field. The presence of classical texts, including Lawless (2003) and Balakrishnan (2000), underscores the importance of censoring schemes and lifetime modelling theory. Overall, the local citation pattern reveals a research community strongly anchored in classical reliability theory while progressively building advanced generalizations upon it.

Table 13: Most Local Cited References

Cited References	Citations
MUDHOLKAR GS, 1993, IEEE T RELIAB, V42, P299, DOI 10.1109/24.229504	79
GUPTA RD, 1999, AUST NZ J STAT, V41, P173, DOI 10.1111/1467-842X.00072	68
GUPTA RD, 2001, BIOMETRICAL J, V43, P117, DOI 10.1002/1521-4036(200102)43:13.0.CO	61
MUDHOLKAR GS, 1995, TECHNOMETRICS, V37, P436, DOI 10.2307/1269735	60
AARSET MV, 1987, IEEE T RELIAB, V36, P106, DOI 10.1109/TR.1987.5222310	57
EUGENE N, 2002, COMMUN STAT-THEOR M, V31, P497, DOI 10.1081/STA-120003130	48
MARSHALL AW, 1997, BIOMETRIKA, V84, P641, DOI 10.1093/BIOMET/84.3.641	46
CARRASCO JMF, 2008, COMPUT STAT DATA AN, V53, P450, DOI 10.1016/J.CSDA.2008.08.023	41
STACY EW, 1962, ANN MATH STAT, V33, P1187, DOI 10.1214/AOMS/1177704481	41
WEIBULL W, 1951, J APPL MECH-T ASME, V18, P293	38
LAI CD, 2003, IEEE T RELIAB, V52, P33, DOI 10.1109/TR.2002.805788	36
MUDHOLKAR GS, 1996, J AM STAT ASSOC, V91, P1575, DOI 10.2307/2291583	35
GUPTA RD, 2001, J STAT COMPUT SIM, V69, P315, DOI 10.1080/00949650108812098	33
LAWLESS J.L., 2003, STAT MODEL METHODS L, V2ND ED.	32
ALZAATREH A, 2013, METRON, V71, P63, DOI 10.1007/S40300-013-0007-Y	30
CORDEIRO GM, 2010, J FRANKLIN I, V347, P1399, DOI 10.1016/J.JFRANKLIN.2010.06.010	28
GUPTA RC, 1998, COMMUN STAT-THEOR M, V27, P887, DOI 10.1080/03610929808832134	28
BALAKRISHNAN N., 2000, PROGRESSIVE CENSORING: THEORY, METHODS, AND APPLICATIONS	27
KUNDU D, 2005, COMPUT STAT DATA AN, V49, P187, DOI 10.1016/J.CSDA.2004.05.008	27
LEE C, 2007, J MOD APPL STAT METH, V6, P173, DOI 10.22237/JMASM/1177992960	27

3.1.17 Reference Spectroscopy

The reference publication year spectroscopy reveals the historical roots and intellectual evolution of research on generalized Weibull distributions. Early citation peaks correspond to foundational works from the 1950s–1970s, including the original formulation of the Weibull distribution and early reliability models, which continue to influence later studies. A noticeable increase in cited references begins in the 1990s, reflecting the emergence of flexible hazard models and formal Weibull generalizations. The strongest citation intensity is observed from the early 2000s onward, indicating rapid expansion and consolidation of the field during this period. Pronounced deviations from the five-year median highlight years associated with seminal methodological contributions that shaped subsequent research. Overall, the spectroscopy confirms that contemporary studies are firmly grounded in both classical reliability theory and modern statistical advancements.

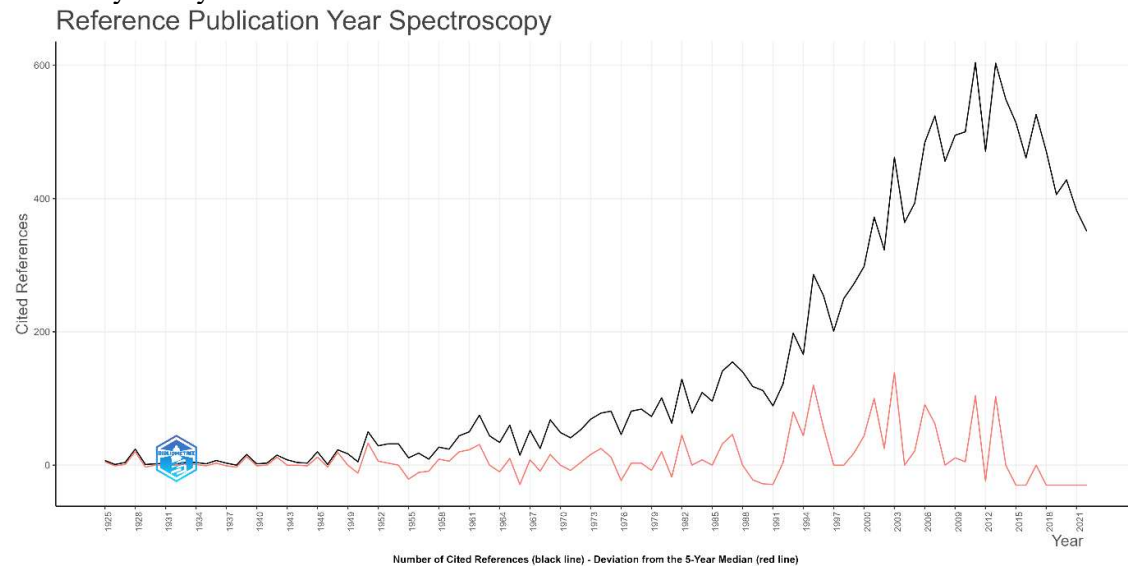


Figure 8: Reference Spectroscopy

3.1.18 Word cloud

The word cloud shows the main keywords in papers about generalized Weibull distributions. The frequent appearance of “Weibull distribution” shows it is the main topic. Words like parameters, maximum likelihood estimation, Weibull family, distribution, and reliability show that model creation and statistical deduction are important. The presence of keywords about estimation, deduction, and reliability analysis indicates that theory and real-world applications are closely linked. The word cloud suggests that this field is well-developed, with constant attention to both new methods and practical uses.



Figure 9: Word cloud

3.1.19 Tree Map

A tree map shows how often keywords appear in studies about generalized Weibull distributions. The biggest block, Weibull distribution (12%), confirms that it's the main topic. Words like family, distribution, parameters, Weibull, and model suggest a strong interest in the structure of distributions and how the models are made. Keywords for inference and estimation, like maximum likelihood, estimation, and moments, indicate that the research is deep methodologically. Smaller blocks for terms like mixture, Bayesian, simulation, and hazard function point to newer, more specific research areas. The tree map shows a well-developed research area with a central focus and broadening methodological and applied subtopics.



Figure 10: Tree Map

3.2 Network Analysis

Network analysis, a core part of bibliometrics, explores relationships between academic elements like authors, institutions, countries, papers, and keywords. By displaying these elements as nodes and their connections—co-authorship, co-citation, or keyword co-occurrence—as links, this type of analysis shows patterns in teamwork, knowledge spread, and the structure of thought within an area of study. It pinpoints noted authors, key research groups, and new topics by looking at centrality and density. Seeing these networks makes it easier to understand complicated relationships and how scientific work and research directions change. In short, network evaluation gives more than just publication numbers by revealing the connected workings of academic research

3.2.1 Clustering by Coupling

Document coupling clustering shows the intellectual layout of generalized Weibull distribution studies through shared references. Clusters that are both central and high-impact often relate to keywords like Weibull distribution, maximum likelihood estimation, and distribution. This points to their key part in the existing studies. Topics tied to generalized exponential distribution also have a noticeable impact, which mirrors their close conceptual relation to Weibull generalizations. Clusters with moderate centrality focus on estimation methods, showing how important inference is to the advancement of this area. In general, the coupling layout indicates a balanced research area led by core distribution theory, moving toward advanced estimation and censoring methods.

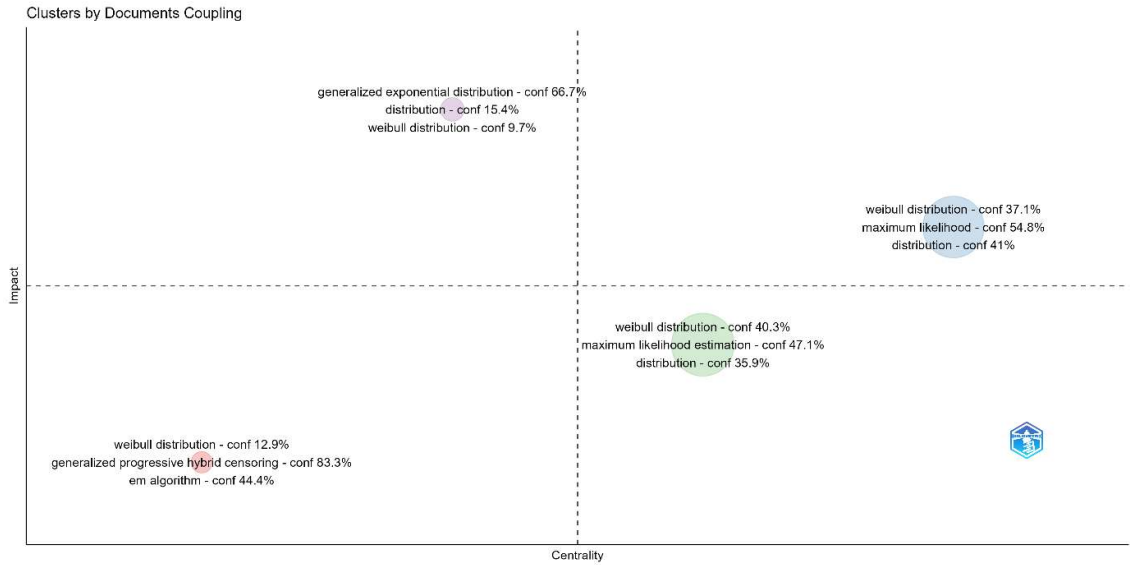


Figure 11: Clustering by Coupling (map view)

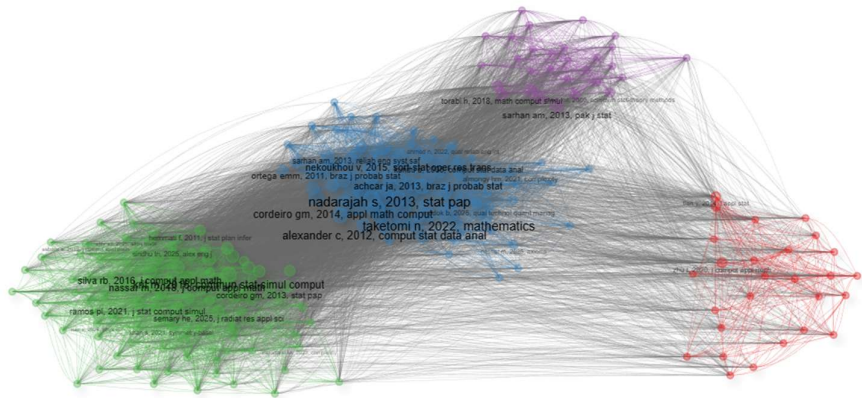


Figure 12: Clustering by Coupling (network view)

The map and network representations of document in coupling Figure 9 and Figure 10, provide complementary perspectives on the intellectual structure of the field. The map view emphasizes the strategic positioning of clusters based on centrality and impact, clearly distinguishing core themes such as Weibull distributions and maximum likelihood estimation from peripheral and emerging topics like censoring schemes and computational algorithms. In contrast, the network view highlights the density and strength of interconnections among documents, revealing how clusters are linked through shared references and identifying influential papers that act as bridges between themes. While the map facilitates interpretation of thematic importance and maturity, the network visualization offers deeper insight into collaboration intensity and knowledge flow. Together, these representations provide a comprehensive understanding of both the conceptual hierarchy and relational complexity within the generalized Weibull distribution literature.

3.2.2 Co-occurrence Network

The keyword co-occurrence network illustrates the thematic structure and conceptual relationships within research on generalized Weibull distributions. The Weibull distribution appears as the most central and dominant node, indicating its foundational role and strong connectivity with multiple research themes. Distinct clusters correspond to major thematic areas, including parameter estimation and inference methods, distributional families and generalizations, and reliability and lifetime modelling. Strong linkages between estimation-related keywords - maximum likelihood, Bayesian estimation and distributional terms reflect the close integration of theory and methodology. Peripheral nodes represent specialized topics and emerging applications, suggesting ongoing diversification of research directions. Overall, the network demonstrates a well-connected and mature research field, with a clear core theme supported by complementary methodological and applied clusters.

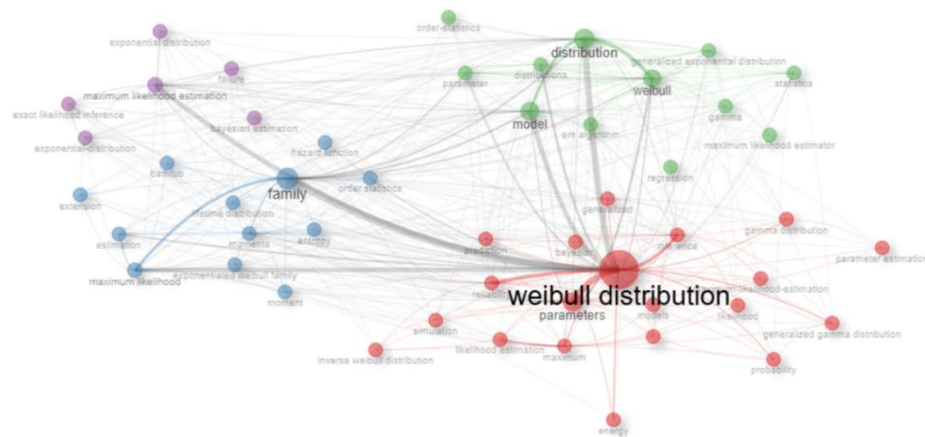


Figure 13:Co-occurrence Network

3.2.3 Co-citation Network

The co-citation network reveals the intellectual foundations and knowledge structure underlying research on generalized Weibull distributions. Prominent nodes such as Mudholkar (1993), Gupta (1999), and Eugene (2002) occupy central positions, indicating their seminal influence and frequent joint citation within the literature. Distinct clusters correspond to classical reliability theory, Weibull generalizations, and methodological developments in lifetime modelling. Strong interconnections among core references suggest a well-integrated theoretical framework that has guided subsequent research. Peripheral nodes represent earlier statistical foundations and specialized methodological contributions that support, but are less central to, current studies. Overall, the network demonstrates that contemporary research is deeply rooted in a cohesive set of influential works that continue to shape advancements in the field.

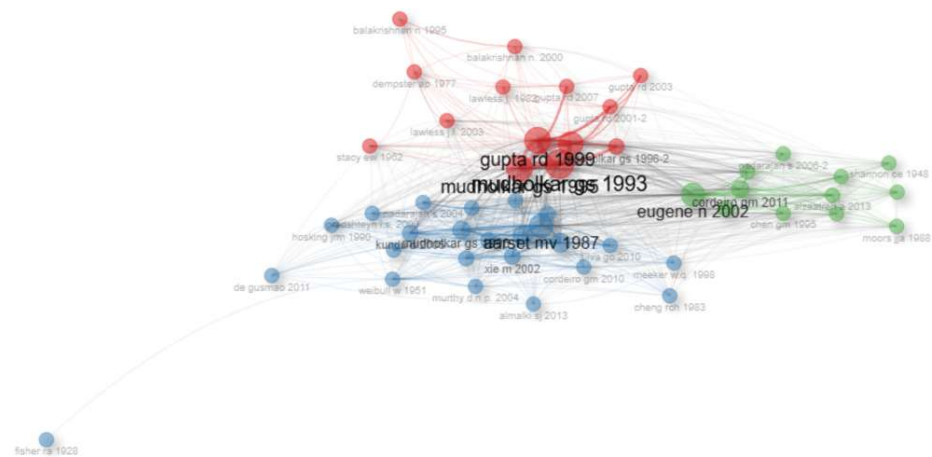


Figure 14: Co-citation Network

3.2.4 Historiograph

The Historiograph maps the chronological development and intellectual lineage of research on generalized Weibull distributions. Early influential works, particularly those by Kundu, Gupta, and Nadarajah in the mid-2000s, form the foundational nodes from which later studies evolved. The dense connections among these core papers indicate strong citation continuity and cumulative knowledge building over time. Subsequent research branches into multiple directions, including new Weibull generalizations, advanced estimation techniques, and application-driven studies. More recent publications appear as peripheral yet connected nodes, reflecting ongoing diversification and expansion of the field. Overall, the Historiograph demonstrates a coherent evolutionary trajectory, with contemporary research firmly anchored in a set of seminal early contributions.

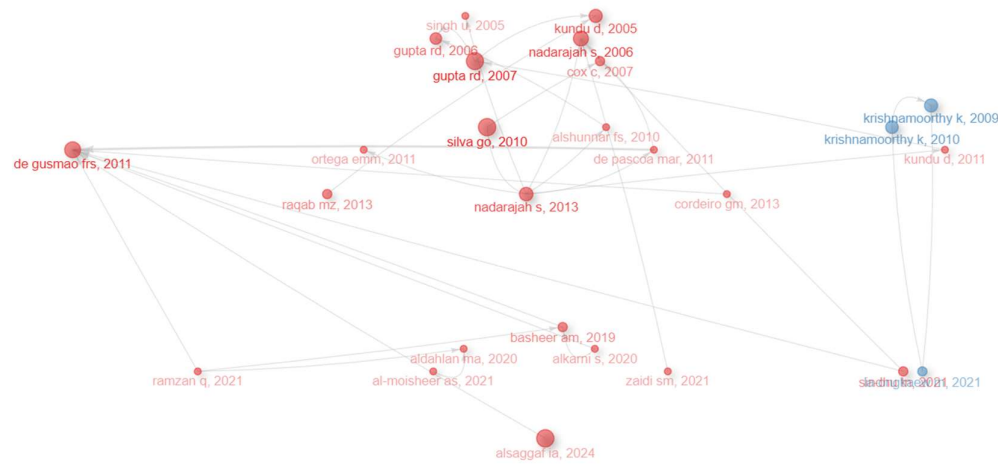


Figure 15: Historiograph

3.2.5 Collaboration Network

The collaboration network illustrates the co-authorship structure and research partnerships within the generalized Weibull distribution literature. A few highly connected authors, notably CORDEIRO GM and ORTEGA EMM, occupy central positions, indicating their key role in driving collaborative research and knowledge dissemination. Distinct clusters represent research groups formed around leading contributors, often reflecting institutional or regional collaborations. The presence of inter-cluster links suggests moderate cross-group interaction, facilitating the exchange of methodological ideas across research communities. Several peripheral authors appear with limited connections, highlighting opportunities for broader collaboration. Overall, the network reflects a partially centralized yet increasingly collaborative research field with growing international connectivity.

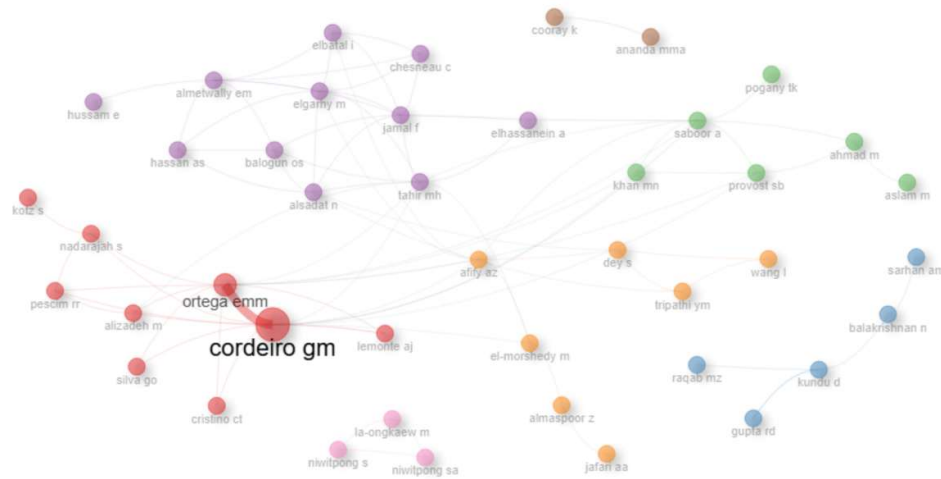


Figure 16: Collaboration Network

3.3 Potential Application Areas of Generalized Weibull Distributions

Generalized Weibull distributions are quite useful because they are flexible when modelling different data and hazard rates. By adding more shape and scale parameters, these distributions can show non-monotonic, bathtub-shaped, and heavy-tailed traits often seen in real data sets. (Silva, G.et.al., 2010).

In reliability engineering and survival analysis, generalized Weibull models are extensively used to analyse failure times of mechanical components, electronic systems, and industrial processes (Shama, M.et. al., 2023). Their ability to model early-life failures, wear-out periods, and maintenance effects makes them particularly suitable for reliability assessment and risk prediction (Saad J. et.al., 2014). In medical and biomedical studies, these distributions are applied to patient survival times, disease progression, and treatment response modelling. Generalized forms provide improved goodness-of-fit compared to classical models, especially when survival data exhibit heterogeneity or non-standard hazard patterns (Voinov, V. et.al., 2013). In environmental and hydrological sciences, generalized Weibull distributions are used to model extreme events such as rainfall intensity, wind speed, flood frequency, and drought duration (Sarhan, A. M. & Zaindin, M. 2009). Their flexibility enables accurate representation of skewed and heavy-tailed environmental data, which is critical for climate risk assessment and resource management (Cordeiro, G. M., & de Castro, M. 2011). In finance and insurance,

these models are employed to analyse claim sizes, loss severity, waiting times between events, and risk exposure (Kumar, C. S. & Nair, S. R. 2018). The ability to accommodate tail behaviour and variability enhances their usefulness in actuarial modelling and financial risk analysis (Farcomeni A, and Nardi A., 2010).

Additionally, generalized Weibull distributions find applications in engineering sciences, quality control, energy systems, and materials science, particularly in fatigue life testing and degradation modelling (F. Merovci and I. Elbatal, 2014). Emerging research also explores their integration with Bayesian frameworks, machine learning, and hybrid statistical models, expanding their potential use in data-driven and computationally intensive applications (Abdelall, Y. et.al., 2024). Generalized Weibull distributions are useful because they are both versatile and adaptable to many theoretical and applied fields. They work with both older statistical methods and newer analytical ways of doing things.

4. Limitations and Future Scope

This study has some limits. It only uses info from the Web of Science database, so it might miss some good articles listed in other places. Also, newer articles haven't had time to be cited much yet. Remember that counting citations is just one way to measure impact, and it might not show all the ways an article helps the field.

Future studies could use more than one database and sort of test different Weibull models to see which works best. A good direction would be to combine those Weibull models with some other methods, like Bayesian stuff, machine learning, and applying them to areas where we have a lot of info about reliability and survival.

5. Conclusion

This study looks at research on generalized Weibull distributions using a method that combines data analysis and a broad overview. It shows how the field has grown, who the key thinkers are, and how researchers work together. The method mixes performance measures with visual mapping to find the main writers, journals, and research topics that have shaped how Weibull variations have changed. The steady increase in articles and how often they're referenced shows that the field has gone from basic theories to a fully developed research area.

The data show a main focus on Weibull distributions, guessing parameters, and reliability models. This is backed by growing groups working on methods and uses. Looking at the connections shows that the research is well-organized, with current work based on old reliability theories but adding new analysis tools and computer methods. The rise of global teamwork, especially in new research countries, that current research is globally linked.

In short, this study pulls together scattered information into one place. It clears up how new theories, better methods, and applied work all play a role in Weibull research. The data suggest that future work will likely centre on ways to combine approaches, mixing generalized Weibull distributions with Bayesian computing, machine learning, and tricky data settings. By giving a structured look at what's happened and what's coming, this study is helpful for guiding future work in stats models, reliability studies, and lifetime data work.

Conflict of Interest: The authors declare no conflict of interest.

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