



AI-Powered Citation Classification: Understanding Contrasting and Supporting Citations in Scholarly Research

Suruchi Jangid^a and Prof. Rupak Chakravarty^b

^aResearch Scholar, Department of Library and Information Science, Panjab University, Chandigarh, Pin 160014, India.

E-mail: suruchi.j@pu.ac.in

^bProfessor, Department of Library and Information Science, Panjab University, Chandigarh, Pin 160014, India.

E-mail: rupak@pu.ac.in

Received: 24 May 2025; Accepted: 28 July 2025

Citations play a critical role in the assessment of scholarly research. This study employs scite.ai, an artificial intelligence-based citation tool, which classifies citations into three categories: supporting, contrasting, and mentioning. The objective of the study is to explore the relationship between these citation types—particularly supporting and contrasting citations—and total citation counts in journals published by Elsevier. Using the journal-level search feature provided by Scite, data were manually collected from 3,151 Elsevier journals. Key metrics analysed include the Unweighted Scite Index (USI), total citation count, and the distribution of supporting, contrasting, and mentioning citations. Descriptive statistics and correlation analyses were conducted to examine these relationships. The results reveal statistically significant and positively correlated associations ($p < 0.01$) between supporting, contrasting, and total citation counts, highlighting a meaningful linkage between citation polarity and overall citation impact in scholarly publishing.

Keywords: Scite, AI, Citation Analysis, Supporting, Contrasting/Disputing, Mentioning

Introduction

Citations are a commonly used metric to evaluate an author or journal. The number of citations is used to assess the quality of a publication, author, and institution (Aksnes et al., 2019). The number of citations indicates the frequency of references to a work. The more citations an article has, the more influential it is considered, but here all citations are considered equally and given equal weight (Rüdiger et al., 2021).

However, this citation count does not clarify the types of citations that individual articles, authors, and institutions have received. Not all citations have equal significance. The author's intent in referencing an article may vary. They can either support, mention, or oppose the article's findings in their own work. These reasons explain why an article is cited. Nevertheless, assigning equal significance to each citation could be considered a limitation of research evaluation criteria. Nicholson et al. (2021) highlighted the limitations of traditional citation indices, which often fail to convey the context behind citations. They suggest that without understanding the intent of citations—whether they support or contradict the referenced work—research evaluation may be misleading. The

citation context can be an additional metric in the evaluation of any journal, author, and article.

Understanding the reasons behind citations is important because contradictory research plays a significant role in research. Karl Popper's falsification theory posits that a scientific hypothesis must be falsifiable; it must be testable and able to be disproven. He contended that scientific advancement occurs via audacious theories and their disproof, rather than by validation (Popper, 2002). Conflicting research can lead to attempts to verify the accuracy of research and potentially lead to new knowledge. Ranganathan's spiral of the scientific method generates theories and hypotheses at the peak, while the ascending stage derives empirical rules. In the descending stage, we test these theories and hypotheses that emerge from the development of new inferred knowledge through additional observation, experimentation, and experience. If the test results contradict the theories and hypotheses, the cycle begins again, with new empirical evidence accumulating at the lowest level (Ranganathan, 1957). Citation context can also highlight aspects of a work that require further theory and empirical testing, which can significantly change the interpretation of a

given work or even explain why a claim is incorrect (Anderson & Lemken, 2023). Researching contrasts can improve existing knowledge, leading to the discovery of new knowledge. By pointing out weaknesses and limitations in earlier studies, negative citations can enhance the quality and rigour of scientific research (Catalini et al., 2015).

The type of citation plays a crucial role in the process of knowledge creation, but it's often overlooked. By examining different types of citations, we can learn more about how they increase knowledge. This paper examines the relationship between contrastive, supportive, and total citations in journals published by Elsevier. The aim of this study is to examine the types of citations in journals published by Elsevier based on scite data. Through this analysis, we identify a pattern of contrastive and supportive citations in knowledge development.

Scite:

This paper uses Scite.ai, a smart citation index. Scite was Founded in 2018, and it is now part of Research Solutions. Scite contains over 1.3 billion citation statements extracted from more than 187 million scholarly publications and has partnered with more than 30 major publishers to provide researchers with unparalleled access to scientific literature (Scite data and services, 2025). It works by extracting and analysing citation statements in the full text of scientific articles.

Scite uses deep learning models, particularly SciBERT, to categorise citation contexts as supporting, contrasting, and mentioning citations (Nicholson et al., 2021). Unlike traditional citation counts, Scite provides contextual information by indicating whether subsequent research supports, contradicts, or simply mentions a cited claim.

- Supporting citations occur when other researchers cite a paper in a way that endorses or validates its findings, methodology, or conclusions.
- Contrasting citations refer to instances where a study is cited to present conflicting findings, criticisms, or alternative interpretations. These may challenge the cited work's assumptions, methods, or conclusions.
- Mentioning citations are neutral references, used to acknowledge a source without necessarily supporting or disputing its claims.

Scite also provides the Unweighted Scite Index, which measures the level of scholarly consensus around a paper. It is calculated by dividing the

number of supporting citation statements by the total of supporting and contrasting statements. This indicates how much a paper is supported relative to the criticism it receives.

Scite does not classify citations based on positive or negative sentiment. As noted by Scite, "citations are classified by rhetorical function, not by positive or negative sentiment." For instance, a supporting citation might contain negative sentiment (e.g., supporting a critique), and a contrasting citation could contain positive sentiment. Therefore, sentiment and rhetorical function are not correlated.

To enhance accuracy, Scite combines automated machine learning classification with human curation, allowing researchers to review and, when necessary, correct citation classifications (Cordova, 2024). This human-in-the-loop feature ensures higher reliability in understanding how scientific works are being cited.

Research Questions:

The study focuses on the issue of not paying attention to different types of citations (contrasting, supporting, and mentioning), which is an important factor that is often ignored. It suggests using the Scite smart citation index as a possible solution to this problem.

RQ 1: Do total citations and contrasting citations have a statistically significant and positive correlation?

RQ 2: Do total citations and supporting citations have a statistically significant and positive correlation?

RQ 3: Do contrasting and supporting citations have a statistically significant and positive correlation?

Research Methodology:

This study analysed how Elsevier journals receive mentions, supporting, and contrasting citations using Scite's journal-level search.

The data for this study was collected manually by searching for the publisher name "Elsevier" using the Scite search feature for journals. The dataset included information on total citations, contrasting citations, supporting citations, mentioning citations, and the Unweighted Scite Index (USI) for each journal. Initially, data was gathered for 4,152 journals published by Elsevier. After identifying and removing 1,001 duplicate journal entries, the final dataset comprised 3,151 unique journals. Among these, the USI was available for only 2,052 journals, as 1,099 journals did not meet the required threshold of at least

100 supporting and contrasting citations within the measurement period set by Scite to calculate the USI.

A descriptive statistical analysis was used to summarise and explore the key features of the dataset. This included calculating measures of central tendency (mean, median) and dispersion (standard deviation, range) and identifying distribution patterns. To further understand the relationships between key variables, Pearson correlation analysis was conducted between supporting citations, contrasting citations, and total citations—three metrics commonly used to assess the impact and influence of academic research. All statistical analyses were performed using Jamovi and JASP, which are open-source statistical software platforms designed for robust data analysis in bibliometric and social science research.

Study Limitation:

- This analysis solely took Elsevier into consideration as a publisher. Data from a single publisher may not provide a comprehensive view.
- Also, as Scite ingests millions of scientific papers (500k PDFs every day), the findings may vary with time.

Results and Discussion:

3151 Elsevier journals were extracted from Scite. Among these 3151 journals, 2642 (or around 83.84%) contain contrasting citations, whereas 509 journals have no contrasting citations at all. Regarding

supporting citations, there are 2968 journals with supportive citations (about 94.91%) and 183 journals with no supportive citations. The 3147 journals mention citations (about 99.90%), while 4 journals have none at all.

Table 1 presents descriptive statistics for the USI and citation metrics of 3151 journals published by Elsevier. The table shows different averages and ranges for each variable related to the USI, total, contrasting, supporting, and mentioning citations.

USI data is derived from 2052 journals, as 1099 publications lacked at least 100 supporting and contrasting citations during the measurement period to qualify for an SI.

As the data below illustrates, the average number of contrasting citations received, lower than that of support and mention citations, reflects a meaningful level of critical engagement and scholarly debate. In contrast, the notably high average for support citations suggests that the journal's articles are widely validated and frequently referenced, indicating strong integration within the broader academic discourse. Together, these patterns suggest that while journal articles are primarily supported and referenced, they also undergo meaningful scrutiny, which contributes to a balanced and dynamic academic discourse.

The USI's standard deviation points toward very small variance in the degree of support for the publications. The total number of citations' standard deviation highlights the wide range of citation counts.

Descriptives Table 1

	USI	Total Cites	Contrasting Citations	Supporting Citations	Mentioning Citations
N	2052	3151	3151	3151	3151
Missing	1099	0	0	0	0
Mean	0.893	79368	401	3430	73483
Std. error mean	0.000939	3903	19.8	173	3650
95% CI mean lower bound	0.891	71714	362	3090	66326
95% CI mean upper bound	0.895	87021	440	3769	80640
Median	0.9	12741	43	380	11508
Mode	0.94	1	0	0	1
Sum	1833	250087341	1263861	10806455	231544728
Standard deviation	0.0425	219108	1112	9721	204893
Variance	0.00181	48000000000	1240000	94500000	42000000000
Range	0.26	6244777	23384	230063	5943929
Minimum	0.73	1	0	0	0
Maximum	0.99	6244778	23384	230063	5943929
Skewness	-0.312	12.6	8.18	9.26	12.9
Kurtosis	-0.539	271	110	141	283
Shapiro-Wilk W	0.977	0.334	0.368	0.349	0.33
Shapiro-Wilk p	< .001	< .001	< .001	< .001	< .001

Note. The CI of the mean assumes sample means follow a t-distribution with N - 1 degrees of freedom

The USI has a range of 0.260, which shows a wide variation in the level of support for the publications. The total number of citations ranges from 6,244,777, suggesting a large variation in citation counts.

The skewness and kurtosis measurements reveal the shape and distribution of the variables. While kurtosis measures the distribution's peakedness or flatness, skewness measures the distribution's asymmetry. The results for skewness and kurtosis indicate that the variables have various distributions. A somewhat flat and less peaky distribution is shown by the USI variable's slightly left-skewed distribution (-0.312) and slightly negative kurtosis (-0.539). The total number of citations variable has a sharper peak and a longer tail on the right side, which means it is right-skewed (12.6) and has positive kurtosis (271). Examining the data's normality is done using the Shapiro-Wilk test. The result indicates a deviation from normality since all variables have extremely low p-values (< 0.001).

Table 2 lists the top 10 USI journals published by Elsevier. All of these ten journals relate to mathematics and computer science. The proportion of supportive citations in journals related to mathematics and computer science is higher. Generally, this indicates that the scientific community has widely accepted and validated the research findings. It reflects a consensus among researchers. This endorsement may also indicate that the research addresses important questions, solves significant problems, or promotes fresh exploration in the discipline.

Table 3 lists the bottom 10 USI journals published by Elsevier. Each of these ten journals has a medical focus. This implies that journals related to medicine have a higher proportion of contrasting citations. This evidence suggests that medical science journals receive more criticism or opposing views, indicating that new knowledge is generated when research that contradicts previously established theories or widely accepted practices in medical science is published. This field needs further research to address gaps.

Tables 4 and 5 provide a top 10 list of Elsevier journals ranked by their contrasting and supporting citation counts. These tables rank the journals in descending order based on their contrasting and supporting citation counts.

Out of these journals, three journals are from the field of medicine: The Lancet, Gastroenterology, and Journal of the American College of Cardiology; four journals are in the field of biochemistry:

Table 2 — Top 10 USI Journals

S N	Journal	USI
1.	Journal of Geometry and Physics	0.99
2.	Bulletin Des Sciences Mathématiques	0.99
3.	Journal of Functional Analysis	0.98
4.	Advances in Mathematics	0.98
5.	Stochastic Processes and Their Applications	0.98
6.	Journal of Algebra	0.98
7.	Linear Algebra and Its Applications	0.98
8.	Journal of Combinatorial Theory Series	0.98
9.	Journal of Approximation Theory	0.98
10.	Finite Elements in Analysis and Design	0.98

Table 3 — Bottom 10 USI Journal

S N	Journal	USI
1.	The Saudi Journal for Dental Research	0.73
2.	Hellenic Journal of Cardiology	0.74
3.	Revue des Maladies Respiratoires	0.77
4.	Journal of Gynecology Obstetrics and Human Reproduction	0.77
5.	International Journal of Obstetric Anesthesia	0.78
6.	International Journal for Parasitology Parasites and Wildlife	0.78
7.	The Saudi Dental Journal	0.78
8.	Anaesthesia Critical Care & Pain Medicine	0.78
9.	Journal of Taibah University Medical Sciences	0.78
10.	Journal of Exotic Pet Medicine	0.78

Table 4 — Top 10 journal with Contrasting Citations

S N	Journal	Contrasting Citations
1	The Lancet	23384
2	Cell	18967
3	SSRN Electronic Journal	14943
4	Brain Research	10720
5	Food Chemistry	10718
6	Neuron	10440
7	Gastroenterology	10173
8	Biochemical and Biophysical Research Communications	9966
9	Journal of the American College of Cardiology	9750
10	Neuroimage	9723

Table 5 — Top 10 journal with Supporting Citations

S N	Journal	Supporting Citations
1	Cell	230063
2	SSRN Electronic Journal	134325
3	The Lancet	129984
4	Neuron	124134
5	Journal of Molecular Biology	103674
6	Brain Research	100270
7	Biophysical Journal	99936
8	Neuroimage	96916
9	Biochemical and Biophysical Research Communications	95318
10	Food Chemistry	78422

Cell, Biochemical and Biophysical Research Communications, Journal of Molecular Biology, Biophysical Journal; and three journals are from the field of neuroscience: Brain Research, Neuron, and Neuroimage. One journal is from the field of agricultural and biological sciences: Food Chemistry. One journal is from the field of social sciences: SSRN Electronic Journal. The Lancet journal received the highest number of contrasting citations, and Cell Journal received the highest number of supporting citations. The results showed that fields such as medicine, biochemistry, social sciences, neuroscience, agriculture, and biological sciences had higher proportions of contradictory and supportive citations, suggesting that these fields have a balanced academic environment because validation and critical engagement exist simultaneously, promoting a rich and dynamic scholarly discussion. Researchers in these fields engage more in academic writing to examine opposing views, evaluate the wisdom of findings, and also validate previous work.

Correlation Analysis

Table 6 presents the correlation coefficient, denoted "r," shows how strongly and in which direction two variables are related linearly. The correlation coefficient's value is always in the range of -1 and +1. The numbers +1, -1, and 0 indicate whether there is a positive, negative, or no connection between two variables. Strong positive relationships are those between 0.7 and 1.0, moderate positive

relationships are those between 0.3 and 0.7, and weak positive relationships are those between 0 and 0.3. If the p-value is less than 0.05, the correlation coefficient is statistically significant.

Table 6 and Figure 1 show the Pearson correlation coefficient (r) between total citation and contrasting was found to be 0.885; contrasting and supporting is 0.927, while its value for the correlation between supporting and total citation was 0.948 (Table 2). The finding suggests that they are strongly positively correlated, as seen by their respective values, which indicate a highly positive relationship. The association is statistically significant because the P value is less than 0.01, according to the data. It demonstrates that as the total number of citations increases, so do the contrasting and supporting citations, and that as the contrasting citations increase, so do the supporting citations.

Total, supporting, and contrasting citations all demonstrate very strong positive correlations as indicated by their respective correlation analysis scores. The association is statistically significant since the P value is less than 0.01, according to the data. It indicates that the contrasting and supporting citations rise in number as the total number of citations does, and that the supporting citations increase in number as

	Total Cites	Contrasting	Supporting
Total Cites	Pearson's r — p-value —		
Contrasting	Pearson's r 0.885 *** p-value < .001	—	
Supporting	Pearson's r 0.948 *** p-value < .001	0.927 ***	—

Note. * p < .05, ** p < .01, *** p < .001

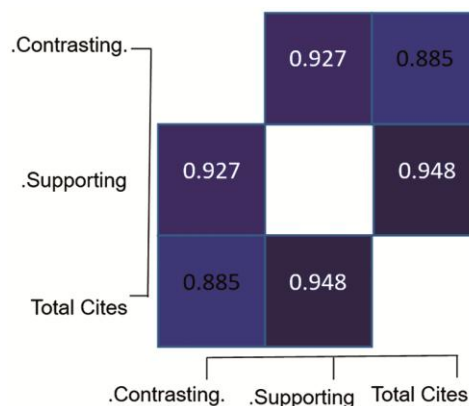


Fig. 1 — Pearson's r heatmap

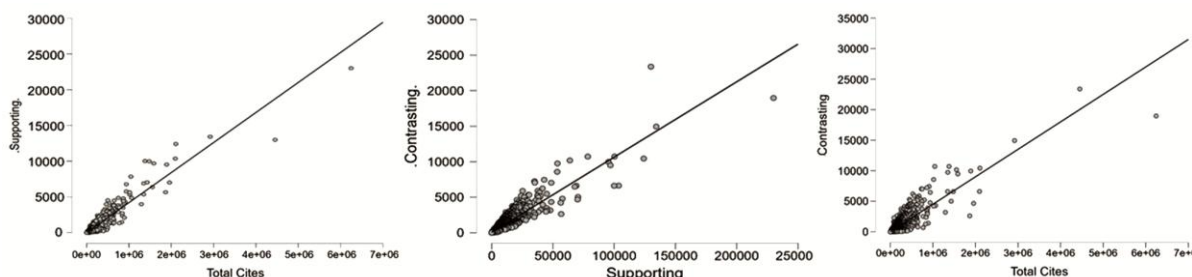


Fig. 2 — Correlation plot

the contrasting citations do. It indicates active engagement and debate within the scientific community and highlights the importance of the topic. This correlation reflects rigorous scrutiny and validation, which contributes to the advancement of knowledge. Both supportive and contradictory quotes demonstrate a balanced approach, ensuring that findings undergo rigorous testing instead of blind acceptance. This dynamic interaction helps identify areas in need of further research, guiding future studies to address gaps or inconsistencies, ultimately leading to a more comprehensive understanding of the topic.

Conclusion

The correlation analysis showed that there was a meaningful and positive relationship between total citations and contrasting citations, total citations and supporting citations, and between contrasting and supporting citations for research published in Elsevier journals. Scite.ai's "Citation Analysis" feature offers researchers a detailed perspective on how peers cite their or others' scientific papers. This categorisation, such as supporting, mentioning, or contrasting citations, provides valuable insights about the reception and impact of research papers in the scientific community. Researchers can use supporting citation information to identify influential papers in their field and to build on well-established research foundations. Mentioning citations can be useful for them to identify related studies or to situate their own work within a larger body of literature. Contrasting citations play a pivotal role in the growth and refinement of global knowledge capital. By highlighting disagreements, discrepancies, and alternative viewpoints within the scientific literature, they stimulate rigorous debate and critical examination of existing research. This process fosters innovation, encourages researchers to address knowledge gaps, and ultimately leads to more comprehensive and reliable knowledge bases. In a world where information is constantly evolving, the presence of contrasting citations ensures that our collective understanding continually adapts and improves, ultimately enriching the global repository of knowledge across diverse fields of study. This cross-disciplinary perspective can

be valuable for understanding the broader impact of scientific research.

References

Book

Popper K R, *The logic of scientific discovery*, Reprint edn, Routledge, London, 2002.

Periodicals

- 1 Aksnes D W, Langfeldt L and Wouters P, Citations, citation indicators, and research quality: An overview of basic concepts and theories, *SAGE Open*, 9(1) (2019). <https://doi.org/10.1177/2158244019829575>
- 2 Anderson M H and Lemken R K, Citation context analysis as a method for conducting rigorous and impactful literature reviews, *Organizational Research Methods*, 26(1) (2023) 77–106. <https://doi.org/10.1177/1094428120969905>
- 3 Catalini C, Lacetera N and Oettl A, The incidence and role of negative citations in science, *Proceedings of the National Academy of Sciences of the United States of America*, 112(45) (2015) 13823–13826. <https://doi.org/10.1073/pnas.1502280112>
- 4 Nicholson J M, Mordaunt M, Lopez P, Uppala A, Rosati D, Rodrigues N P, Grabitz P and Rife S C, Scite: A smart citation index that displays the context of citations and classifies their intent using deep learning, *Quantitative Science Studies*, 2(3) (2021) 882–898. https://doi.org/10.1162/qss_a_00146
- 5 Ranganathan S R, Library Science and Scientific method, *Annals of Library Science*, 4(1) (1957)19–32. [https://nopr.niscpr.res.in/bitstream/123456789/28515/1/ALIS%204\(1\)%2019-32.pdf](https://nopr.niscpr.res.in/bitstream/123456789/28515/1/ALIS%204(1)%2019-32.pdf)
- 6 Rife S C, Rosati D and Nicholson J M, Scite: The next generation of citations, *Learned Publishing*, 34(3) (2021) 454–456. <https://doi.org/10.1002/leap.1379>
- 7 Rüdiger M S, Antons D and Salge T-O, The explanatory power of citations: A new approach to unpacking impact in science, *Scientometrics*, 126(12) (2021) 9779–9809. <https://doi.org/10.1007/s11192-021-04103-w>

Websites

- 8 Cordova J, How are citations classified?, Research Solutions Help & Support Center, Available at <https://help.researchsolutions.com/hc/en-us/articles/31949617584148-How-are-citations-classified> (Accessed on 25 July 2025).
- 9 Elsevier, This is Elsevier, Available at <https://www.elsevier.com/about/this-is-elsevier> (Accessed on 25 July 2025).
- 10 JASP, JASP (Version 0.17.2.1), Available at <https://jasp-stats.org/> (Accessed on 20 July 2025).
- 11 Jamovi, Jamovi (Version 2.6), Available at <https://www.jamovi.org/> (Accessed on 20 July 2025).
- 12 Scite, Scite data and services, Available at <https://scite.ai/data-and-services> (Accessed on 20 July 2025).