Beyond Boundaries: Collaboration Networks and Research Output in Brazilian Computer Science

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Abstract. *This paper examines collaborative dynamics within Brazilian computer science research through network analysis and bibliometric methods. Although Brazil demonstrates a high level of publication output, its collaboration reveal certain limitations, which may explain the comparatively low citation impact of its research. Therefore, we use network analysis to address two key questions: (1) to what extent do Brazilian subfields engage in collaborations with researchers and institutions internationally, and (2) how do collaboration levels vary among the different subareas of Brazilian Computer Science research? Our results demonstrate varied collaboration patterns across computer science subfields: theoretical areas favor international partnerships, while applied areas prefer domestic collaborations. We identified few "bridge" researchers as key structural elements in high-impact networks. We also mapped these networks and demonstrated the link between strategic international partnerships and research impact, offering insights for improving collaborations and evaluation policies.*

1. Introduction

There is widespread agreement that collaborations, domestic or international, serve as a key metric for assessing the quality and relevance of postgraduate programs and research proposals. Researchers are subject to evaluations that scrutinize publication counts, citation metrics, journal impact factors, and collaborative networks, with international partnerships often conferring enhanced prestige and visibility [Ramos 2017]. Consequently, the existing evaluation system may exert pressure on researchers to pursue collaborations with authors from other subfields or other countries, potentially leading to shifts in academic research priorities. A notable example can be found in the domain of computer science, which has experienced remarkable growth and transformation in recent decades [Bird et al. 2009, Wainer et al. 2009, Madaan and Jolad 2014].

Despite significant global growth in computer science research, regional disparities persist in research output, citation impact, and international participation. Emerging research communities, such as Brazil's, clearly demonstrate this disparity. While Brazil holds the 12th spot in global computer science publication output, an examination of its domestic and international collaborations suggests a possible link to reduced citation impact when compared to leading countries. In this context, understanding the collaborative structures that underpin successful research ecosystems becomes essential for countries seeking to enhance their global scientific position. Collaboration networks provide valuable insights into knowledge production dynamics and can help identify strategic pathways for strengthening research communities. This analytical approach is particularly relevant for

Brazil, where computer science research has exhibited consistent growth but continues to face challenges in achieving worldwide recognition proportionate to its publication volume. By examining these networks, we can better understand the structural dynamics of research collaborations, additionally, we might get insights of scientific trends and their impact in Brazilian computer science.

The present study examines the collaborative dynamics within Brazilian computer science research through network analysis and bibliometric methods. Our investigation addresses two key motivating questions:

- **Q1:** To what extent do Brazilian computer science engage in collaborative research with international researchers and institutions?
- **Q2:** How do collaboration levels vary among the different subareas of Brazilian Computer Science research?

To address the proposed motivating questions, we conduct a comprehensive analysis using data from OpenAlex, focusing on publication trends, citation metrics, and co-authorship relations from 2015 to 2024. Our findings reveal notable variations in collaboration intensity among different subfields, reflecting the diverse research cultures. Based on our analysis, we offer three significant contributions to the understanding of research collaboration in computer science:

- We quantify international collaboration rates by classifying publications as internationally collaborative when at least one co-author is affiliated with a non-Brazilian institution. Our analysis compiles 11 computer science subfields, presenting detailed collaboration metrics, partner country distributions, and citation performance across international and domestic publications;
- We mapped interdisciplinary collaboration patterns by assigning each author a primary subfield based on publication history and categorizing publications as single-subfield or multi-subfield. Our approach enables a nuanced examination of interdisciplinary engagement, revealing publication rates, citation averages, and the frequency of authors publishing across different computer science subfields;
- By leveraging network visualization techniques, we identify that high-impact networks feature few "bridge" researchers who connect different research communities and countries, facilitating knowledge transfer.

This paper is structured as follows: Section 2 reviews prior work on collaboration networks in computer science research. Section 3 outlines our methodology, including data collection and analytical techniques. Section 4 presents an overview of the global research landscape in computer science. Sections 5 and 6 address our motivating questions by analyzing international collaboration patterns and subfield network differences, respectively. Finally, Section 7 concludes the paper and proposes directions for future research.

2. Related Work

Early studies established key structural features of scientific collaboration using network science. [Newman 2001a, Newman 2001b] observed power-law distributions in productivity across physics, biomedicine, and computer science, and introduced weighted networks to reflect co-authorship frequency. These works also revealed that theoretical fields have fewer collaborators than experimental ones. [Barabási et al. 2002] demonstrated scale-free networks with preferential attachment in mathematics and neuroscience journals. [Newman 2004] compared collaboration networks in biology, physics, and mathematics, finding consistent small-world properties and reinforcing essential network characteristics: scale-free structure, preferential attachment, temporal evolution, and disciplinary differences. [Elmacioglu and Lee 2005] confirmed the "six degrees of separation" phenomenon and power-law distribution using DBLP data, demonstrating rising clustering coefficients over three decades. [Madaan and Jolad 2014] analyzed DBLP data, revealing an increase in computer science collaboration and average authors per publication.

2.1. International Collaboration

Studies on international scientific collaboration have evolved methodologically and in geographic scope. Initially, [Luukkonen et al. 1993] proposed fundamental metrics, distinguishing between absolute and relative measures to analyze collaboration. [Guan and Ma 2004] applied these metrics to six countries (USA, UK, Germany, Japan, India, and China) between 1993 and 2002, highlighting the dominance of the USA in computer science publications and the decreasing international visibility of China due to the rapid increase in its publications. In a study on international research collaboration in China, [Niu and Qiu 2014] revealed a significant increase in such collaborations, with a concentration of over 80% of internationally co-authored publications occurring in partnerships with scientifically advanced countries.

[Wainer et al. 2009] compared Brazil with other Latin American countries, BRIC countries, and developed economies, concluding that, although Brazil led in the region, it still lagged behind the global leaders. [Delgado-Garcia et al. 2014] complemented this analysis by documenting the growth of coauthorship networks in Latin America (1994-2013), with strong ties between Brazil-Chile and Argentina-Brazil. In the intra-national context, [Pessoa Junior et al. 2022] analyzed interdisciplinary collaborations in Brazil, showing that geographic proximity influences collaboration networks, reflecting regional economic disparities. More recently, [Okamura 2023] analyzed half a century of global scientific collaboration using OpenAlex data, highlighting the growth of China and a global "Shrinking World" phenomenon, with increased collaboration but a post-2019 divergence between the US and China. [Haunschild and Bornmann 2024] explored the use of OpenAlex to create global bibliometric maps, demonstrating normalization techniques for meaningful comparisons across authors and institutions.

2.2. Computer Science Disciplinary Patterns

Studies utilizing network analysis of computer science collaboration patterns have revealed distinct variations across specializations. Using DBLP data, [Bird et al. 2009] demonstrated significant interdisciplinary differences, with Data Mining and Software Engineering exhibiting high collaboration, while Theory and Cryptography showed more isolated patterns. This was further supported by [Biryukov and Dong 2010], who tracked community evolution from 1970 and found that Algorithms & Theory, Cryptography, and Programming Languages favored smaller, less connected collaborations, contrasting with the high intensity seen in Computational Biology and Web areas. [Franceschet 2011] corroborated Lotka's law for computer science productivity using DBLP data from 1936 to 2008, characterizing computer science collaboration as moderate compared to other fields, and noting higher collaboration intensity in conference papers, reflecting the conference-centric culture of the field.

[Chakraborty 2018] further quantified interdisciplinarity using Reference and Keyword Diversity Indices, confirming a steady increase in interdisciplinary research, particularly in Web and Data Mining, compared to traditional areas. Beyond collaboration, impact analysis reveals subfield disparities. [Druszcz and Vignatti 2024] found significant citation differences within Brazilian computer science, with Computer Vision receiving substantially more citations than Algorithms or Formal Methods. Their research highlighted limitations in applying uniform citation-based metrics across diverse specializations, and propose normalization techniques to enable fairer comparisons across the diverse landscape of computer science.

3. Methodology

We employ OpenAlex [Priem et al. 2022], an open-access scholarly index, for our analysis. It provides comprehensive metadata and, as shown by [Culbert et al. 2024], offers reference coverage and citation rates comparable to proprietary databases like Web of Science and Scopus. Furthermore, [Velez-Estevez et al. 2023] highlight the superior metadata of OpenAlex, including higher ORCID identifier rates, detailed institutional affiliations, and extensive funding information. Our initial exploratory analysis utilized the OpenAlex web GUI[1] to filter for computer science articles and book chapters published between 2015 and 2024. This yielded a dataset with key metrics, including publication count, citation data, open-access percentage, and rankings of countries, universities, subfields, and others.

After initial exploration, we required more detailed data. While OpenAlex provides a full database snapshot, we chose to utilize their API for granular data retrieval, storing the results as CSV files. To effectively use the API, we studied the underlying database model, as illustrated by the simplified entity-relationship diagram in Figure 1.

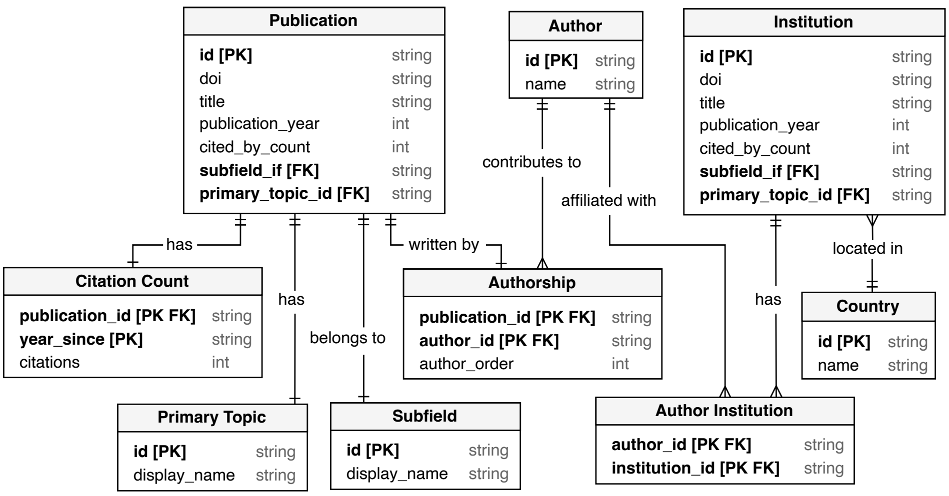

Figure 1. Simplified entity–relationship diagram from OpenAlex database. Adapted from OpenAlex API Documentation.

Figure 2 illustrates our complete *Extract*, *Transform*, and *Load* (ETL) pipeline. The *Extract* phase involved retrieving data from the OpenAlex API using Python scripts

[1] https://openalex.org/

(version 3.13.0). We highlight that the API provides two levels of metadata: *API Response Metadata*, comprising the total record count and citation counts; and *Publication Metadata*, which contains detailed information for each publication (e.g., title, authors, publication year, and country affiliations). This dual-level structure allowed us to efficiently gather both aggregate metrics and granular publication details. For simpler metrics such as publication counts for each country and/or subfield, we utilized only the API Response Metadata. It should be noted that by using exclusively the Response Metadata, we cannot apply specific filters or any data cleaning. Therefore, when it comes to detailed analyses – specifically for Brazilian publications – we retrieved the comprehensive Publication Metadata, which in turn provides much more information. Due to API request limitations, we implemented a batching strategy, to handle pagination constraints (maximum 25 records per request) and organized extraction by logical groups (e.g., one subfield at a time, one country at a time). The output of this phase is raw data stored in CSV.

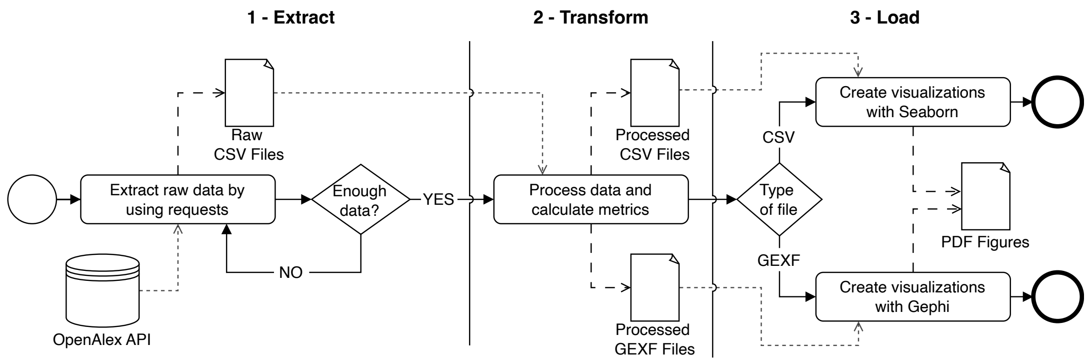

Figure 2. Data collection process.

In the second phase, *Transform*, we consolidated the batched data through concatenation and performed data cleaning to create processed files. For instance, we removed duplicated entries and works without DOI. For collaboration network analysis, we constructed co-authorship networks, where the nodes represent researchers and edges represent collaborative relationships, weighted by collaboration frequency. We exported these networks as GEXF files, by using the Python NetworkX library (version 3.4.2).

Finally, in the *Load* phase, we used two approaches for data visualization: Seaborn (0.13.2) to plot data from CSV and Gephi (0.10.0) for GEXF networks. Both produced PDF figures for publication. The code, extracted dataset, and documentation are available on our public GitHub repository[2].

4. Global Research Landscape

Understanding the global landscape is essential before analyzing Brazilian collaboration patterns. Therefore, in this section, we provide a global overview of computer science research from 2015 to 2024, by using exclusively the *API Response Metadata* from OpenAlex (see Section 3). According to Table 1, Brazil in the 12th position in publication output (76,184), with 447,919 citations. This places Brazil in the mid-range of global productivity, significantly behind leaders like China and the US, but ahead of other Latin American countries. However, Brazilian citation ratio (5.88) is considerably lower than

[2]https://github.com/viniciusmioto/beyond_boundaries

high-impact nations like Australia (22.8), Great Britain (21.62), and the US (20.21), indicating a disparity between publication volume and citation impact.

	Code	Country	Total Publications	Citations	Ratio
1	CN	China	694,103	8,280,834	11.93
2	US	United States of America	474,474	9,590,230	20.21
3	IN	India	311,644	2,224,750	7.14
4	ID	Indonesia	266,047	755,078	2.84
5	DE	Germany	141,044	1,960,782	13.90
6	GB	Great Britain	140,019	3,026,576	21.62
7	JP	Japan	103,265	799,048	7.74
8	FR	France	92,131	1,011,787	10.98
9	CA	Canada	84,076	1,562,176	18.58
10	RU	Russian Federation	83,214	363,210	4.36
11	IT	Italy	80,647	1,021,944	12.67
12	BR	Brazil	76,184	447,919	5.88
13	ES	Spain	75,433	944,337	12.52
14	KR	South Korea	74,421	994,882	13.37
15	AU	Australia	68,502	1,561,906	22.80

Table 1. Research output and citation count (articles and book chapters only) metrics across 15 countries, showing publication volume, cumulative citations, and citation ratios. Data from 2015 to 2024, inclusive.

Figure 3 compares the research priorities of Brazil, China, the United States, and India, revealing unique patterns in Brazilian computer science research profile. Specifically, Brazil shows a clear specialization in Information Systems, maintaining 35-40% of its publications in this area throughout the analyzed period. This is significantly higher than the US (15%) and China, which saw a peak of 20% followed by a decline to 10%. Artificial Intelligence (AI) is Brazilian second most productive area (20-25%), aligning with global trends but with a more moderate focus than the US and China, which saw AI output rise sharply from 30% to nearly 40% between 2015 and 2024. AI is the leading subfield in India, demonstrating a similar growth trend, albeit with less relative disparity. Brazil exhibits lower activity in Computer Vision & Pattern Recognition compared to the other countries. Computational Theory & Mathematics remains a relatively small area (less than 10%) across all four countries.

The stability of Brazilian research distribution across subfields from 2015 to 2024 contrasts sharply with other nations, especially the significant shift of China towards Artificial Intelligence. While data from 2023-2024 shows a slight decrease in Information Systems and increase in AI, the overall stability of Brazil suggests entrenched institutional structures and funding mechanisms that favor continuity rather than realignment. This stability fosters deep expertise in specific domains, but may hinder adaptation to evolving global research priorities.

5. International Collaboration in Brazilian CS Subfields (Q1)

In order to answer our first question, we analyzed international collaboration patterns by classifying publications as internationally collaborative when at least one co-author was affiliated with a non-Brazilian institution. Table 2 demonstrates varying international

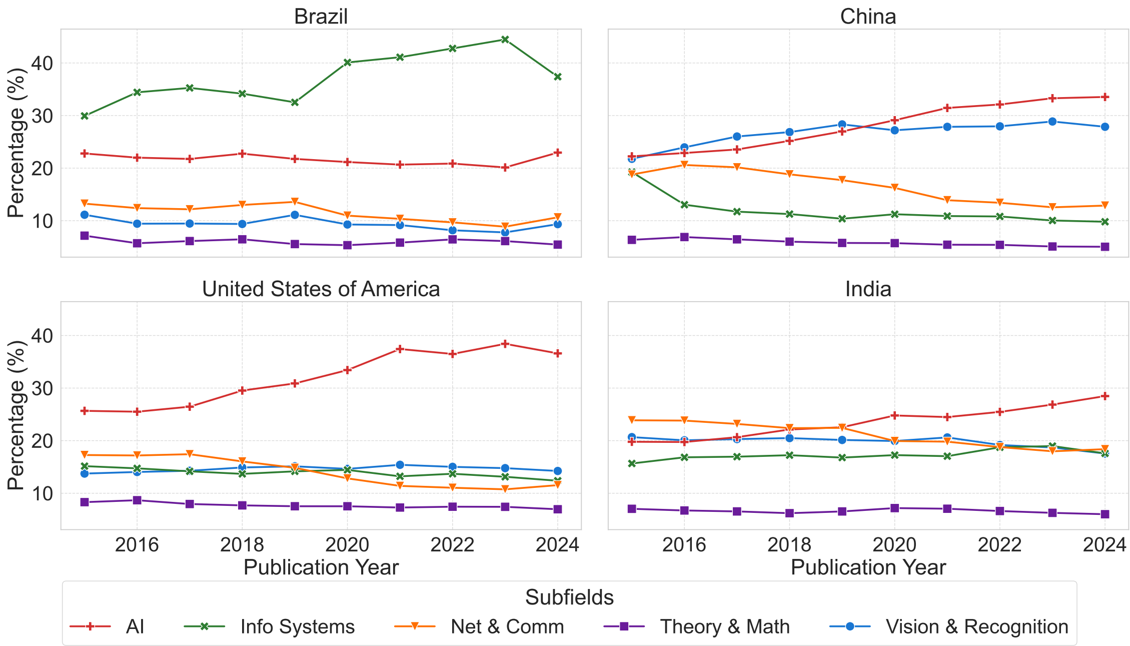

Figure 3. Distribution of publications in the top five computer science subfields for Brazil, China, the U.S., and India (2015–2024), relative to the total publications per year for each country.

collaboration rates across Brazilian computer science subfields. Computational Theory & Mathematics reaches the highest rate (37.46%), followed by Computer Networks & Communications (32.66%). Notably, Information Systems, the subfield with the largest publication volume (22,135), has the lowest international collaboration rate (16.74%). All of the subfields reached higher citation averages on publications with international collaborations.

Subfield	**Domestic-only**			**International Collaboration**		
	Publications	%	Avg. Cit.	Publications	%	Avg. Cit.
Theory & Math	2,471	62.54	5.92	1,480	37.46	13.87
Networks & Comm	5,309	67.34	4.89	2,575	32.66	14.30
Graphics & CAD	251	68.21	3.00	117	31.79	7.82
Hardware & Arch	811	69.38	3.39	358	30.62	6.88
AI	10,009	70.68	5.51	4,152	29.32	14.11
Vision & Recognition	4,470	71.93	6.20	1,744	28.07	14.43
Signal Processing	1,543	72.20	5.60	594	27.80	12.96
Software	583	72.24	4.67	224	27.76	11.17
CS Apps	2,260	74.69	4.60	766	25.31	10.21
HCI	1,443	78.42	4.24	397	21.58	12.35
Info Systems	22,135	83.26	2.16	4,450	16.74	9.95
Total	**51,285**	**75.26**	**3.95**	**16,857**	**24.74**	**12.56**

Table 2. International vs domestic publication in Brazilian computer science.

Figure 4 depicts nuanced international collaboration patterns, showing normalized percentages of non-Brazilian authorship across subfields. Collaboration intensity varies by partner country and subfield. The US is the primary collaborator of Brazil across all subfields, with strong ties in Computational Theory & Mathematics (21%), Computer Graphics & Computer-Aided Design (20.7%), and Hardware & Architecture (20.3%). Portugal emerges as the second most significant collaborator, likely facilitated by shared linguistic and cultural ties. Other European countries like France, Germany, and Spain exhibit specialized collaborations, with France notably engaging in Hardware & Architecture (11.7%) and Computational Theory & Mathematics (9.4%).

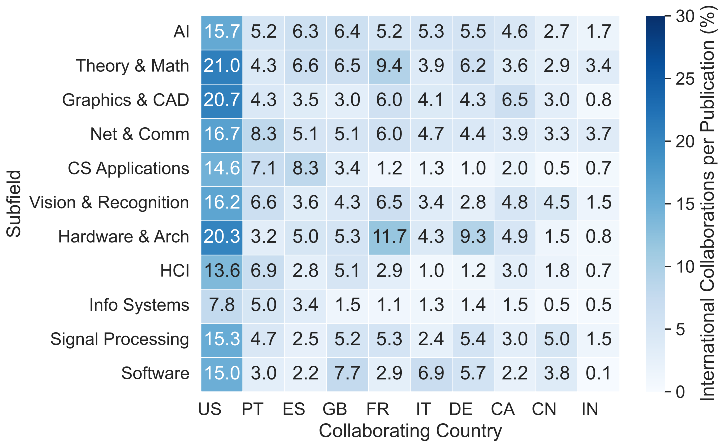

Figure 4. International collaboration heatmap (subfield and country). The percentage of collaborations is normalized by total publications in the subfield.

To examine recurrent collaborations in highly cited publications, we analyzed co-authorship networks, as shown in Figure 5. This network visualization presents recurrent co-authorship relationships in Brazilian computer science publications with at least 40 citations (1,687 publications). Nodes, representing authors, are sized proportionally to their publication count and colored by country affiliations of the authors. Edges, weighted by co-authorship frequency for better visualization, depict collaborative relationships. We filtered out single collaborations and isolated authors to highlight recurrent partnerships, this gave us 1,016 nodes and 2,122 edges. The Fruchterman-Reingold layout algorithm was used to arrange nodes based on their connectivity patterns.

The network features a structure with several small clusters and few larger connected components. The largest component consists predominantly of Brazilian authors (gray nodes) forming a central hub, surrounded by international collaborators. This clustering pattern suggests that while many researchers collaborate within smaller, tightly knit groups, fewer engage in broader international networks. Notably, authors from the United States (dark blue) and European countries such as Italy (light blue), Germany (purple), and France (green) appear frequently in co-authorship relationships with Brazilian researchers. These international collaborations, however, appear concentrated around specific sub-networks rather than being evenly distributed throughout the network.

The collective analysis of these network structures, collaboration rates, and international partnerships express a strong preference for domestic collaboration, with 75.26% of publications involving exclusively Brazilian researchers. While this demonstrates robust internal research capacity, it also highlights potential for expanding international engagement. The pronounced variation in international collaboration rates across subfields, ranging

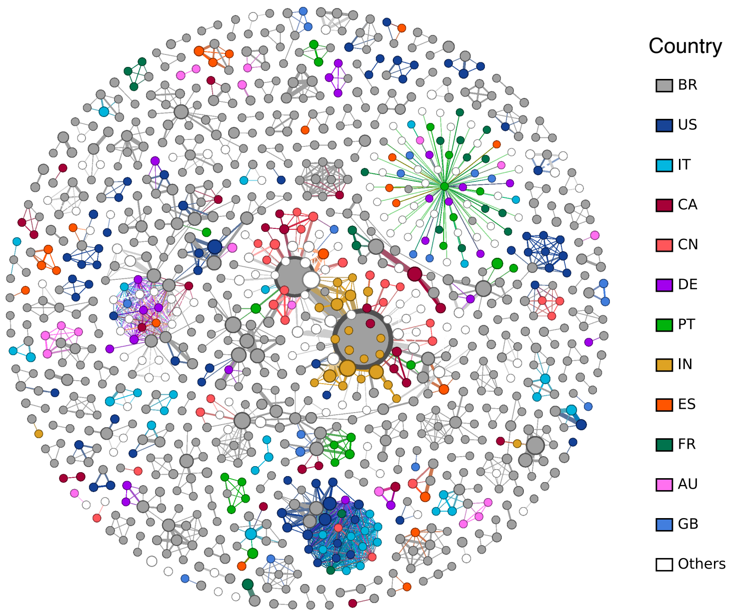

Figure 5. Network of international co-authorship recurrence patterns in Brazilian CS publications with at least 40 citations.

from 16% to 37%, indicates that some computer science domains are more prone to international partnerships than others. Specifically, technical and theoretical fields show higher internationalization, while applied fields like Information Systems and Human-Computer Interaction are more domestically oriented.

6. Collaboration Network Differences Across Subfields (Q2)

Our analysis reveals distinct interdisciplinary collaboration patterns across Brazilian computer science subfields. We assigned each author a primary subfield based on their publication history, then classified publications as *single-subfield* (all authors from same primary subfield) or *multi-subfield* (at least one author from a different primary subfield).

As seen in Table 3, Software leads in multi-subfield publications (57.04%), followed by Signal Processing (53.66%), and Hardware & Architecture (51.40%). However, the two first subfields have a small amount of total publications. In contrast, Information Systems shows the lowest interdisciplinary collaboration rate (12.24%) despite having the largest publication volume, with Theory & Math (17.13%) also favoring single-subfield collaboration. Multi-subfield publications achieve higher average citations (6.53) than single-subfield works (3.53) across all subfields, suggesting a broad advantage for interdisciplinary research. Nonetheless, this advantage is subtle for some subfields like Signal Processing, Hardware & Architecture, and Theory & Math.

Table 4 exhibits which secondary and tertiary subfields authors publish in most frequently beyond their primary specialization, along with the percentage of authors who have published across multiple subfields. Hardware & Architecture researchers appear as the most interdisciplinary authors (19.25%), frequently publishing with Networks & Communications and Artificial Intelligence colleagues. Although Information Systems has the highest number of researchers, it demonstrates the lowest cross-disciplinary engagement, with only 3.62% of its authors publishing in AI and Networks & Communications.

Subfield	Single-subfield			Multi-subfield		
	Publications	%	Avg. Cit.	Publications	%	Avg. Cit.
Software	183	42.96	3.82	243	57.04	4.81
Signal Processing	563	46.34	4.54	652	53.66	4.85
Hardware & Arch	295	48.60	3.18	312	51.40	3.36
Graphics & CAD	108	54.55	2.96	90	45.45	3.44
CS Apps	1,116	57.59	3.30	822	42.41	5.36
HCI	690	58.03	2.83	499	41.97	7.79
Vision & Recognition	2,266	59.76	5.76	1,526	40.24	7.62
Net & Comm	2,970	65.03	5.69	1,597	34.97	6.38
AI	6,252	72.07	5.09	2,423	27.93	7.08
Theory & Math	1,959	82.87	5.70	405	17.13	5.99
Info Systems	15,604	87.76	1.91	2,177	12.24	4.80
Total	**32,006**	**74.86**	**3.53**	**10,746**	**25.14**	**6.12**

Table 3. Summary of single and multi-subfield publications across subfields with corresponding percentages and average citations counts.

Comparing Tables 3 and 4 we noticed a subtle picture of cross-disciplinary engagement among the subfields. While Software and Hardware & Architecture have higher proportions of multi-subfield publications, their overall publication volumes and number of authors are relatively small. In contrast, Artificial Intelligence and Information Systems exhibits a lower percentage of multi-subfield publications, which might suggest a more focused, within-field publication pattern. On the other hand, Table 4 shows that both AI and Information Systems frequently appear as a secondary or tertiary subfield for many authors from other specializations. This juxtaposition reveals that while AI and Information Systems primarily publish within their own domains, they simultaneously serve as critical collaborative partners for researchers from other, less prolific subfields.

Primary Subfield	Authors	Cross-field %	2nd Subfield	3rd Subfield
Hardware & Arch	1,392	19.25	Net & Comm	AI
Signal Processing	2,478	14.77	AI	Vision & Recognition
Net & Comm	10,696	13.77	Info Systems	AI
Vision & Recognition	9,802	13.50	AI	Net & Comm
Software	868	12.44	Info Systems	AI
AI	22,909	9.75	Info Systems	Vision & Recognition
CS Apps	4,788	9.73	Info Systems	AI
HCI	3,039	9.51	Vision & Recognition	Info Systems
Graphics & CAD	537	7.45	Vision & Recognition	AI
Theory & Math	7,151	6.70	AI	Net & Comm
Info Systems	60,121	3.62	AI	Net & Comm

Table 4. Subfields researchers most frequently publish in beyond their specialization and the percentage of authors that have published in other subfields.

In a collaboration network, betweenness centrality measures how often a researcher acts as a "bridge" connecting separate groups in a collaboration network [Freeman 1978]. Betweenness centralization quantifies how reliant a network is on a few key "connectors" to link its members [Bird et al. 2009]. Figure 6 shows Hardware & Architecture consistently maintaining the highest centralization, indicating influential researchers who bridge previously separate research groups. This subfield also experienced dramatic centralization growth until 2022 before declining sharply. AI demonstrated stable, moderate centralization throughout the period, while Software exhibited significant fluctuations suggesting community reorganization. Computer Vision & Patter Recognition shows an increasing peak until 2019, followed by a more stable period, indicating that some researchers have emerged and dominated a big portion of collaborations in the first period. The overall centralization increase until 2022 followed by decline potentially signals a maturing research ecosystem.

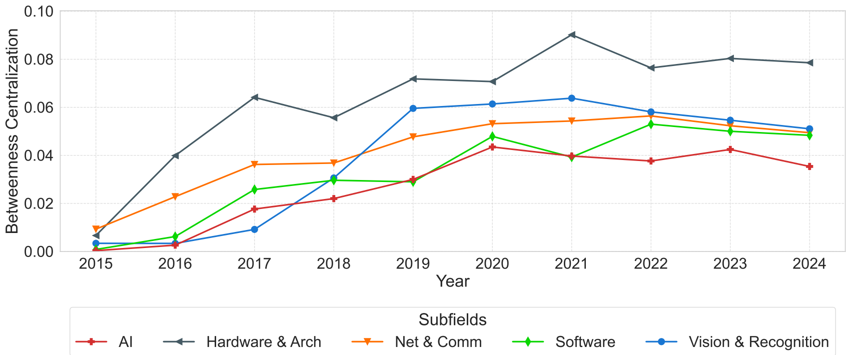

Figure 6. Betweenness centralization of top 5 most centralized computer science subfields in Brazil from 2015 to 2024.

Network visualization by subfield (Figure 7) exhibits distinct clustering patterns, with clear modularity for Information Systems, Theory & Mathematics, and Artificial Intelligence. This indicates that despite cross-disciplinary efforts, highly cited research primarily emerges from within-field collaborations. The exception lies in bridge nodes, researchers connecting otherwise separate communities, who facilitate knowledge transfer across disciplines, particularly between AI and Computer Vision, and between Networks and Information Systems.

These findings collectively demonstrate that Brazilian computer science exhibits significant variation in cross-disciplinary engagement. While AI demonstrates broad collaborative reach, subfields like Computational Theory maintain specialized research ecosystems. Despite some cross-disciplinary engagement, Brazilian computer science remains primarily organized along traditional subfield boundaries, with knowledge transfer largely dependent on a relatively small number of bridging researchers, as suggested by the patterns in Table 3.

7. Conclusions and Future Works

This study analyzes the dynamics of collaboration in Brazilian computer science research, using bibliometric data from OpenAlex and network analysis. Regarding our first motivating question, we found that approximately 75% of Brazilian computer science publications involve exclusively domestic partnerships, yet publications originating from international collaborations tend to have a higher average number of citations. International collaboration is highest in Computational Theory & Mathematics (37.47%) and Computer Graphics & CAD (31.79%), and lowest in Human-Computer Interaction (21.58%) and Information Systems (16.76%). The US is the primary international partner, with European countries

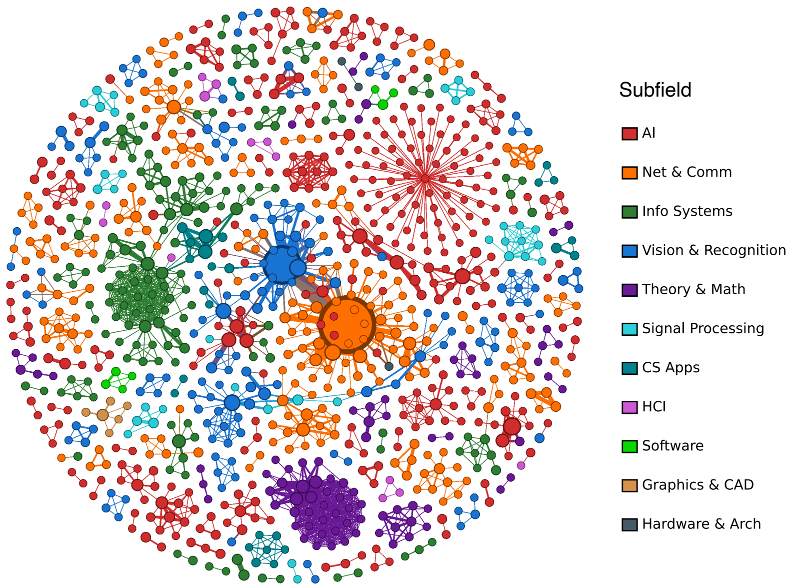

Figure 7. Network of subfield co-authorship recurrence patterns in Brazilian CS publications with at least 40 citations.

(particularly France, Germany, and Spain) showing more specialized collaboration patterns. For the second question, our analysis shows substantial variation in cross-disciplinary collaboration among subfields. Hardware & Architecture researchers exhibit the widest collaborative scope, whereas Computational Theory & Mathematics and Information Systems maintains specialized research ecosystems.

Network centralization metrics indicate bridging researchers are key for collaborations and knowledge transfer, despite Brazilian computer science communities remaining primarily organized along traditional subfield lines. These findings have significant implications for research policy and funding. The focused initiatives to increase cross-border partnerships, particularly in applied areas like Information Systems and AI, might enhance the global impact of Brazilian research. Likewise, supporting key bridging researchers is vital for fostering interdisciplinary innovation.

Finally, our methodology provides a framework for future studies. These could extend the analysis in three key areas: 1) integrate additional databases (Scopus, Google Scholar, DBLP, etc.) to validate findings and improve coverage; 2) explore the impact of institutional factors (e.g., funding, geography, organization) on collaboration patterns; 3) employ other measures of impact and quality beyond research output, citation counts, and averages. These methodological enhancements may disclose previously unrecognized value patterns and foster more equitable evaluation of research contributions across disciplines.

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