

Research on the Influence of International Cooperation of ESI Highly Cited Papers Based on CNCI*

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Abstract: ESI highly cited papers represent the top level of global scientific research papers, and their influence also represents the scientific research strength of institutions. Taking the highly cited papers of Northwest Polytechnical University in May 2022 as an example, this paper analyzes the distribution of countries, institutions and disciplines of international cooperation papers in highly cited papers of ESI based on the CNCI index, explores the forms and characteristics of international cooperation in highly influential papers, and provides reference for establishing high-quality research partnership.

Keywords: Category Normalized Citation Impact, CNCI, ESI Highly Cited Papers, International Collaboration, Influence.

1 INTRODUCTION

With trending scientific statistics drawn from more than 12 million articles from over 12,000 global journals, the Essential Science Indicators (ESI) database provide comprehensive coverage for research performance benchmark and analysis. Based on a 10-year rolling file, Essential Science Indicators is updated every two months. The ESI highly cited papers are publications rank amongst the top 1% on citation counts compared with other papers published in the same field in the same year. They effectively represent the academic achievement and global impact of an research university. Since ESI highly cited papers often exhibit cross institutional collaborations from multiple disciplinaries, an emerging research topic is to characterize the international collaboration and partnership of those papers.

Recent works ^[1-2] leverages bibliometrics to characterize the state-of-art in international collaborations. They provide objective evaluation, but emphasized mostly on Global ^[3] or a country/region ^[4] or a specific discipline ^[5-6], hence failed to capture the diverse institutional partnerships. Meanwhile, most related researches have adopted criterial such as average citing rate ^[3,7] or H-Index ^[8] to represent the impact factor of an international collaboration. But these criterial also suffers from bias since citation rates vary by field and older papers are cited more than recent papers.

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Category Normalized Citation Impact (CNCI) is a valuable and unbiased indicator of impact irrespective of age, subject focus of document type. In this work, we use CNCI to quantitatively analyze the ESI highly cited papers published by Northwestern Polytechnical University (NWPU) in May 2022. We deep dived into the characteristics of the participating countries, institutions, and ESI disciplinaries, to reveal the principles of an influential international collaboration. Our assessment showcased the research status, strength and weakness of NWPU among its international peers. This work aims to provide educated insights for senior leaderships on resource planning and perspective partnership fostering, in hope that NWPU could further advance on the global competitiveness and research impact.

2 DATASET OVERVIEW

2.1 Data Source

We retrieved the top 1% highly cited papers from ESI database (most recently updated on May 2022) on June 12th, 2022, of which are published by NWPU between its 10-year rolling window from January 1st of 2012 to February 28th of 2022.

2.2 Methodology

We first inquires the raw ESI highly cited paper dataset from Web of Science (WOS) database and saved as Excel format, then exported them into Clarivate's InCites analytics platform. Next, we parse the institution, region, subject information from InCites and transformed them into analytical attributes such as publication counts, percentage of international collaborated works, and CNCI values.

Note that we use both institutional name and its physical address to distinguish a unique record. During the data cleansing, we have identified and manually combined some records when a variant of institutional name present that matches with existing record. For example, the record {Nanyang Technological University & National Institute of Education (NIE) Singapore} will be merged with {Nanyang Technological University}

Using the Excel built-in statistic functions, we can pre-process the WOS raw data and parse the collaborators types (i.e., intra-university vs. domestic vs. international) and their statistics. All of the authors / institutions in a paper are weighted equally during our analysis, meaning we count by their appearance, not by the particular order their name presents. For example, if a paper have 3 authors from 2 independent institutes, each authors and institutes gets 1 point. This method are compliant with the principles of unbiased analytics released by ESI and InCites.

3 INTERNATIONAL RESEARCH COLLABORATIONS AND PARTNERSHIPS CHARACTERIZATION

3.1 Anatomy of NWPU Published ESI Highly Cited Papers

Upon our most recent retrieval in May 2022, there are 622 highly cited papers from ESI database are associated with NWPU. The corresponding institutional CNCI value is 13.02, which far exceed the baseline value 1 and global average institutional CNCI value of 1.29, indicating

NWPU is very influential and well positioned among its international peers. Figure 1 portrays the annually ESI highly cited papers count, CNCI trends, and the ratio of international collaborations from year 2012 to 2022. Starting from 2018, the number of NWPU associated ESI highly cited papers have growing rapidly, and peak at 154 papers in 2021. CNCI impact factor during the same period remains relatively flat (except current year 2022) with the low of 7.19 in 2013 and high of 15.0 in 2021. Overall, the ratio of international collaborated papers are trending downwards, with a small rebound in 2022.

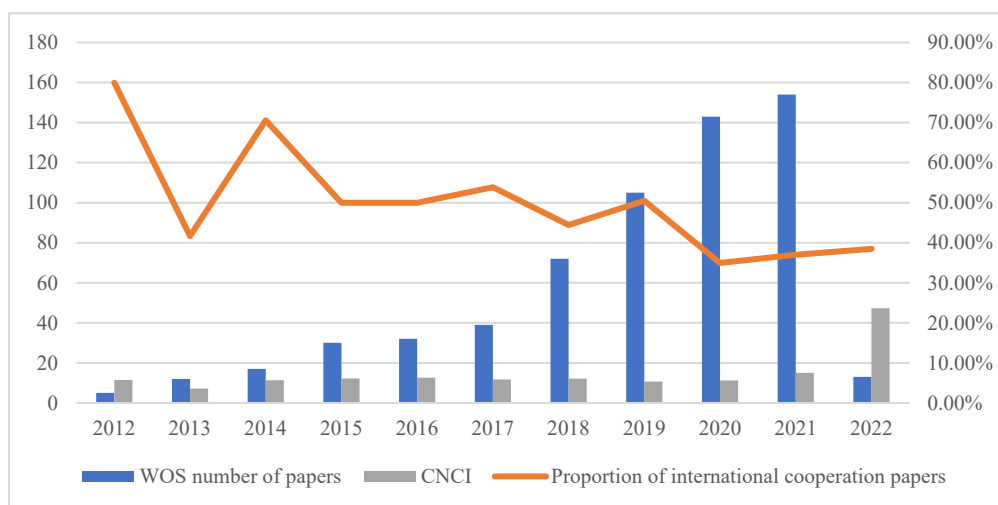


Fig 1. Chronological distribution of ESI highly cited papers

We've labeled the collaboration type of academic entities into: {international collaboration, domestic collaboration, intra-institute collaboration, and no collaboration}. As illustrated in Figure 2, 270 out of 622 or 43.41% highly cited papers are from international collaborations, higher than the domestic collaborations 25.21%, and intra-university collaborations 20.74%. However, the CNCI value of international collaborated papers are among the lowest (i.e., 12.08) in all categories, even lower than NWPU's institutional CNCI value 13.02. It is clear that for NWPU, non-international collaborated papers are more influential.

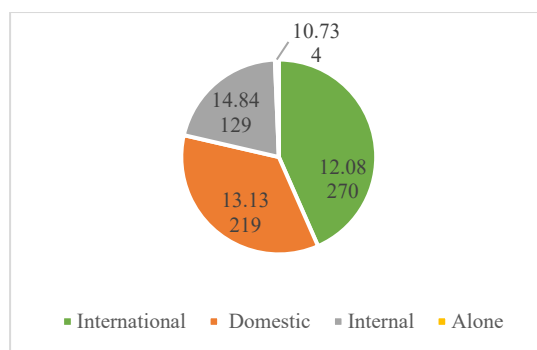


Fig 2. Categories of Collaborations

3.2 The Nationality Characteristic of International Collaborators

The paper's international co-authorship implies there are more than one authors and they are from more than one countries /regions [6]. As more authors from different institutions / countries collaborate on a paper, they expand and deepen the international co-authorship. The breadth and depth of an paper's co-authorship usually reflect the degree of influence of this research on international stage [9].

3.2.1 Co-Authors' Demography

We have identified 50 countries or regions (including Hong Kong, Macau, and Taiwan as regions of China) among 270 internationally collaborated papers. Figure 3 rank the top 11 countries/regions in descending order with their corresponding CNCI impact factor. Overall, each countries has more than 15 coauthored papers with CNCI value higher than 10. Collaborations between NWPU and USA (104) are among the highest, but the respective CNCI value (12.05) are unmatched for the top 3 countries in terms of CNCI value, where Canada is 14.90, Japan is 14.85, and Italy is 14.41. Whereas the collaborations between NWPU and Singapore ranked the 3rd on publications with relatively high CNCI values of 13.65.

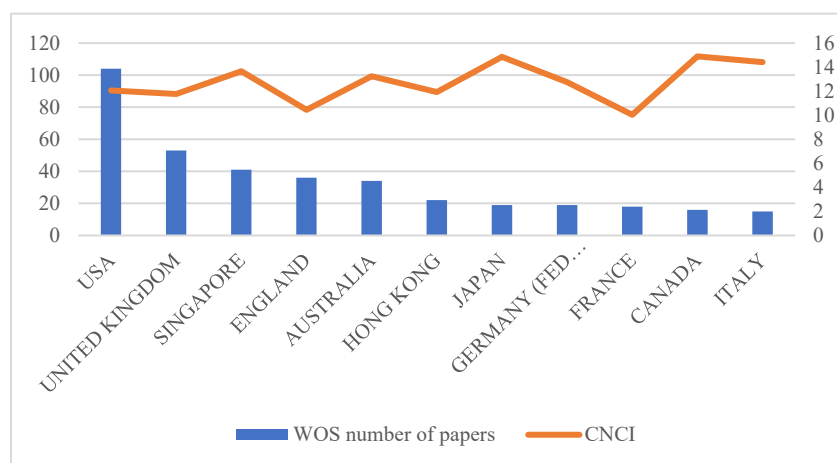


Fig 3. TOP11 Countries and Regions of the International Collaborators

3.2.2 Collaboration Types

Table 1 presents the types of collaborations (number of countries in a coauthored paper) we identified from the 270 internationally collaborated papers. Most frequent types of collaboration are unilateral, meaning two countries or regions coauthoring a paper. Multilateral collaboration where there are more than 5 countries / regions in a research partnership ranks the least frequent types of collaboration, yet their CNCI value are among the highest. It shows the importance of multilateral collaboration and extending partnership to more countries will likely result higher impact research. In our record, the highest degree of multilateral collaboration is from a partnership with more than 15 regions or foreign countries, the corresponding CNCI value is 20.07.

Table 1 Degree of Cooperation

Collaboration Types	Number of Papers	Proportion of Papers(%)	CNCI
Unilateral	168	62.22	12.06421
Bilateral	67	24.81	12.03428
Trilateral	19	7.04	10.39675
Four sided and above	16	5.93	14.44934

3.3 The Institutional Characteristic of International Collaborators

3.3.1 Statistics of the Foreign Collaboration Institutes

Among the 270 internationally collaborated papers, we have identified 347 foreign institutes, including 36 institutes contributing 4 or more papers. In these 36 frequently collaborated institutes, 11 of them are in United States; 6 of them are in France; 3 of them are in Singapore, British, Germany and Australia, respectively; 2 of them in Japan and Russia, respectively; and 1 of each from Italy, Scotland, Sweden, and Wales.

From the collaboration frequency's perspective, NWPU have partnered with Nanyang Technological University for 24 times over the past 10 years, with a CNCI value of 14.58 ranking at the 1st on the list. The second place of the list goes to National University of Singapore (NUS) with 16 coauthored papers and CNCI value is 13.16. Compared with the University of Tennessee System (ranked 3rd place on our list), the coauthored papers with UDICE-French Research Universities have better influential result and a higher CNCI value of 12.01, despite having fewer coauthored papers. Other 2 institutes tied on 4th place of our list are State University of New York System (CNCI is 12.47) and Moscow Institute of Physics & Technology (CNCI is 11.17). More statistics of aforementioned partnership institutes and subsidiaries are highlighted in Table 2.

Table 2 TOP6 Institutional Partnership

Institution Name	International Cooperation Papers	CNCI	Cooperative Secondary Unit(Papers)	ESI subject
Nanyang Technological University	24	14.58	Sch Aerosp & Mech Engn(7); Sch Phys & Math Sci, Div Phys & Appl Phys(5); Sch Chem & Biomed Engn(3); Sch Mat Sci & Engn(3)	Material Science, Chemistry
National University of Singapore	16	13.16	Dept Elect & Comp Engn(6); Dept Chem(5); Dept Mat Sci & Engn(3)	Physics, computer science
University of Tennessee System	14	10.75	Dept Chem Biomol Engn, Integrated Composites Lab(12)	Material Science, Chemistry

State University of New York System	9	12.47	Dept Geosci, Ctr Mat Design(4)	Chemistry ; Physics
UDICE-French Research Universities	9	12.01	Off Natl Etud & Rech Aerosp(2); ONERA French Aerosp Lab(2)	engineering
Moscow Institute of Physics & Technology	9	11.17		Physics; Material Science; Chemistry

3.3.2 The Number of Co-Authoring Institutions

Table 3 shows the collection of coauthoring institutions in each of the 270 internationally collaborated papers. The partnership of NWPU with 3~4 foreign institutions have published more ESI highly cited papers than any other size of partnership. When there are 4 partnering institutions, the publications CNCI value are relatively high (13.30). Whereas the CNCI value peaks at 15.03 when there are 8 or more collaborating institutes. In our record, there is a paper with largest number of partnering institutions (49) coauthored by 92 researchers from 15 countries, including United States, British, Germany, Russia. This paper have a relatively high CNCI of 20.07.

Table 3 Number of Partnering Institutions

Number of Cooperative Institutions	Number of Paper	Proportion of Papers (%)	CNCI
Two	43	15.93%	13.08592
Three	67	24.81%	10.19134
Four	61	22.59%	13.3002
Five	39	14.44%	11.7874
Six	20	7.41%	12.81043
Seven	17	6.30%	8.4299
Eight or more	23	8.52%	15.03308

3.4 The Disciplinary Characteristic of International Collaborators

All 270 internationally collaborated papers are from 16 out of 22 ESI disciplines. As illustrated in Figure 4, Material Science and Engineering having the largest collection of publications with international collaborators, although their CNCI value are not the highest. Mathematics and Physics having the highest CNCI value of 16.54 and 15.42, respectively, followed by Geoscience (14.80) and Clinical Medicine (14.05). Note that these disciplines happen to be the ones that ranked top 1% among all NWPU's discipline. Another coauthored paper between NWPU and NUS in the field of Social Science, has becomes quite influential with CNCI value of 10.56. This paper has contributed considerably in helping NWPU's Social Science becomes top 1% discipline. To summarize, expanding international partnership and

collaborations can improve the research impact of NWPU significantly, especially for disciplines with less degree of internationalization such as Social Science.

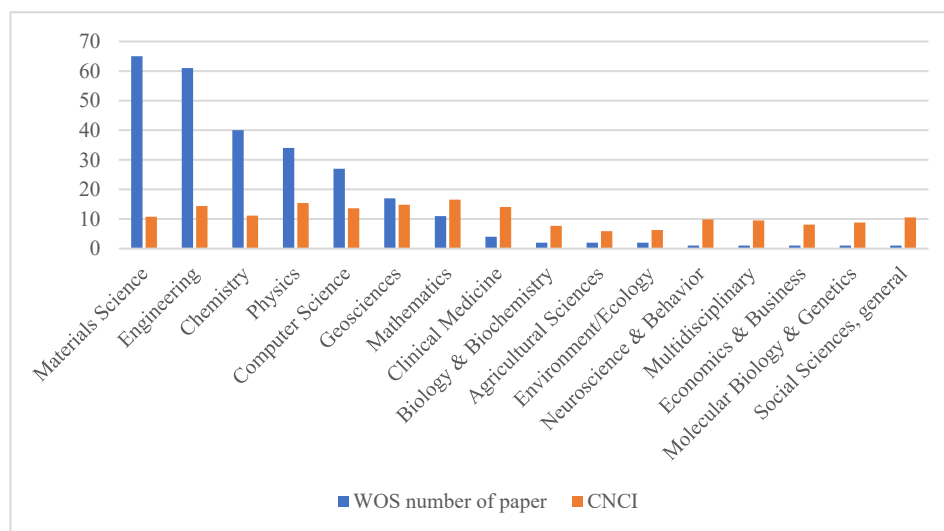


Fig 4. Disciplinary Statistics of International Collaborations

We also cross-referenced the collaborating institutes and their regions with following observations: NWPU had a close partnership with institutes in United States, Saudi Arabia in the field of Mathematics; for Physics, NWPU had more collaborations with institutes in Singapore, United States, British, and Italy, especially had higher influential works with NTU and NUS; in the field of Clinical Medicine, NWPU had often published with University of Sydney and University of Adelaide in Australia, their high quality works all exceeds CNCI value of 12. We should consider expanding our partnership with these institutes in established disciplines, while granting additional resources when recruiting talents from them.

4 CONCLUSIONS AND REVELATIONS

This paper presented a bibliometrics analyze based on CNCI and investigate the impact factors of NWPU's ESI highly cited papers (internationally collaborated portion) from regions, institutions, and ESI disciplines perspective. We have extrapolate the following characteristics from this research:

- (1) The number of ESI highly cited papers are growing over years, with a relatively steady trend on CNCI values, but the percentage of internationally collaborated papers are decreasing. Meanwhile, internationally collaborated papers have a smaller fraction (43.41%) in overall publications than domestic collaboration, but also exhibit lower CNCI values. Both domestic and internal collaborations have higher CNCI values.
- (2) Among the 50 countries that NWPU collaborated with, United States ranks the most frequent collaborator, but the coauthored works' impact factors are unmatched with collaborations with Canada, Singapore, Japan and Italy. In addition, NWPU's collaboration breadth and scale still

have room to improve. We observed the research impact grow with the size of partnership, but currently NWPU still have a large number of unilateral collaborations.

(3) We have identified 347 collaborating institutes, out of which 36 have coauthored more than 4 papers. NWPU and NTU have the largest number of coauthored papers, whereas collaborations with NUS, New York State System, Moscow Institute of Physics & Technology yields high influential papers. Among all internationally collaborated papers, partnership among 3~4 institutes have published more papers than any other size of partnerships. Moreover, collaborations among 4 institutes has the highest CNCI value (13.30) than others. But in general, a paper's impact factor grow with the size of collaborations.

(4) We have identified 16 ESI disciplines among all internationally collaborated papers. Material Science and Engineering having the largest publication base, followed by other highly influential works from Mathematics, Physics, Geoscience and Clinical Medicine. We saw diverged disciplinary characteristics in different countries/regions and institutional variety.

To conclude, NWPU still lack on breadth and depth of international collaborations and partnership. Comparing with the top-tier research universities around the globe, many disciplines' degree of internationalization still have rooms to improve. In the context of China's opening up to the outside world in education and the promotion of "double first-class" construction, more collaborations with foreign institutes can significantly improve the NWPU's degree of internationalization, and further exhibit the influential on the global stage. It also plays critical strategic roles in fostering a beneficial relationship and sharing culture with other countries/regions.

Therefore, NWPU could further expand and deepen of our collaborations with international partner, with emphasis on the quality and outcome rather than quantity of publications. We should hosting more international seminars, exploring visiting and exchange opportunities with foreign partner institutes, alignment with latest scientific trends to broaden our visibilities and upgrade our mentality, to further expand the talent pool of NWPU's research community and improve the impact on global stage.

By fostering and establishing a better visiting scholar exchange program, we can leverage on more resources to boost our own development. And by strategically planning and allocating premium resources, we can strengthen inter-disciplinary cooperation and promoting higher degree of partnership. By exploring potent perspective partners, we can eliminating the gaps between our top disciplines with other fields, enhancing global collaborations in various domain with balanced development strategy.

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