# Informetrics-Based Evaluation and Comparative Study of C9 League Universities and Top Asian Universities: A Postprint

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## Abstract

[Purpose/Significance] To investigate the individual and regional overall performance and main characteristics of top-tier Asian research universities, reveal the differences and distinctive features between China' s top universities and top-tier Asian universities, and provide reference for the construction of world-class universities in China. [Method/Process] Taking China' s C9 universities and top-tier Asian research universities as research subjects, this study conducts statistical analysis based on informetric characteristics to compare the overall and individual characteristics between China' s top universities and top-tier Asian universities. [Results/Conclusion] China' s top universities have experienced rapid development in recent years and demonstrate excellent performance in total academic output, but need to enhance their performance in academic impact through multiple approaches.

## Full Text

## Evaluation and Comparative Study of C9 League and Asian First-Class Universities Based on Informetrics

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### Abstract

**[Purpose/Significance]** This study investigates the individual and regional performance and main characteristics of Asian first-class research universities, revealing the differences and distinctive features between China' s top universities and other Asian first-class universities to provide references for China' s world-class university construction. **[Method/Process]** Taking China' s C9

League universities and Asian first-class research universities as research objects, this paper conducts statistical analysis based on informetric characteristics to compare the overall and individual features of Chinese first-class universities with their Asian counterparts. [**Result/Conclusion**] China' s top universities have developed rapidly in recent years, demonstrating excellent performance in total academic output, but still need improvement in academic impact through multiple approaches.

**Keywords:** informetrics; Asian first-class university; C9 League

## 1 Introduction

Chinese universities have made rapid progress in many aspects in recent years, with some institutions' evaluative indicators reaching Asia-leading and world-advanced levels. However, the performance of individual institutions or disciplines cannot represent the national overall level. In a major strategic deployment for national development, the State Council issued the "Overall Plan for Coordinately Promoting the Construction of World-Class Universities and First-Class Disciplines" in 2015, followed by the Ministry of Education, Ministry of Finance, and National Development and Reform Commission' s issuance of the "Implementation Measures for Coordinately Promoting the Construction of World-Class Universities and First-Class Disciplines (Provisional)" on January 25, 2017. The goal is to promote a group of high-level universities and disciplines into world-class ranks, comprehensively enhance China's higher education strength in talent cultivation, scientific research, social service, cultural inheritance and innovation, and international exchange and cooperation, and play a major role in supporting the national innovation-driven development strategy.

There is no universally recognized or established quantitative standard for defining what constitutes a first-class university or discipline. Most current university or discipline rankings face considerable controversy due to various limitations in their adopted measurement methods, while peer review also has many problems because experts must evaluate very large entities and their cognitive distance from assessment targets is too great [1]. However, in a sense, bibliometric methods have statistical significance for institutional or regional research, and informetric indicators can be regarded as the sum of typical peer reviews, capable of reflecting macro-level realities and development situations [2].

This study selects China' s C9 League universities and first-class universities in Chinese Hong Kong, Chinese Taiwan, Japan, Singapore, and South Korea as research objects. Using quantitative analysis methods, we compare and analyze the overall profiles and main characteristics of Asian first-class research universities, reveal the position of China' s top universities in Asia and their differences with other institutions, provide ideas for building world-class research universities in China, offer references for relevant researchers and administrators, and hope to contribute to China' s "Double First-Class" university construction.

## 2 Research Status

Using informetric methods to evaluate and compare universities is currently a hot topic in higher education research, mainly involving the application of quantitative evaluation methods in institutional evaluation and discipline assessment, as well as research on university ranking indicator systems. For example, Zhao Fei et al. evaluated Peking University's overall research output and development trends over the past decade through statistical data analysis [3]; Zhang Shanshan conducted statistics and analysis on Zhengzhou University's SCIE-indexed and cited papers from 2005-2014, including quantity, subject classification, document type, source publications, cooperative institutions, corresponding authors, and funding situations, to reflect the university' s recent research and discipline development [4]; Xuan Xiaohong et al. conducted detailed comparative research on evaluation indicator systems of university rankings from *U.S. News & World Report*, *Times Higher Education*, *Maclean*' *s*, Guangdong Institute of Management Science, and Netbig [5]. Additionally, annual releases of university rankings by *Times Higher Education*, QS (Quacquarelli Symonds), and *U.S. News & World Report* use informetric methods with specific indicator systems to rank universities worldwide based on their resources and capabilities, representing external evaluations of university strength by third-party institutions. These evaluation and comparison studies all select independent institutions as research objects, using informetric methods for overall or partial assessments.

Comparative studies of university alliances using informetric methods are relatively rare. Research on the C9 League mainly involves management and cooperation methods, as well as one-to-one comparisons among member institutions. For instance, Liu Wei compared and analyzed differences between China' s C9 and the U.S. CIC university alliances from perspectives of cooperation forms and management [6]; Jiang Hua compared first-class disciplines between China' s C9 and Australia' s G8 League based on ESI and InCites databases [7]; Li Ang examined the future development of China' s C9 League by comparing it with the U.S. Ivy League from perspectives of location comparison, student organizations, and project cooperation [8].

Overall, existing literature lacks studies treating all universities within an alliance as a whole, and no research has conducted regional evaluations comparing C9 universities with other Asian first-class universities. This paper takes regional first-class universities as research objects, using quantitative analysis methods to compare their overall profiles and main characteristics, which has certain practical significance for higher education research and provides valuable references for China' s Double First-Class development.

## 3 Research Methods

### 3.1 Research Methods and Informetric Tools

Based on the informetrics methodology system, this study employs statistical analysis, citation analysis, and computer-aided informetric analysis methods [9]

to investigate the informetric characteristics of Asian first-class research universities. From a quantitative analysis perspective, we compare multiple indicators across three dimensions: educational strength, talent cultivation, and academic output and impact, including faculty and student numbers, educational funds, publication volume, citation counts, h-index, and other metrics. To present comparison results more objectively, we consider short-, medium-, and long-term data performance of these universities on relevant indicators, avoid bias from single-platform data, and account for the non-comparability of citation impact across different disciplines. We utilize various bibliometric and analysis platforms including Scopus, ESI, Web of Science (WoS), SciVal, and InCites, as well as statistical analysis tool SPSS, and introduce field-weighted citation impact indicators that exclude discipline and time effects.

### 3.2 Research Content

Taking C9 as the reference system for mainland China, the selection of other Asian first-class universities primarily refers to QS and *Times Higher Education* Asian university rankings. The selected universities include: Mainland China C9—Peking University, Tsinghua University, Zhejiang University, Fudan University, Shanghai Jiao Tong University, Nanjing University, University of Science and Technology of China, Xi' an Jiaotong University, and Harbin Institute of Technology; Chinese Taiwan—National Taiwan University, National Tsing Hua University, National Cheng Kung University, and National Chiao Tung University; Chinese Hong Kong—City University of Hong Kong, Hong Kong Baptist University, Hong Kong University of Science and Technology, Chinese University of Hong Kong, University of Hong Kong, and Hong Kong Polytechnic University; South Korea—Seoul National University, Korea Advanced Institute of Science and Technology, Yonsei University, Korea University, Pohang University of Science and Technology, and Sungkyunkwan University; Singapore—Nanyang Technological University and National University of Singapore; Japan —University of Tokyo, Tohoku University, Osaka University, Nagoya University, Tokyo Institute of Technology, Kyushu University, Kobe University, University of Tsukuba, Kyoto University, and Hokkaido University.

Using relevant basic data from these Asian first-class universities as the foundation, we examine each university' s performance across selected indicators and analyze their informetric characteristics. Detailed research content is shown in Table 1 .

### 3.3 Data Sources

Data collection emphasizes reliability and accessibility of sources, and the statistical process follows principles of relevance, accuracy, representativeness, comparability, and cumulativeness, striving for comparative analysis through homologous data. Some indicators were not compared due to non-equivalent data availability for domestic universities, such as Nobel Prize winners and publications in *Science* and *Nature*. Except for educational and research funds of

C9 universities, which are self-reported data, most other data are from unified third-party statistical results. When unified-source data were unavailable, we used publicly available annual report data from each university. To ensure data completeness, we selected relevant data from 2015 [10-20]. Specific data sources include: - C9 university data from internal materials compiled by the Ministry of Education' s University Affairs Department and the National Natural Science Foundation of China homepage; - Hong Kong university data from the University Grants Committee and annual reports of individual universities; - Singapore university faculty and student data from university annual reports; - South Korean university data from the Korean Ministry of Education statistics website; - Taiwan university faculty and student data from Taiwan' s education statistics department; - Japanese university faculty and student data from university annual reports; - Student quality data from QS World University Rankings; - Research data primarily from Elsevier' s Scopus database and SciVal analysis platform, Thomson Reuters'ESI database, Web of Science database, and InCites analysis platform.

## 4 Evaluation and Comparison

### 4.1 Educational Strength

Faculty is a crucial indicator of university educational strength, and sufficient educational funds help attract first-class faculty and improve educational environments. Since absolute quantity advantages cannot objectively reflect first-class levels and school size effects must be considered, this paper uses total faculty and educational funds, student-faculty ratio (ratio of student numbers to full-time faculty numbers), per-student educational funds, and per-faculty research funds to reflect educational strength. Comparisons between countries/regions are detailed in Table 2 (where "school average" in this table and subsequent text refers to the mean value of selected universities in each country/region for a given indicator), while statistical characteristics of member universities within each country/region are shown in Tables 3 and 4 .

Table 2 shows that Japanese universities have the lowest student-faculty ratio at only 7, followed by C9, Chinese Hong Kong, Chinese Taiwan, Singapore, and South Korea. The data indicate that Japanese universities have equipped relatively sufficient faculty according to student scale to ensure teaching quality, while mainland China' s faculty allocation is also relatively good among Asian universities.

In terms of educational funds, Singapore has the highest school-average funding (excluding unavailable South Korean data), but Japan has the highest per-student funding. C9 ranks second in school-average educational funds and third in per-student funding. Regarding research funds, Singapore shows the best performance in both school-average and per-faculty metrics (excluding South Korea and Taiwan data). C9 universities and Japanese first-class universities also have relatively sufficient research funds, placing them in the second tier,

while Chinese Hong Kong shows a large gap with the top three. Among all Asian first-class universities, the University of Tokyo tops the list in research funds, 0.7 billion USD higher than Tsinghua University, which ranks first among C9 universities. However, compared with previous years, the research funding gap between the two has narrowed.

Tables 3 and 4 present descriptive statistics of faculty and funding for member universities within each country/region using SPSS. Since only two universities were selected from Singapore, which lacks statistical significance, some characteristic values exclude Singapore in the following analysis of statistical features within each country/region.

Table 3 shows that Taiwan' s member universities have the median and mean faculty numbers closest to each other, indicating little variation in faculty data across Taiwan' s universities. Japan has the largest standard deviation, indicating the most dispersed faculty numbers among its member universities. The interquartile ranges for Japan, South Korea, Chinese Hong Kong, and Chinese Taiwan are all larger than C9' s, indicating more uneven faculty numbers among their member universities. All skewness values are greater than zero, indicating right-skewed dispersion of faculty numbers across all member universities. In terms of student-faculty ratio, C9 has the smallest standard deviation, indicating relatively balanced ratios among C9 member universities.

Table 4 shows that Singapore' s two universities have educational funds far exceeding the maximum values of Chinese Hong Kong and Taiwan universities. C9 and Japanese member universities have similar medians and means in educational funds, but C9's interquartile range is much larger than Japan's, indicating more dispersed educational funds among C9 member universities with greater inter-institutional differences. In research fund performance, C9 and Japanese universities have similar standard deviations and skewness values, both greater than zero, indicating similar variability in research funds among their member universities with right-skewed data.

These findings demonstrate that Singaporean universities show excellent performance in educational strength, with total and per-capita educational and research funds significantly higher than other Asian countries/regions. Japan excels in faculty allocation. C9 universities' faculty allocation and funding performance, both overall and individually, rank second, showing very good development momentum.

### 4.2 Talent Cultivation

Cultivating specialized talent is universities' earliest and most basic social function, as well as the fundamental mission of first-class university construction. This paper uses student scale, structure, graduate quality, and international students to reflect talent cultivation. Student scale is reflected through total student numbers; student structure through undergraduate numbers, graduate numbers, and undergraduate-to-graduate ratio; graduate quality through stu-

dent quality scores; and international students through international student ratios. Data comparisons across the six countries/regions are shown in Table 5 .

Student scale is a basic indicator reflecting institutional size, correlated with disciplinary quantity and structure. Table 5 shows that Asian universities have large student populations, with Singapore and mainland Chinese universities having the largest school averages at approximately 35,000 students each.

The undergraduate-to-graduate ratio reflects a university' s talent cultivation level and educational structure to some extent. Generally, a lower ratio indicates more prominent research-oriented characteristics. C9, Chinese Taiwan, and South Korea have relatively low ratios around 1; Japan' s ratio is 1.57, while Singapore' s is the highest at 2.77. This indicates that mainland China, Taiwan, and South Korea currently have higher proportions of graduate students, while Singapore relatively emphasizes undergraduate education.

Graduate quality reflects teaching quality to some extent and is a subjective soft indicator. This paper references QS rankings, which primarily use employer reputation surveys to measure graduate quality. The study obtained 2015 QS World University Rankings scores for member universities across the six countries/regions. Results show Singaporean universities perform most impressively with a mean score of 98.8; Taiwan universities rank last with a mean less than half of Singapore' s; South Korean universities rank second in Asia, while the other three countries/regions show similar graduate quality scores.

International student numbers are an important manifestation of a university' s global influence and international exchange cooperation. Table 5 shows that Japanese first-class universities have the highest average international student ratio at 10.12%, followed by Chinese Hong Kong at 7.09%. C9, South Korea, and Taiwan have average international student ratios below 5% (4.73%, 4.13%, and 2.77% respectively). Among all these universities, six have international student ratios above 10%: one from Hong Kong and five from Japan; fifteen have ratios below 5%: one from Hong Kong, five from South Korea, four from Taiwan, and five from C9. This indicates significant gaps in international student ratios among Asian first-class universities.

In summary, through continuous expansion of graduate and undergraduate enrollment in recent years, C9 universities rank in Asia' s first tier in student scale and undergraduate-to-graduate ratio. However, they still lag behind Singapore and South Korea in graduate quality scores, and show considerable distance in internationalization level and influence, indicating substantial room for improvement.

### 4.3 Academic Output and Research Impact

We examine the academic output and research impact levels of first-class universities across the six countries/regions through data from ESI, Scopus, SciVal,

WoS, and InCites, as detailed in Tables 6 and 7 .

**4.3.1 Academic Output** Recent publication volume can reflect academic output activity to some extent. This paper uses 2015 WoS publication volume and three-year (2013-2015) Scopus publication volume for measurement. Tables 6 and 7 show that C9 universities rank first in 2015 WoS publication volume with a mean exceeding 6,000 papers, followed by Singaporean universities; Japan and South Korea are between 4,000-5,000 papers; Taiwan and Hong Kong universities are between 2,000-3,000 papers. The three-year Scopus publication volume means vary significantly across countries/regions, with C9 universities leading far ahead, while Singapore, Japan, and South Korea are between 10,000-20,000 papers, and Taiwan and Hong Kong are below 10,000 papers.

The nearly 11-year ESI-indexed paper count reflects universities' academic scale output and accumulation. During the statistical period, C9 universities surpassed previously top-ranked Singaporean universities to become Asia' s leader in school-average ESI-indexed papers; Japan ranks third; South Korean universities also exceed 30,000 papers on average, while Taiwan and Hong Kong universities are below 30,000 papers.

Thus, C9 universities rank first in one-year WoS, three-year Scopus, and 11-year ESI-indexed papers, showing clear advantages in both current and cumulative scales, indicating that mainland universities have grown significantly in recent years and now lead Asia in academic output.

**4.3.2 Academic and Research Impact** We compare academic and research impact and development levels across countries/regions based on citation data and international collaborative paper percentages from SciVal and InCites. Citation data includes total citation counts, average citations per paper, highly-cited paper performance, field-weighted citation impact (FWCI/CNCI), 10-year institutional h-index, and other indicators.

**(1) Total Citation Count.** Total citation count refers to the total number of times an institution's papers were cited during the statistical period in the corresponding database. Universities with higher total citation counts are generally considered to have greater academic impact.

Singaporean universities show the most prominent performance in total ESI-indexed paper citations, with a school average exceeding 600,000 citations, followed by Japanese universities with over 500,000 citations. The third tier includes C9 and South Korean universities with averages between 400,000-500,000 citations. Taiwan and Hong Kong universities have relatively lower values, both below 300,000 citations.

In terms of WoS paper total citations, Singaporean and C9 universities perform best, both exceeding 5,000 citations. South Korea, Japan, and Hong Kong universities average between 2,000-3,200 citations, while Taiwan universities rank

last. Considerable differences exist among Asian first-class universities: five universities have WoS total citations exceeding 6,000, namely University of Tokyo, Tsinghua University, Peking University, National University of Singapore, and Seoul National University. The two lowest-ranked universities have fewer than 1,000 citations, with Hong Kong Baptist University' s WoS total citations being only 8.6% of Asia' s top-ranked University of Tokyo.

Overall, C9' s recent performance (2015 WoS citations) is better than its long-term performance (10-year ESI citations), indicating that mainland universities' recent emphasis on paper quality has achieved good results.

**(2) Average Citations Per Paper.** Higher average citations per paper can indicate that an institution or individual generally has greater academic impact. ESI average citations per paper (recent 10 years) equals total ESI citations divided by total ESI papers. Scopus average citations per paper (recent 3 years) equals total citations received by papers published during the statistical period divided by total papers published during that period. WoS average citations per paper (2015) equals total citations received by papers published in 2015 in the Web of Science Core Collection (including SCI-E, SSCI, and A&HCI) divided by total papers published that year.

According to Tables 6 and 7, Singaporean universities rank first in long-term ESI average citations, followed by Japan and Hong Kong. South Korea ranks fourth, Taiwan fifth, and C9 universities rank last with a mean value only 70% of top-ranked Singapore.

In three-year Scopus average citations, Singaporean universities also lead far ahead at 6.5 citations per paper, followed by Hong Kong, South Korea, Japan, C9, and Taiwan, all around 4 citations.

In 2015 WoS average citations, Singaporean universities still rank highest, followed by Hong Kong, C9, South Korea, and Japan, with Taiwan ranking last. Significant gaps exist among Asian first-class universities in WoS average citations, with only three universities exceeding 1 citation per paper: Hong Kong University of Science and Technology, Nanyang Technological University, and National University of Singapore.

Overall, Singapore ranks first in average paper impact across 1-year, 3-year, and 10-year periods. C9 universities rank last in 10-year long-term average citations but show a year-by-year upward trend. However, C9' s average citation performance generally lags behind its performance in total volume indicators.

**(3) Highly-Cited Papers.** Highly-cited paper count refers to the number of papers in ESI ranked in the top 1% by citation frequency within their respective disciplines and years. Highly-cited papers have high impact and typically represent high-quality research, with the count reflecting an institution' s influence at the research frontier. According to Tables 6 and 7, significant gaps exist in average ESI highly-cited paper counts across countries/regions. Singapore leads with a school average of 981 papers. C9 and Japan form the second tier

(400-600 papers), South Korea and Hong Kong the third tier (300-400 papers), and Taiwan ranks last with only 229 papers. C9' s average is only 60% of Singapore' s. Among all Asian first-class universities, University of Tokyo ranks first with 1,303 ESI highly-cited papers, followed by National University of Singapore (1,099 papers). Tsinghua University (938 papers) and Peking University (916 papers) rank third and fourth.

Analysis of member university data shows Singaporean universities have the highest average highly-cited paper percentage (over 2%), followed by Hong Kong (1.77%). C9, Japan, and South Korea have similar averages (1.1%-1.4%), while Taiwan' s average is below 1.0%, ranking last.

Scopus TOP paper percentages from the SciVal platform include TOP 1% and TOP 10% cited paper percentages, calculated by citation counts ranked by discipline, publication year, and document type. Table 7 shows Singaporean and Hong Kong first-class universities lead Asia in TOP 1% paper percentages with school averages of 3.9% and 2.4% respectively. C9, South Korea, Japan, and Taiwan all have averages below 2%, indicating mediocre overall performance in this indicator.

Similarly, Singaporean and Hong Kong universities lead in TOP 10% paper percentages with benchmarks of 26.6% and 20.8%. C9, South Korean, and Japanese universities have benchmarks between 17%-18%, while Taiwan' s benchmark is 15.4%, ranking last in Asia.

Overall, Singapore undisputedly ranks first in research frontier influence. C9 and Japan show good ESI highly-cited performance but are less impressive in Scopus TOP 1% and TOP 10% paper percentages.

**(4) Field-Weighted Citation Impact (FWCI/CNCI).** Field-weighted citation impact refers to the ratio of a paper' s actual citations to the expected citations for papers of the same type, publication year, and discipline, excluding publication year, discipline, and document type effects. An FWCI/CNCI value of 1 represents world average quality, above 1 indicates above-average quality, and below 1 indicates below-average quality. Commonly used indicators include FWCI from the SciVal platform and CNCI from the InCites platform.

According to Table 7, Singapore leads far ahead with a school-average FWCI of 1.90, followed by Hong Kong (1.67). South Korea, C9, Taiwan, and Japan have school-average FWCI values between 1.10-1.30. All 37 selected Asian first-class universities have FWCI values exceeding 1, indicating their ESI paper quality is above world average. Nanyang Technological University (2.08), Hong Kong University of Science and Technology (1.93), and City University of Hong Kong (1.79) rank as Asia' s top three.

Similarly, Singapore and Hong Kong lead in CNCI school averages at 1.48 and 1.39 respectively. C9, South Korea, and Taiwan have CNCI values between 1-1.10, while Japan' s CNCI value (0.97) is below 1. Among Asian first-class universities, Hong Kong University of Science and Technology (1.59), University

of Hong Kong (1.56), and Nanyang Technological University (1.51) are the only three universities with CNCI values exceeding 1.5. Eight universities have CNCI values below 1, indicating their citation performance is below global average.

Overall, Singapore and Hong Kong universities show excellent performance in field-weighted citation impact, both overall and individually, while C9' s performance is average.

**(5) Institutional h-Index.** If an institution' s h-index is $n$, it means the institution has at least $n$ papers each cited at least $n$ times. The h-index balances paper quantity and impact, reflecting high-quality paper output. Table 7 shows Singaporean first-class universities lead with a 10-year h-index, being the only country with a mean exceeding 200. Japan (185), C9 (167), South Korea (162), Hong Kong (142), and Taiwan (129) follow. Among the 37 selected Asian universities, eight have 10-year h-indices above 200: three from Japan, two from Singapore, one from South Korea, and two from C9.

**(6) International Collaborative Papers.** International collaborative papers, as an important internationalization indicator, reflect a university's openness, cooperation, and talent attraction. This paper defines international collaborative papers as those co-authored by institutions from two or more countries/regions, analyzing three-year Scopus data and one-year WoS data.

Table 7 shows Singaporean universities perform excellently in both calculation methods, with international collaborative paper percentages exceeding 60%. C9 universities' performance is less than half of Singapore' s and ranks very low among all comparison objects. This indicates mainland universities have considerable room for development in academic and research international cooperation.

**4.3.3 Discipline Level** Top-tier discipline counts and advantage discipline counts reflect a university' s overall disciplinary strength and level. This paper uses ESI top-tier discipline counts and advantage discipline counts for comparison.

ESI has established 22 disciplines based on disciplinary development characteristics. Only research institutions ranking in the top 1% worldwide by total citations in a discipline over the past decade can enter ESI discipline rankings. These are called advantage disciplines, with those ranking in the top 100 worldwide designated as top-tier disciplines. Comparisons are shown in Table 8 .

Table 8 shows Singaporean first-class universities rank first in advantage discipline count with a mean of 16 disciplines, followed by Japan and C9 (15 disciplines each), South Korea and Hong Kong (14 disciplines each), and Taiwan (12 disciplines) ranking last. Among Asian first-class universities, University of Tokyo leads with 21 advantage disciplines, while University of Hong Kong and Seoul National University also reach 20 advantage disciplines. The lowest-ranked are two Taiwan universities with only 7 advantage disciplines each.

Singaporean universities rank first in top-tier discipline count with a school

average of 6, while C9 and Japan tie for second with 4 each. Taiwan universities rank fourth with a mean of 3, and South Korea and Hong Kong tie for fifth with 2 each. Among Asian first-class universities, only two Japanese universities—University of Tokyo and Kyoto University—have more than 10 top-tier disciplines (including 10).

These data indicate that Singaporean universities perform well in both top-tier and advantage discipline counts, Japanese universities excel in top-tier discipline count, and C9 universities show moderate performance in both aspects.

## 5 Conclusion

This paper conducts a comprehensive comparative analysis of Asian first-class universities based on informetric methods, examining individual and regional profiles and main characteristics of Asian first-class research universities. The main conclusions are:

(1) Among Asian universities, China' s top universities have good faculty allocation, sufficient funding, and rank in Asia' s first tier in student scale and undergraduate-to-graduate ratio, but show certain gaps compared to Singapore and South Korea in graduate quality scores. National advancement levels show that undergraduate-to-graduate ratios are not directly proportional to quality. Japan and Singapore have higher ratios, relatively emphasizing undergraduate education, yet both countries' education quality and scientific strength rank among Asia' s leaders. Therefore, higher graduate student proportions are not necessarily better; reasonable student structure and excellent student quality are more conducive to national innovation development.

(2) China' s top universities have very active academic and research activities in recent years, but their average performance generally lags behind their performance in total volume indicators. The study also shows that institutional scale and accumulation are very important factors affecting total academic volume indicators. C9 ranks first in short-, medium-, and long-term academic output totals, leading Asia, and has achieved obvious results in total citations through recent efforts. However, in average paper impact, C9 universities rank last in 10-year long-term average citations, though showing a year-by-year upward trend. Their field-weighted citation impact performance is inferior to Singapore and Hong Kong' s overall and individual performance. In research frontier influence, C9 shows good ESI highly-cited performance but is less impressive in TOP 1% and TOP 10% paper percentages, and shows moderate performance in top-tier and advantage discipline counts. Therefore, to lead Asia and the world in science and technology, domestic universities need to accelerate progress, strengthen basic disciplines, and cultivate first-class experts, disciplinary leaders, and innovation teams active at international academic frontiers.

(3) C9 universities rank low among Asian first-class universities in interna-

tional student numbers and international collaborative papers. The internationalization process and academic exchange of mainland China' s top universities need urgent strengthening. Through cooperative education, attracting overseas high-quality faculty, student exchange with world-class universities, and joint training programs, more international students can be attracted to China. By increasing policy, funding, and resource support, researchers can achieve more and deeper academic exchanges and research cooperation with world-class universities and academic institutions, thereby enhancing the country' s international influence in science, technology, and culture.

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## Author Contributions

**Tian Ji:** Conceived the idea, designed the paper framework, and wrote the manuscript;
**Shen Lihua:** Designed the research framework and analyzed data;
**He Xiaowei:** Collected data and analyzed data;
**Yu Minjie:** Collected data and analyzed data.

*Note: Figure translations are in progress. See original paper for figures.*