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Original Article

Research output of science, technology and bioscience publications in Asia

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Abstract

Publication growth rates in Asia have been rapidly increasing since 2000. Amid this constant rise in the quantity of papers, however, concerns over the quality of research output in Asia have also increased. The purpose of this paper is to examine science and technology journals in Asia where research is burgeoning and to find ways to enhance the visibility and frequency of citation of articles published by non-Organization for Economic Cooperation and Development and developing countries in Asia. In this work, the research output of twelve countries in science and engineering over the last five years is studied, using the Scopus database. We compared publication growth, number of citations per publication, the field-weighted citation impact of publications, national and international collaboration rates, and the number of journals in each country found in the Scopus database. We find that a predominant number of research papers produced in developing Asian countries are in technology. Hence, most research papers produced in Asian regions appear to have lower citation rates and are often devaluated. We suggest this devaluation relates to an individual state's strategy for national development, or policy priorities for choosing whether to invest primarily in basic science or applied science. Further, this work suggests that enhancing the accessibility and visibility of local academic journals can be conducive to enhancing the quality of research output, both in developing countries and in the world overall.

Keywords

Asia; Citation; Publication; Science; Technology

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Introduction

Among 1,685,703 total academic papers published on science, technology and bioscience in 2013 [1], 33.4% were produced in the European Union, 20.7% in the United States, and 38.3% were from the largest countries in Asia (the sum of China, India, Japan, Korea, and Taiwan). Publication growth rates in Asia have been rapidly increasing since 2000, particularly in China. China has now become the world's second largest country in terms of size of research publica-

tion: the country has published more research work than the United Kingdom, and is projected to surpass the United States as the largest academic producer by 2020. Other emerging academies in countries such as Brazil, India, and South Korea are also expected to surpass France and Japan in terms of research output in the next six years [2].

Amid this constant rise in the quantity of papers, however, concerns over the quality of research output in Asia have also increased. In Asia, technology appears to be a more important field than science, given an emphasis in many countries on practical subjects. The purpose of this paper is to examine science and technology journals in Asia where research is burgeoning, and to find ways to enhance the visibility and frequency of citation of articles published by non-Organization for Economic Cooperation and Development (OECD) and developing countries in Asia.

Methods

This work analyzed the research output of twelve countries in science (physics, chemistry, mathematics, and earth and planetary sciences), technology (engineering, computer science, chemical engineering, energy, and materials science), and bioscience (biochemistry, genetics, agricultural and biological sciences, and neuroscience). The outputs of China, India, Indonesia, Japan, Korea, Malaysia, Mongolia, the Philippines, Singapore, Taiwan, Thailand, and Vietnam over the last five years (2009 to 2013) were compared using the Scopus database. We compared publication growth, number of citations per publication (CPP), national and international collaboration rates, and the number of journals from each country in the Scopus and SciVal databases.

Results

Science research performance

Approximately 90% of sciences papers in Asia come from four countries: China, Japan, India, and Korea. Since 2010, China and India have shown rapid publication growth rates (Fig. 1). Excepting Japan, research output has increased in all other Asian countries. In Japan, research output in the sciences has grown only in earth science. The share of Chinese articles in science has grown at a compound annual growth rate of 8.14% from 2009 to 2013. When compared to other subjects, publications in mathematics in China have grown slowly. However, output of articles from Indonesia, Malaysia, and Vietnam's output have nearly doubled.

On citation value, Singapore leads Asian countries. While citation of Chinese papers is generally low, however, CPP are gradually increasing, which may suggest the quality of Chinese publications is increasing (Fig. 2). In mathematics, physics, chemistry, and biochemistry, Singapore has the highest CPP, suggesting high quality papers, while Vietnam and Japan show high CPP rates in mathematics and earth and planetary science, respectively.

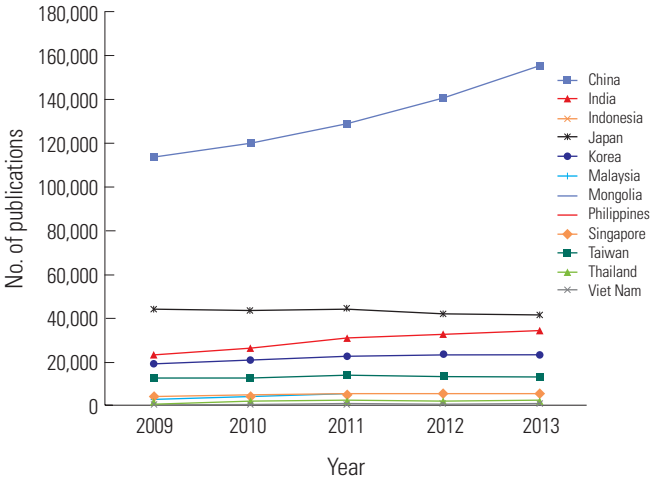

Fig. 1. Number of publications by science field of Asian countries from 2009 to 2013.

Mongolia is the most collaborative of the twelve countries studied (Fig. 3). Excepting China, the collaboration rates in all other countries are above average (world average rate, 23.1%). Japan has shown a marginal increase in international collaboration over the past five years. Both the relatively high level and growth of international collaboration in Singapore may be one of key factors contributing to their increasing citation impact.

Technology research performance

Research output among the five relatively large Asian economies—China, Japan, Korea, India, and Taiwan—occupies 93% of total publications in technology (Fig. 4). In China, Japan, Korea, Taiwan, and Singapore, the growth rate of research output in technology was higher than that of science. Computer science research output in China has declined by 25.2% since 2010. Japan experienced declines in all sectors—including 11% in engineering and materials—save a 6.6% increase in environmental sciences (Fig. 5). India experienced sharp output increases in computer science (75.7%) and chemical engineering (63.7%) during the study period. In Asia, the CPP rate in technology was lower than the CPP rate in science overall, except in Malaysia. As in science, Singapore's CPP rate in technology is remarkably higher than in other countries.

In technology, Mongolia is the most internationally collaborative country (Fig. 6). Overall, collaboration figures are larger for smaller and less scientifically active countries. China's

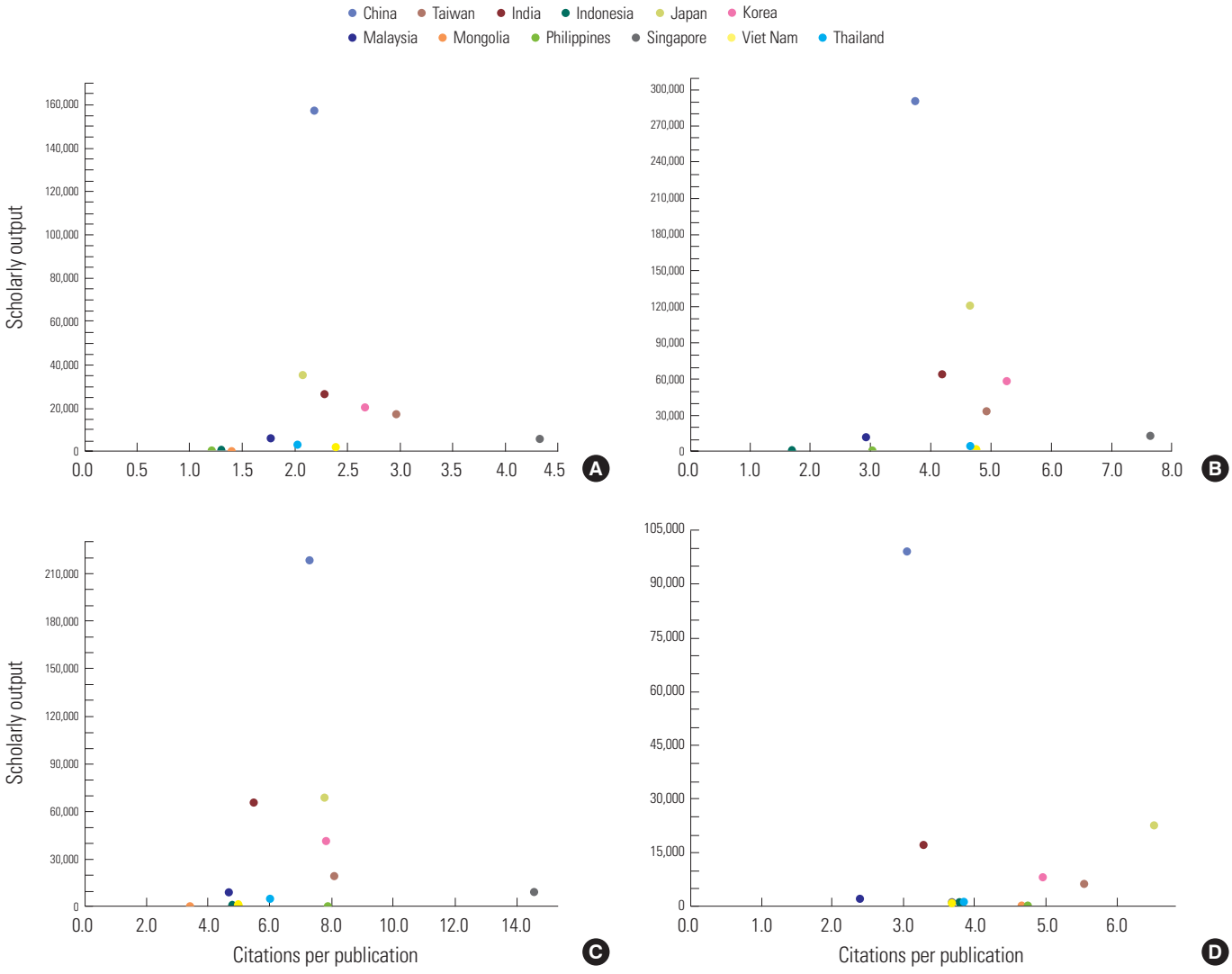

Fig. 2. Number of publications and citations per publication, by Asian country in sciences fields, from 2009 to 2013: (A) mathematics, (B) physics, (C) chemistry, and (D) earth and planetary science.

publication growth is the fastest, however, but many researchers need time to become established before they are in a position to seek collaborators. While India, Taiwan, and China's collaboration rates are under 20%, Korea and Japan's collaboration rates are 25.8% and 24.4%, respectively; these are relatively low compared to European countries. These countries need to boost their collaboration rates to increase research impact.

Bioscience research performance

Among twelve countries, Malaysia shows the highest output increase in bioscience, while both Vietnam and Indonesia have increased bioscience output by over 100% (Fig. 7). Bioscience articles in Japan, in contrast, increased by only 0.8%, while science and technology output decreased. Overall, the rate of publications has increased more in bioscience than in science and technology.

In addition to Bioscience research output, it is important to measure of quality of publications. As verified data (Table 1), Citation and its CPP in Biochemistry and NuroScience in Citation is very higher than other subjects. However, 11 countries' CPP in 'Biochemistry, Genetics and Molecular Biology' and 'Nuroscience' except Singapore is lower than world average CPP of 8.7 and 8.4 respectively. (Fig. 8) It is noticeable that Philippine is strong at its CPP in Agricultural and Biological Sciences as compared to 11 countries.

India, Japan, Korea, and Taiwan's collaboration rates in bioscience are lower than in science, while world averages trend

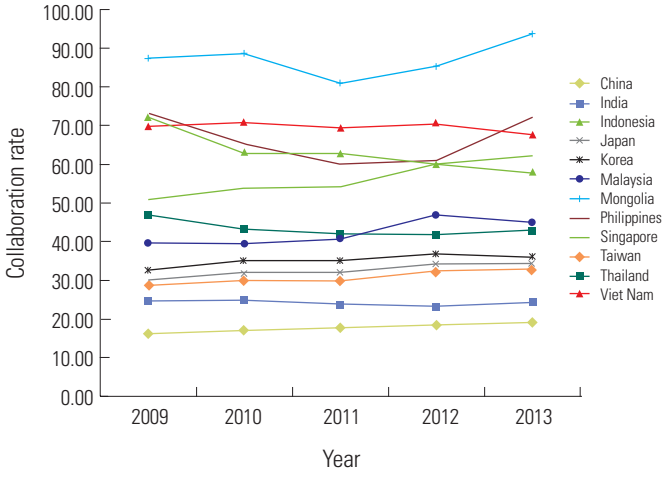

Fig. 3. International collaboration rate of Asian country by science field.

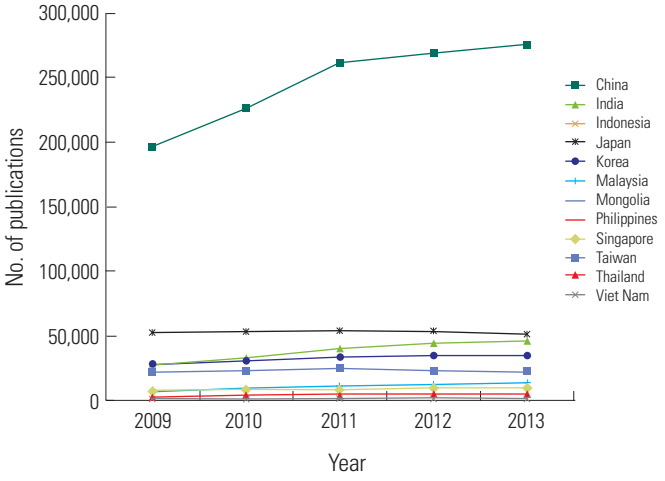

Fig. 4. Number of publications by technology field in Asian countries from 2009 to 2013.

in the opposite direction (Fig. 9). Given China's slowly increasing rate of international collaboration, it seems likely that increased quality of output will follow. Indonesia, Mongolia and Vietnam' collaboration rate in bioscience are around 80%; researchers in these countries may be selected by researchers in other countries with stronger supports for research. Over the last ten years, Singapore's international collaboration rate has steadily increased, while collaboration in bioscience in other countries is fluctuating.

Comparing science, technology, and bioscience

In most Asian countries, research output is predominantly in technology- rather than science-related disciplines (Fig. 10). Forty eight percent of articles are assigned to technology, with agricultural and biochemistry making up an average of 21.5% of these. Overall, output ratios in agricultural and biology fields (agricultural and biological sciences, biochemistry, genetics, and molecular biology) are lower than average in all twelve countries. Individually, however, India and Mongolia show strength in science while the Philippines shows better performance in agriculture and biology. China shows a predominant focus on technology rather than science, agricultural, and biochemistry. Japan and India have more strength in science, agriculture, and biology than in technology. Taiwan's percentage of agricultural and biology articles are lower than that of other countries (average, 21.5%). The Philippines and Mongolia seem to focus more on agriculture and biology than other countries.

Average CPP in bioscience was higher than in science and technology (Fig. 11). CPP in Singapore stands out among other countries. Japan's CPP rate in bioscience is higher only than Korea, but Korea has second highest CPP rate overall. Only Malaysia's CPP in technology was higher than its CPP in science and bioscience. Given their publication rate, CPP rates in the Philippines are strong. Overall, the bioscience CPP rate among these twelve countries is relatively low compared to the world average (7.67), while the technology CPP rate is higher than the world average (4.88). Only Malaysia's CPP in technology was higher than science and bioscience. Philippine CPP is quite good as compared to its publication quantities.

Discussion

China, Taiwan, Malaysia, and Singapore show a tendency to focus more on technology than on science and bioscience (Fig. 10). In Japan, academic works focus more on science than technology; Japan's bioscience output rate is similar to the average rate for the twelve countries. Korea's output rate in both science and technology are higher than that of bioscience. Meanwhile, scientific research in the Philippines, Thailand, and Mongolia focus more on bioscience compared to other countries. Amid the constant rise in the quantity of papers, however, concerns over the quality of research output in Asia have also been increasing (Figs. 1, 4, and 7). To find ways to enhance the visibility and frequency of citation of articles published by non-OECD and developing countries in Asia, we consider both increasing collaboration to increase CPP, and improving the visibility of articles by indexing journal titles on international indexing databases.

In countries overall, the average CPP rate in science-related disciplines (except mathematics) are higher than technology-related disciplines (Table 1). The same trend appears in Asia. A country's average CPP generally increases when publications in science-related, rather than technology-related, disciplines increase. CPP is higher in biochemistry, genetic and molecu-

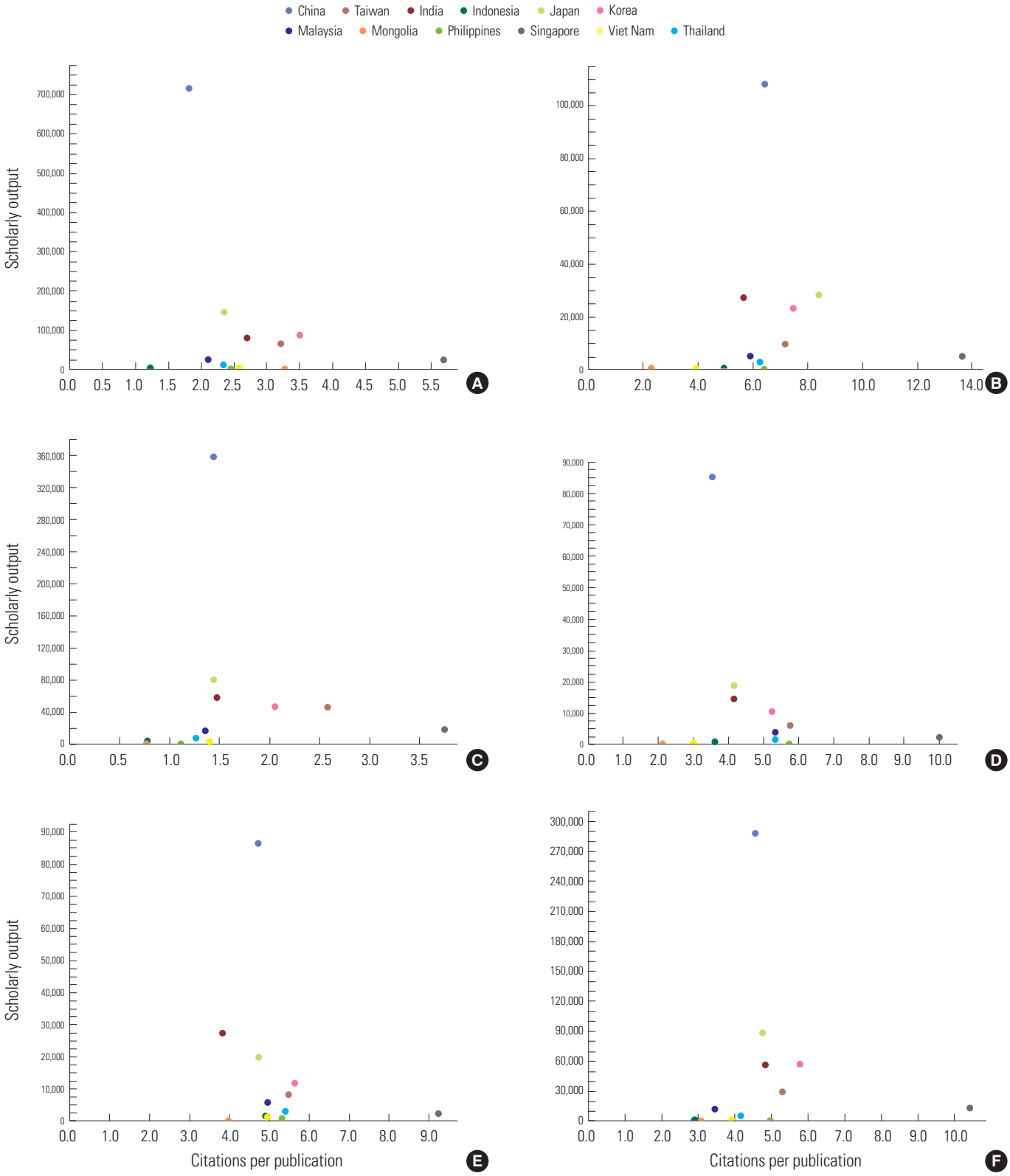

Fig. 5. Number of publications and citations per publication in Asian countries by technology field from 2009 to 2013: (A) engineering, (B) chemical engineering, (C) computer science, (D) energy, (E) environmental science, and (F) materials (continued to the next page).

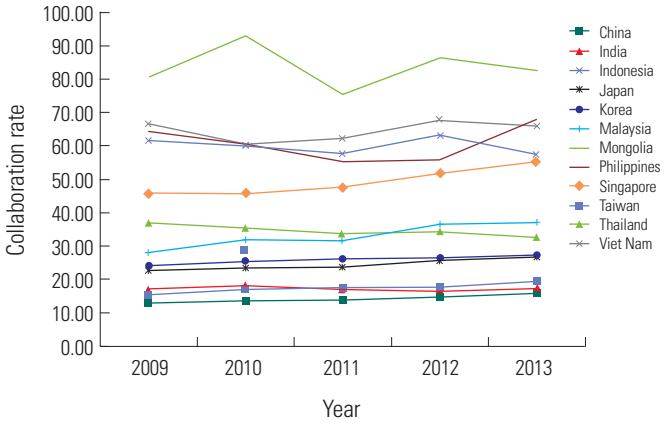

Fig. 6. International collaboration rate of each country by technology field.

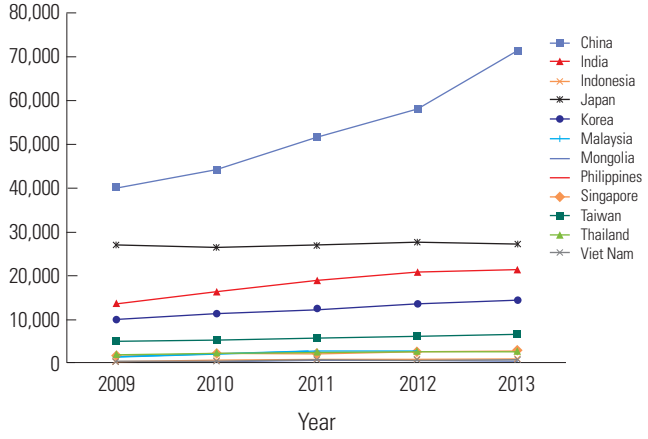

Fig. 7. Number of publications by bioscience field for Asian countries from 2009 to 2013.

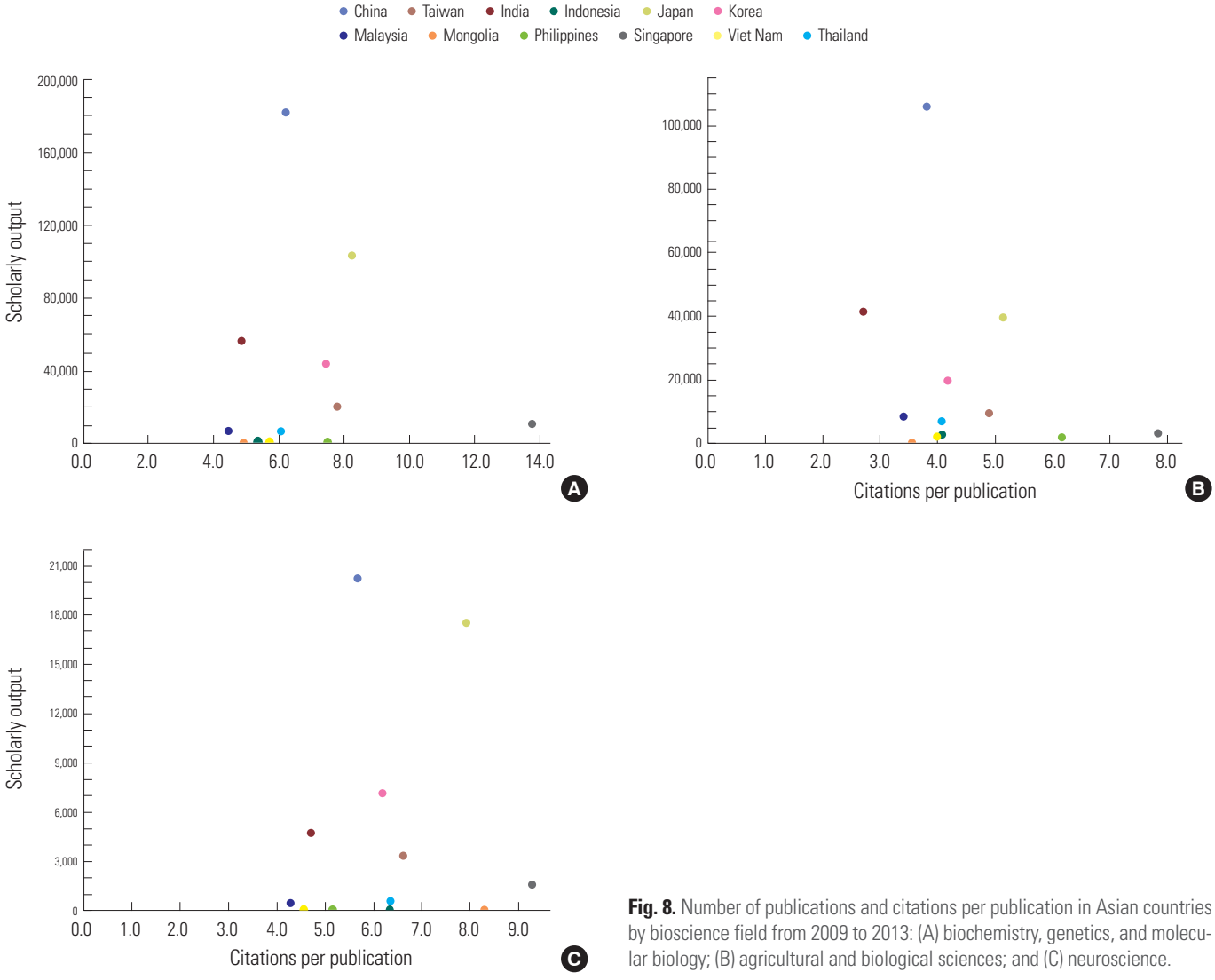

Fig. 8. Number of publications and citations per publication in Asian countries by bioscience field from 2009 to 2013: (A) biochemistry, genetics, and molecular biology; (B) agricultural and biological sciences; and (C) neuroscience.

Table 1. Comparison of CPP rates, by discipline, in Asia and the world overall

	2011		Rank of CPP
	Asia	World	
Biochemistry, genetics, and molecular biology	8.0	9.1	1
Chemistry	8.0	8.1	3
Chemical engineering	7.9	7.6	4
Environmental	5.2	5.2	5
Materials	5.3	5.1	6
Agricultural and biological science	4.9	5.1	6
Earth	4.2	4.6	8
Physics	4.2	4.6	8
Engineering	2.3	2.6	11
Math	2.5	2.6	11
Computer	1.8	2.2	13
Energy	4.8	4.4	10
Neuroscience	7.2	8.7	2

CCP, citations per publication.

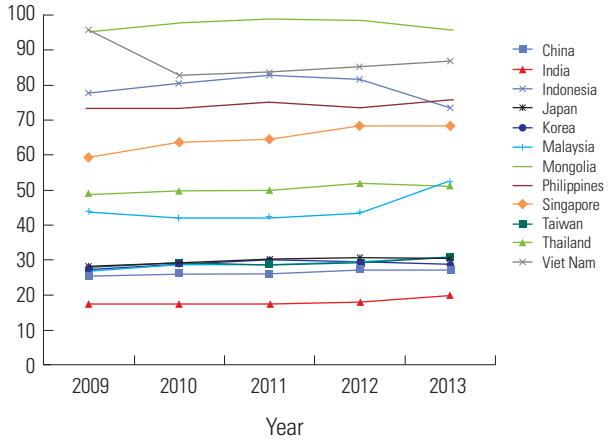

Fig. 9. International collaboration rate for Asian countries by bioscience field.

lar biology, chemistry, and chemical engineering, while notably lower in computer science, engineering, and mathematics due to the characteristics of the subjects in those disciplines. Lower CPP is generally understood to reflect lower quality of paper. In fact, however, the number of average authors per paper, cited publication ratio and journal count in several sectors such as engineering, mathematics and computer science are smaller than those of other disciplines like chemical engineering and chemistry. These factors lead to relatively low citation: the number of authors per paper, 1.69 for computer, 1.56 for mathematics, 1.75 for engineering, 2.12 for chemical engineering, 1.89 for chemistry and 2.46 for biochemistry.In-

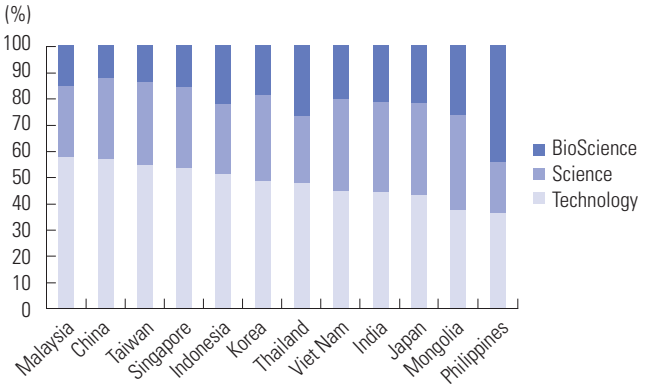

Fig. 10. Comparison of research output in science, technology, and bioscience.

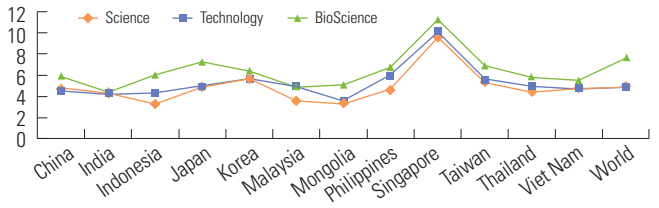

Fig. 11. Comparison of citations per publication in science, technology, and bioscience.

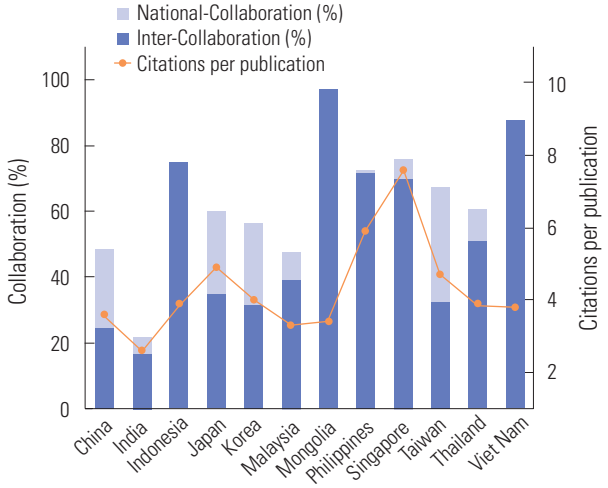

Fig. 12. Collaboration rate (national and international) and citations per publication.

ternational collaboration strongly affects the citation rate of papers [2]. Including an international author brings a corresponding increase in CPP rate or the impact of research. A project that includes two countries gives twice as many citations, and increasing the number of countries involved creates a linear increase in citations. Excepting a few countries—Mongolia, Vietnam, and Indonesia—higher inter-collaboration

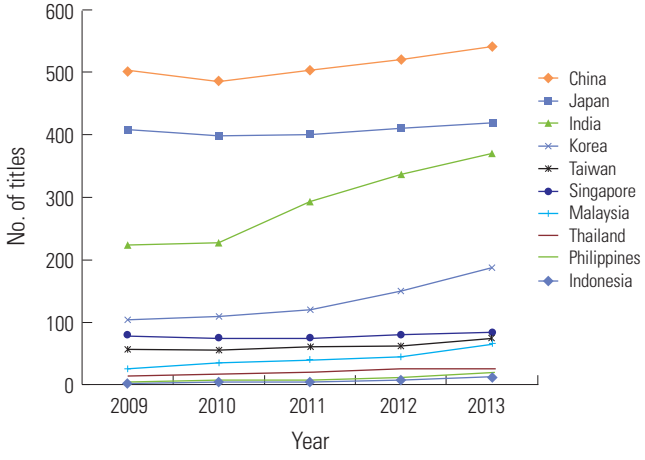

Fig. 13. Number of indexed titles by country in Scopus database.

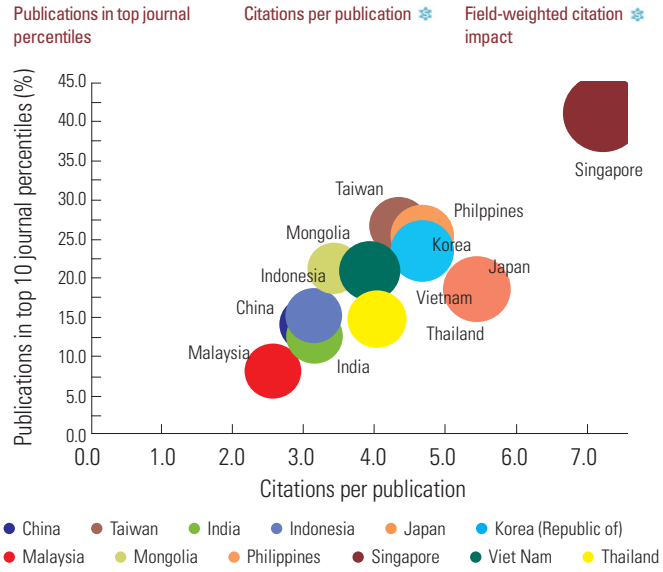

Fig. 14. Relationship between percentiles of publication in top journals (in science, technology, and bioscience) and citations per publication.

rate leads to a higher CPP rate (Fig. 12). Countries with higher international collaboration rate are relatively strong in technology compared to science.

Among twelve countries, Mongolia is the most internationally collaborative country (Fig. 12). International collaboration figures are larger for smaller and less scientifically active countries. China's publication growth has been the most rapid, but many researchers need time to become established before they are in a position to seek out collaborators. Japan has shown a marginal increase in international collaboration over the past five years. Relatively high level and growth of international collaboration in Singapore may be one of key factors contributing to their increasing citation impact. Compared to other European countries (the collaboration rate in France is about 50%), Japan, China, Korea, India, and Taiwan need to boost their collaboration rate to increase research impact.

The surprisingly high level of international collaboration in some developing countries (e.g., 80% in Mongolia) merits further inquiry. In Mongolia and Vietnam, high international collaboration can imply low indigenous research capacity. Where local institutions lack the necessary human and financial resource, foreign scholars are generally the principal investigators that lead most of the research conducted in such countries. Similar explanation can be applied to other developing research economies, including many Sub-Saharan African countries (Daniel Calto, private communication, 2014). Meanwhile, as a country begins to establish a stronger research base or in-country capabilities that are critical for a country to pursue independent research, international collaboration rates also start to decline.

Increasing the number of Asian journals indexed in global databases can contribute to enhancing the visibility of articles. The higher CPP rate of individual countries can be related to the number of journals indexed in Scopus. Though the Scopus database includes non-science and technology disciplines, a higher number of titles indexed from a particular country indicate higher visibility to world readers. The share of journals from China and India indexed in Scopus is rapidly growing, by 2.6% and 2.0%, respectively (Fig. 13). The growth rate of indexed titles in Japan is the lowest among the twelve Asian countries, because of the country's well-developed academia. Since 2009, indexed titles in Indonesia and Philippines have increased by 32% and 31% respectively. Though the total number of indexed titles may be marginal in these two countries, this growth is expected to have a positive effect on increase of publication.

The numbers of citations is entirely dependent on citation culture of research fields, that is, different citation patterns and different publication velocities. For this reason, when comparing different fields it is recommended to use field-weighted citation impact (FWCI) (Daniel Calto, private communication, 2014). There is a linear relationship between percentiles of publications in top journals (in science, technology and bioscience) and CPP, as shown in Fig. 14. This trend is also related to FWCI. For this work, we used FWCI as the measure of citation impact. This is a measure of citation impact that normalizes for differences in citation activity by subject field, article type, and publication year. The world is indexed to a value of 1.00, meaning that values above 1.00 indicate above average citation impact. More specifically, a citation impact of 1.52 indicates a citation impact which is 52% above the average. This result might be explained by the low quality of pa-

pers published by many Asian journals: these papers are not referred to by many scholars worldwide. In the future, however, low CPP rates in Asia would be improved by increasing international collaboration and improving the visibility of articles by indexed titles on international indexing databases.

In conclusion, this study finds that a predominant number of research papers produced in developing Asian countries are in technology, a field with a relatively short citation span than natural science. Hence, most research papers produced in Asian regions appear to have lower citation rates and are often devaluated. We suggest this difference relates to the national development strategies or policy priorities for individual states, which choose whether to invest primarily on basic science or applied science. Further, this work suggests that enhancing the accessibility and visibility of local academic journals in Asian developing countries can be achieved by understanding the characteristics of the disciplines of each country, through collaboration with international projects for high CPP rates, and by indexing titles on international indexing databases.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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