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Analysis of quantitative journal articles and conference papers in the field of electrical, electronic, and information and communication engineering reveals trends in global rivalry and technological transformation.

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Abstract; This research looked at IEEE, the largest academic publisher in engineering, and analyzed their technological and publishing endeavors. We began by creating a unique, all-encompassing database of IEEE-published journals, magazines, and conferences from 1980 through 2008. This database included about 0.36 million journal articles and 1.14 million conference papers. We looked at the changes in technological advancements from two angles: (1) the national level and (2) the level of specialization reflected by IEEE societies. Between 1980 and 2008, the number of papers published in periodicals climbed fourfold, while the number of conference articles increased approximately twentyfold. In instance, China's publication rate for conference papers has skyrocketed since 2002, and in 2008 it even surpassed that of the United States. The IEEE's focus has extended from its original home in the United States to the whole globe. A tri-polar structure of IEEE technical activity has emerged as the percentage of publications written by writers in North America, Europe, and East Asia approaches parity. This long-term study of approximately 30 years' worth of IEEE publications uncovered the phenomenon of 'glocalisation' among IEEE publications and research activities in response to the rise of more active international rivalry. As a result, quantitative research has shown five distinct eras of global rivalry and technological transformation.

Keywords; Technology evolution; Globalization; Conference Proceedings; Quantitative Analysis; Tri-Polar Structure;

Introduction

In the past, scientific and technical progress has always followed general economic growth. In particular, the E&E sector drove both economic expansion and technological progress during the 20th century. Researchers in the domains of E&E and ICT were able to map out the international research infrastructure that supports their work. This study analyzed the technical and publication activities of the Institute of Electrical and Electronics Engineers (IEEE), the largest professional engineering association and engineering publisher in the world, to reach this end. Since the IEEE is responsible for a sizable share of publications in the E&E and ICT domains, it has not only a large numeric influence, but also a sizeable qualitative one. Examining the structure of IEEE's societies—those sub-communities that pursue interests and address concerns regarding technical activities within specific specialized areas—and the coverage and impact of IEEE publications in scientific publishing allowed for a quantitative and qualitative analysis of this impact.

To evaluate developments in science and technology as well as the state of the economy and the job market, the Organization for Economic Co-operation and Development (OECD) released extensive and complex benchmarks (e.g., OECD 2009). Emerging vital technologies such as biotechnology, nanotechnology, environmental sciences, etc. were compared on a global scale (OECD, 2009). Shelton and Holdridge (2004) used bibliometric analysis to show that, by the late 1990s, the European Union had exceeded the United States in the number of scholarly publications published in the fields of science and technology. The structural shifts in science from the triad, which included Japan, to the tetrad, which included China, were explored by Gla nzel et al. (2008), alongside the conflict between the United States and the European Union. They looked at data from the SCIE of WoS's Web of Science to see how many articles fell into each category between 1991 and 2005. The EU, the US, Japan, and China were all included in the comparison, as were Brazil, Taiwan, Korea, and Turkey. Leydesdorff and Wagner (2009) used the SCIE of the WoS from 1995-2006 to analyze temporal patterns seen in international benchmarks emphasizing nanotechnology. They claimed that the United States' formerly dominant position in scientific publishing has shrunk as a result of China's rise to prominence. By analyzing the SCI of the WoS from 1993 to 2004, Zhou and Leydesdorff (2006) further analyzed China's rise and showed the exponential increase of Chinese nanotechnology publications.

In previous years, journal articles were given more weight in assessments than conference proceedings. Godin (1998) provided the following explanations for the reduced value of research presented at conferences.

Articles published in proceedings were often seen as rough versions that would eventually be published in a journal, and they were notoriously hard to get your hands on due to their restricted circulation.

The restricted availability of conference proceedings may be linked to poor appraisal from the standpoint of the dissemination of scientific knowledge, since libraries frequently had to make extra efforts to preserve them (Drott 1995). However, this has lately begun to change as electronic publishing and electronic archiving on the Web have emerged. Access to conference proceedings has increased with the speed with which traditional publications may be published (Ginsperg 1996).

enhancements were seen (Kling and McKim 1999; Goodrum et al. The significance of papers published in conference proceedings has been reevaluated in light of these factors.

Conference article significance

A conference paper is now considered the same level of scholarly output as a journal article in the field of computer science (Drott 1995; Goodrum et al. 2001; Meho and Rogers 2008). It has been noted that the percentage of proceedings papers is disproportionately high in the engineering subjects of computer science, electronics, and others. Using data from the 2008 SCI of the WoS and the Conference Proceedings Citation Index, Bar-Ilan (2010) compared the journal and conference papers of highly cited computer scientists. The retrieved publications were found to heavily reference conference proceedings. According to a study by Wainer et al. (2011a), conference papers account for 40 percent of all citations in ACM journals.

Using data from the SCI of the WoS in 1993, Gla nzel and Schoepflin (1999) demonstrated that the proportion of journals cited in electronic engineering journal articles is 62%, which is lower than the percentages cited in the fields of physics, chemistry, and biology. This statistic reveals that the proportion of conference papers is particularly high in these engineering domains compared to the percentages found in physics, chemistry, and biological sciences, accounting for the remaining 38% of references. Furthermore, about half of the indexed papers in the ISI proceedings' database in 1994-2002 were classified as engineering (Gla nzel et al., 2006), demonstrating the significance of conference articles in proceedings as a resource for engineers.

Despite the growth of both WoS and Scopus, the number of indexed conference publications in computer science and electrical engineering continues to lag behind that of physics and mathematics (Wainer et al., 2011b). In addition, the proportion of references to preceding articles in journals has been on the rise from 1980-2005, as reported by the SCI (Lise'e et al., 2008). Journal papers do not adequately represent real research activity in these domains, hence conference articles are required for research benchmarks in E&E engineering covered by IEEE publications (Shirakawa et al., 2011).

Methodology

Data analysis

We analyzed transitions in technical innovations using data gathered from IEEE periodicals and conference proceedings from two vantage points: (1) national trends, as represented by the country of the publication's first author, and (2) trends within specialized fields.

To conduct our research, we first created a unique, all-encompassing database of journal and magazine articles, as well as conference proceedings published by the IEEE between 1980 and 2008.

Input and output of data

Metadata from Inspec is used to index the official IEEE database, IEEE Xplore. To determine whether or not the material was covered by IEEE Xplore as of the end of February 2010, we first collected the metadata from Inspec, which included around 0.36 million periodical

articles and 1.14 million conference articles. Table 1 outlines the specifics of the database we developed.

The data flow structure for analyzing IEEE publications on international rivalry and technical evolution is shown in Figure 1. For international comparison, we consider the number of papers published in journals and proceedings, the number of nations mentioned in these publications, and the number of conferences held in each nation. Articles published in periodicals and presented at conferences might be filed in a specific category based on the nation to which the original author belongs. We only process the first author because of the restrictions of the Inspec data. We analyze the number of journal articles published within each IEEE society and the number of conference proceedings published within each subfield to determine the rate of technical evolution. Due to the lack of sufficient sponsor attribution of conference proceedings data and the handling of joint conferences, we use the IEEE Xplore topic for the categorization of conference proceedings. And because conference articles lack necessary conference title parameters for the categorization, we count the number of conferences instead.

Results

In this section, we break down the total number of articles published by area and nation. The summaries of IEEE publications may be shown in Figure 2. The total number of articles and the number of publications and conference proceedings are shown in the figure by solid and broken lines, respectively. Over the 30-year period studied, the overall number of papers published rose sharply in step with the growth in the number of journals and conferences. According to the numbers, the number of publications published in conference proceedings skyrocketed after 2002. Between 1980 and 2008, the number of scholarly conference papers published grew by approximately a factor of 20. Starting in 1994, the total number of conference proceedings published each year exceeded the total number of magazines. These tendencies demonstrate the significance of conference proceedings in E&E and ICT bibliometric research.

Table 1 Compendium of sampled data on IEEE publications

Article type	Publication media	Period	Number of articles	Number of publications	Notes
Periodical articles	Journal and magazines	1980–2008	355,891	201	114 Transactions 18 Journals 69 Magazines
Conference articles	Conference proceedings	1980–2008	1,148,164	8,706	Year in which the conference was held Repeated conferences are counted one by one

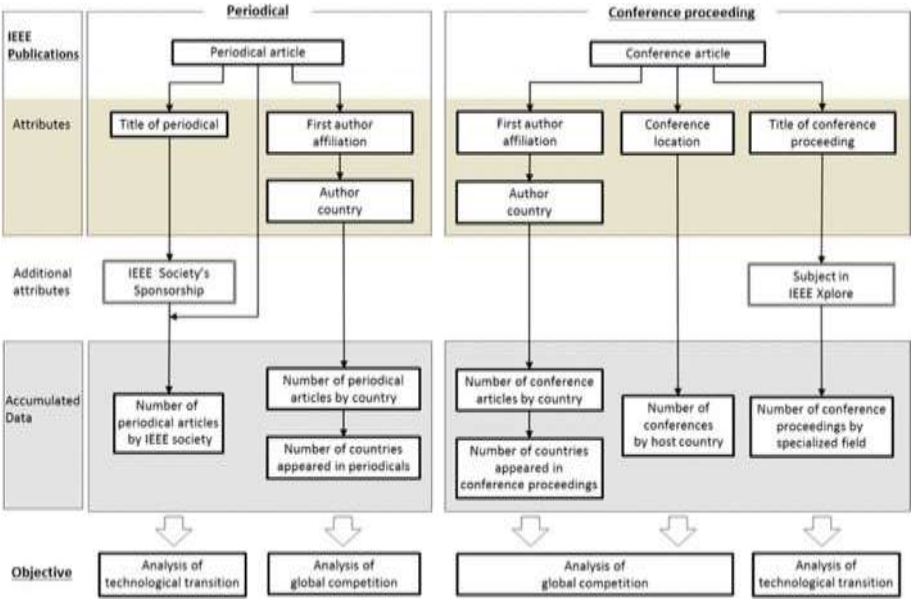

Fig. 1 Data flow diagram for IEEE publication analysis

Global competition

The technical work being done in each area is reflected in IEEE papers written by those in that region. The annual count of articles published in magazines is shown in Figure 3. The number of publications published in 2008 by each of 30 major nations is shown. The United States has consistently ranked first in terms of the total number of articles published in periodicals, however the countries ranking second through fifth have changed between 1980 and 2008. Prior to 2005, Japan held the runner-up spot, but as of 2007, China has moved ahead of them. Prior to 1998, Canada always placed third, but beginning in 1999, many nations shared that honor. The worldwide growth in the number of articles published in periodicals has been especially noticeable in China.

The number of publications published in the proceedings of conferences in the same year they were conducted is shown in Figure 4. In 2008, conferences were held in 30 different nations; Germany and Russia were once known as West Germany and the USSR, respectively. The rise in the number of publications presented at conferences is a phenomenon shared by many nations. The United States led the world in the number of conference articles from 2002 until 2007, with Japan in second place from 2001 until 2008. However, starting in 2003, China's conference article count skyrocketed, putting it in second place, and by 2008, it had surpassed the United States. In 2008, China had the highest total number of conference papers published, over 1.7 times that of the United States, which was in second place at the time.

In the beginning and middle of the 1980s, writers from the United States, Japan, and Canada were credited for the vast majority of IEEE publications. From the late 1980s to the 1990s, the IEEE saw a rise in the internationalization of its technical operations, with more people

from Europe, especially the UK, Italy, France, and Germany, and East Asia, especially South Korea and Taiwan, contributing to publications. In

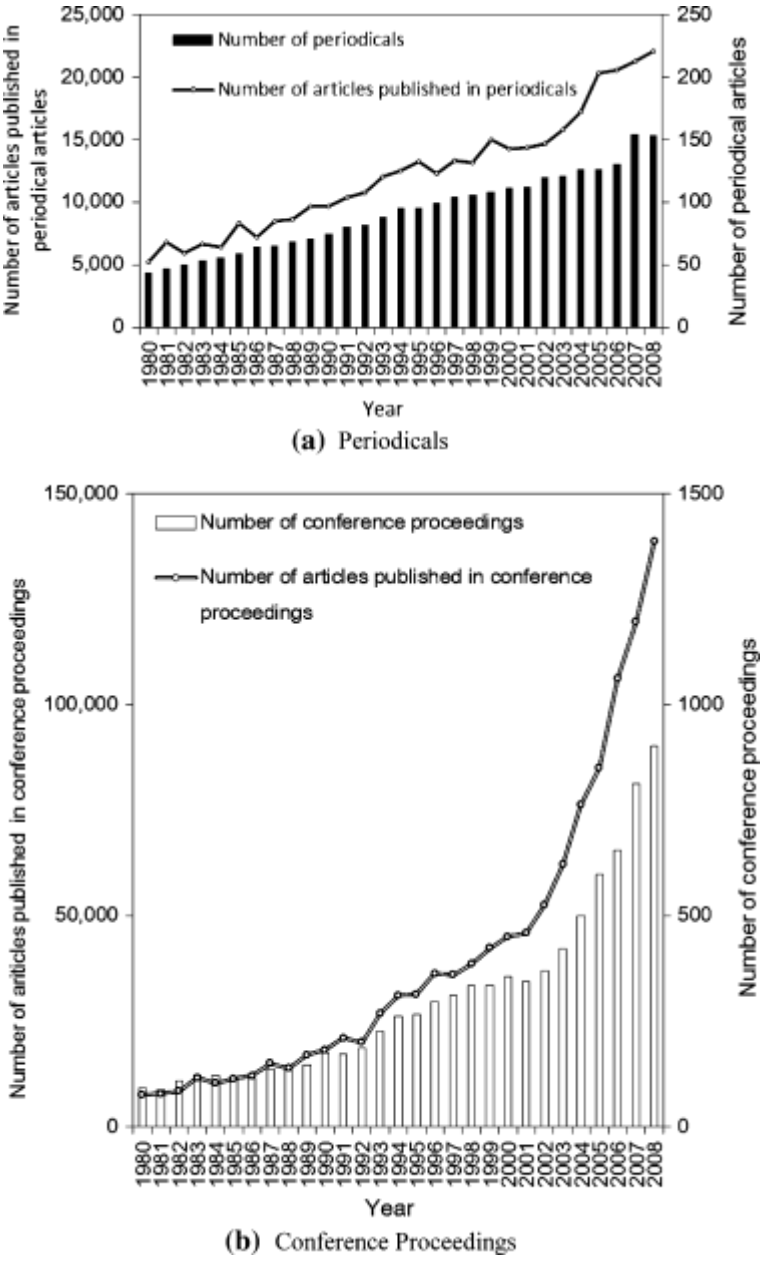

Fig. 2 Number of IEEE publications between 1980 and 2008

Due to political shifts and greater globalization, the IEEE started to undergo a worldwide structural shift around the year 2000. Increased technological activity and a consequent rapid rise in the rate of periodical article publishing in China after the return of Hong Kong are significant indicators that underlying structural changes are becoming increasingly apparent in the country.

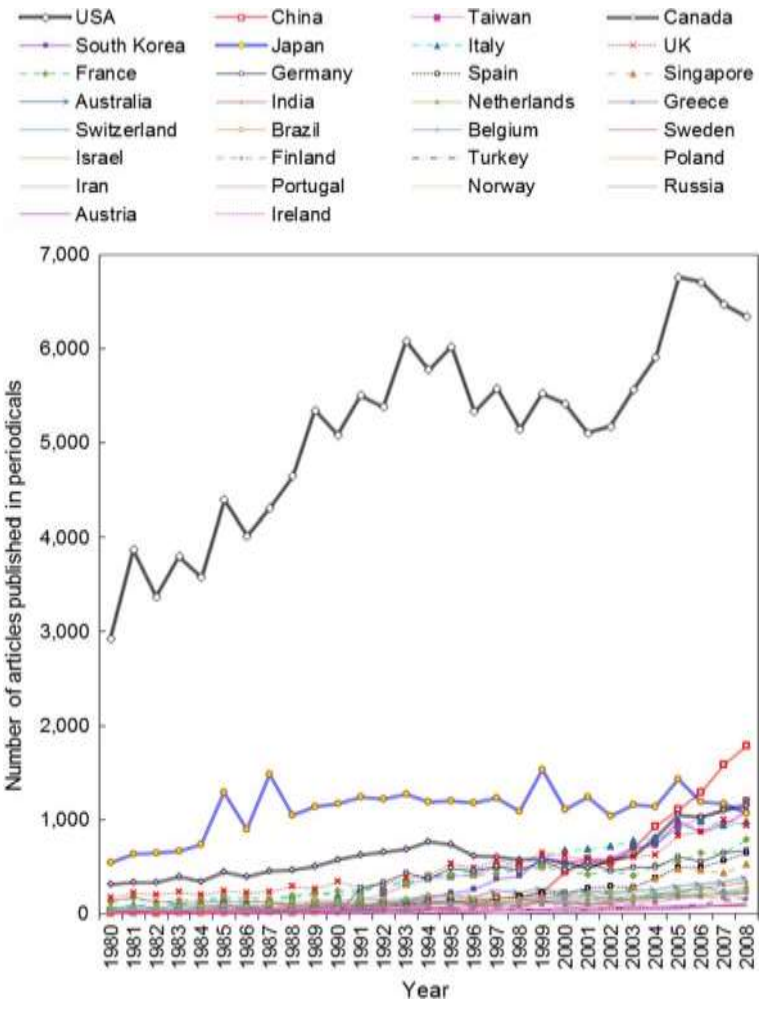

Fig. 3 Number of articles published in periodicals by country between 1980 and 2008

in conference articles. The rapid progress of globalisation has resulted in more emerging countries, including Singapore and Spain, increasing their relative contributions to IEEE periodical articles.

Technological transition

Number of papers published in periodicals by the top 20 IEEE societies, 1980–2008 (Figure 5). We added up the total amount of magazine articles published by each society since each group tends to put out many magazines. The Nuclear and Plasma Science Society at IEEE has been, on average, the most prolific IEEE society in terms of journal publications until that year. The number of papers published by the Electron Devices Society in its journals rose steadily beginning in 1980, allowing them to claim first place by 1986. In the years between 1986 and 1990, the Magnetics Society published more than double as many papers in its journals than any other organization.

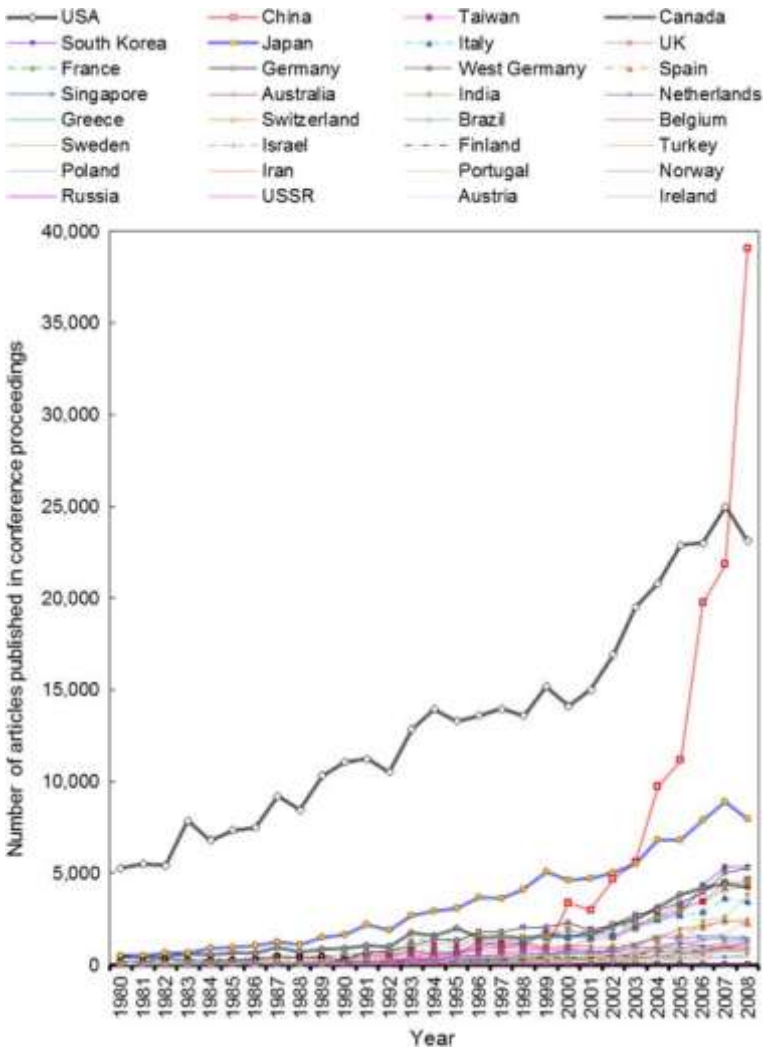

Fig. 4 Number of articles published in conference proceedings by country between 1980 and 2008

1991. Throughout 1992, 1993, 1995, and 1996, as well as 1997–2000, the Photonics Society was in first place. Since 1996, the Computer Society has been at the top. Starting in 2002, the Communication Society shot up from fifth to second position, demonstrating fast expansion. As can be seen, shifts in the dominant society occur about every five years, and the number of periodic papers in IEEE journals is a clear reflection of changes in technological activity by specialized area. In each time period, the following has been the preeminent field:
Nuclear science, early 1980s.

Magnetism and electronic gadgetry of the late '80s.

• Electronics, photonics, and computing in the early 1990s.

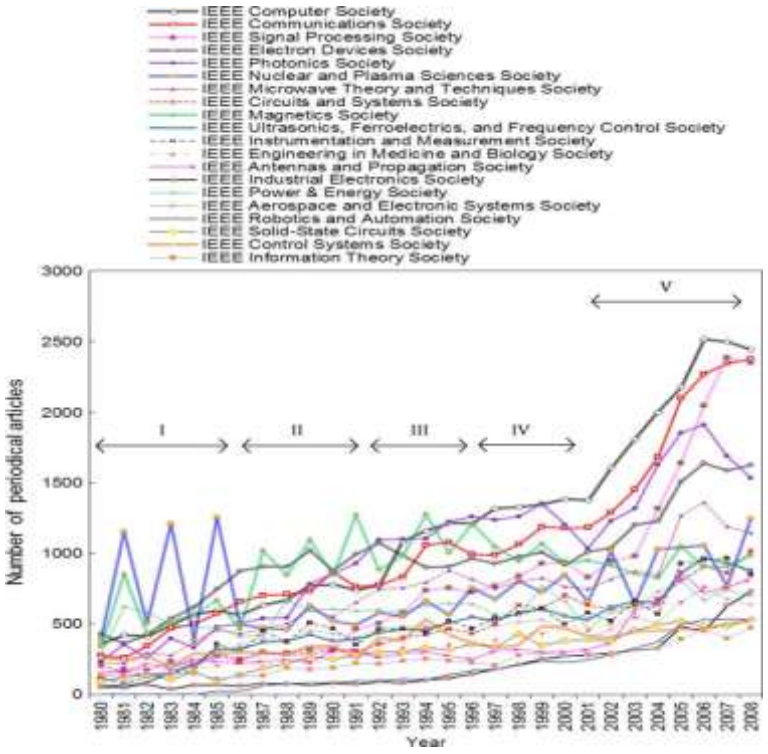

Fig. 5 Number of periodical articles published by IEEE societies between 1980 and 2008

- *Late 1990s*: computers and communications.
- *2000s*: networks, wireless communications, signal processing and computers.

After 2002, there was a meteoric rise in the total number of articles published, mostly due to the proliferation of ICT-related periodicals. Major civilizations are progressing in tandem by encouraging the development of new specialized disciplines that fall within or go beyond the conventional spheres of expertise of each culture.
From 1980 to 2008, Figure 6 displays the distribution of conference proceedings among

several academic disciplines. IEEE societies often collaborate with other organizations in the information and communications technology (ICT) sector to host joint conferences. Joint conferences could not be properly categorized based on characteristics supplied by IEEE societies that sponsored individual events.

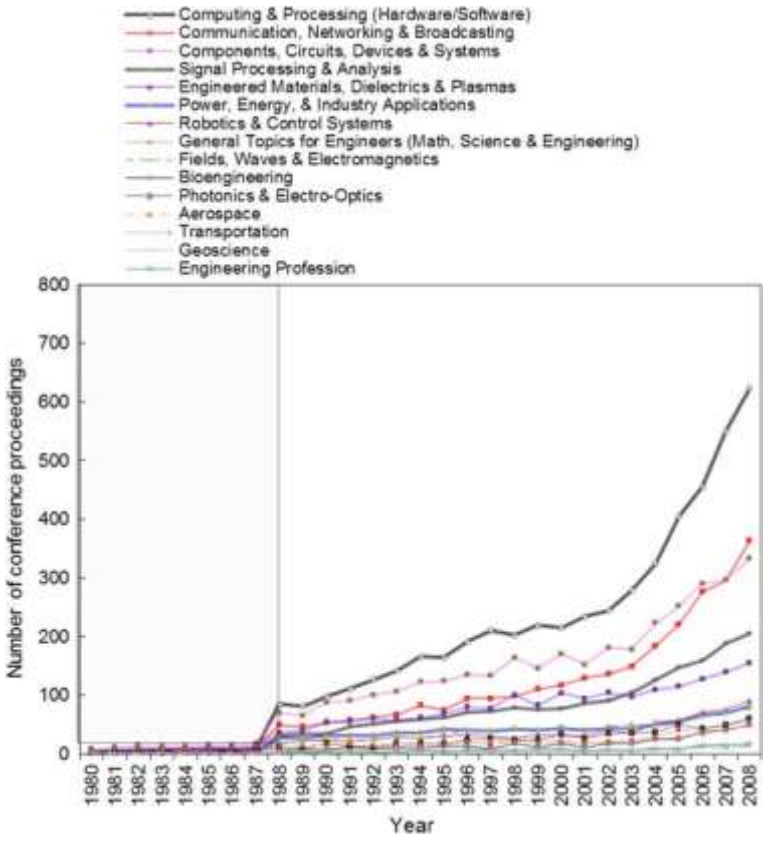

Fig. 6 Number of conference proceedings by specialized field between 1980 and 2008 (before 1988, full coverage was not assured by IEEE Xplore)

conference indexing inconsistencies. Therefore, we use IEEE Xplore subject areas to categorize conference papers, using mapping tables that detail the link between conference names and subject areas. Based on the data shown in Figure 6, the three most prominent subfields in the industry were (1) Computing and Processing (Hardware/Software), (2) Communication, Networking, and Broadcasting, and (1) Components, Circuits, Devices, and Systems between the years 1980 and 2008. Specifically, the number of conferences in ICT-related subjects has expanded considerably since 2002, mirroring the pattern seen in scholarly journal papers. These findings illustrate the movement in leading technologies from E&E to ICT, despite the fact that the shift in significant players shown in Fig. 4 is not obvious in Fig. 5, save for the rise of ICT-related sectors.

Discussion

Globalisation and international competition

We used the Herfin- dahl-Hirschman Index (HHI), often known as the Herfindahl Index (Michelini and Pickford), to objectively assess internationalization.

Using the Sum of Squares Index (1985) to examine the level of concentration, we analyzed the shifts in the types of papers published as part of IEEE's research endeavors throughout time. The following formulas are used to calculate the HHI of journal articles, Hp(t), and conference papers, Hc(t), respectively, in year t.

$$\begin{cases} H_p(t) = \sum_{i=1}^{n_p(t)} p_i^2(t) \\ H_c(t) = \sum_{i=1}^{n_c(t)} c_i^2(t) \end{cases};$$

where pi(t) and ci(t) represent the proportion of journal articles and conference papers published in each nation during a given time period. The number of countries in which the institutions of the initial authors of journal articles and conference papers are situated is denoted by np(t) and nc(t), respectively. Hp(t) and Hc(t) are equal to 10,000 in percentage units if a nation monopolizes the articles published in periodicals and conference proceedings. Hp(t) and Hc(t) go toward 0 if numerous nations share the journal and conference papers.

Figure 7 indicates that during the previous 29 years, when one country has dominated research efforts and publications, both Hp(t) and Hc(t) have shown a downward tendency. Hc(t) is falling at a faster rate than Hp(t), suggesting that globalization is progressing as a result of structural shifts. Despite the United States' continued dominance in the IEEE, the HHI has been on the decline.

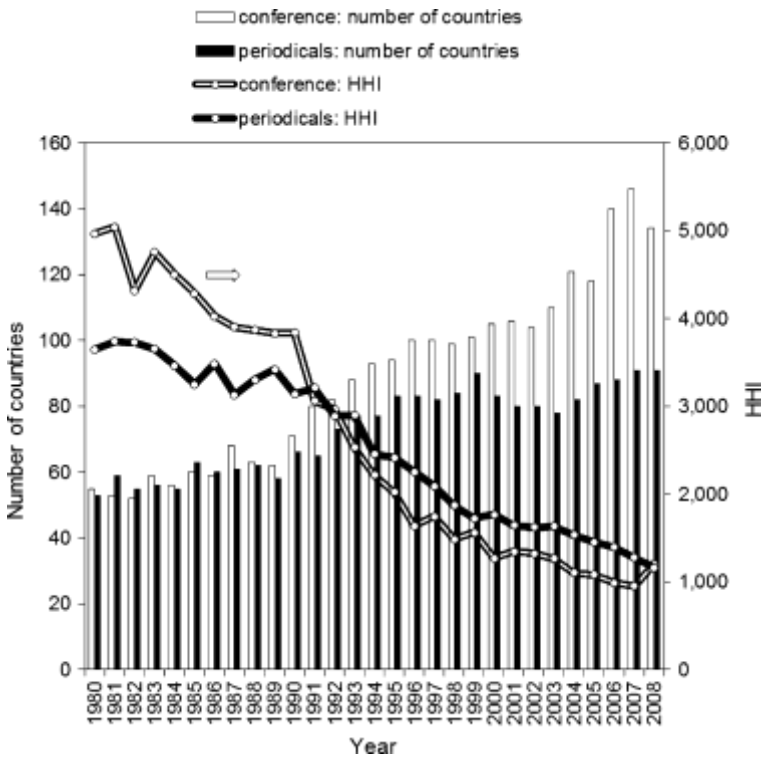

Fig. 7 Number of countries appearing in periodicals and conference proceedings and the HHI trend

creation of conditions where successful international competitiveness flourishes. The IEEE is rapidly transforming into the "E&E association of the world" as it actively promotes international competitiveness and moves away from its US-centric roots.

A tri-polar order is beginning to take shape.

Figure 8 displays the proportion of magazine articles published in each area from 1980 to 2008. The United States has donated the most during the last 30 years, followed by numerous European nations, Canada, and Japan. In the beginning, Japan was the only East Asian country to contribute articles, but later, China, Taiwan, and South Korea also made significant strides. The four nations that make up East Asia in our eyes are Japan, South Korea, Taiwan, and China (adding Hong Kong as a special administrative area in China). Since Singapore is located in South East Asia, it is not included in the East Asian region in this discussion. As a result of rising investment in E&E and ICT research in China, Taiwan, South Korea, and Singapore, the region quickly overtook North America and Europe (EU27) as the third largest donor. A well-balanced tri-polar structure of global contribution is forming as these three areas move closer and closer to parity, testifying to the effectiveness of the IEEE's pursuit of globalization via the encouragement of active international competition. Figure 8 implies a stable tri-polar structure consisting of North America, Europe, and East Asia (including Singapore), notwithstanding recent discussions of the shift from a triad consisting of the United States, Europe, and Japan to a tetrad including China (Gla nzel et al., 2008).

The Internationalization of Conference Sites

We also looked at IEEE's published conference proceedings to see how their papers have spread internationally. From 1980 to 2008, the number of international conferences held in each host country is broken out in Figure 9. As can be seen in Fig. 9, there has been a rise in the number of international conferences organized in locations other than the United States, with the majority of these gatherings presently taking place in China, which has demonstrated the most impressive development in both conference production and article publishing. The return of Hong Kong is a potential explanation for China's quick expansion in item production after 1999. One probable explanation is the rising popularity of China as a venue for international conferences, which makes it easier for Chinese scientists and engineers to go abroad and present their work.
According to the statistics, there has been a considerable increase in the internationalization of IEEE technical activity. Even though IEEE publications are read all throughout the world, particular care is taken to make them accessible to readers in China. 'Glocalisation', or the strategy of global distribution and local accommodation, seems to be a main goal of the IEEE, as shown by the findings of the study of the conference proceedings.

Changes in organization and technology as shown by IEEE publications

The shift seen in this study's examination of IEEE publications is summarized in Table 2. The years 1980-2008 may be broken down into five distinct periods, as we discussed above:

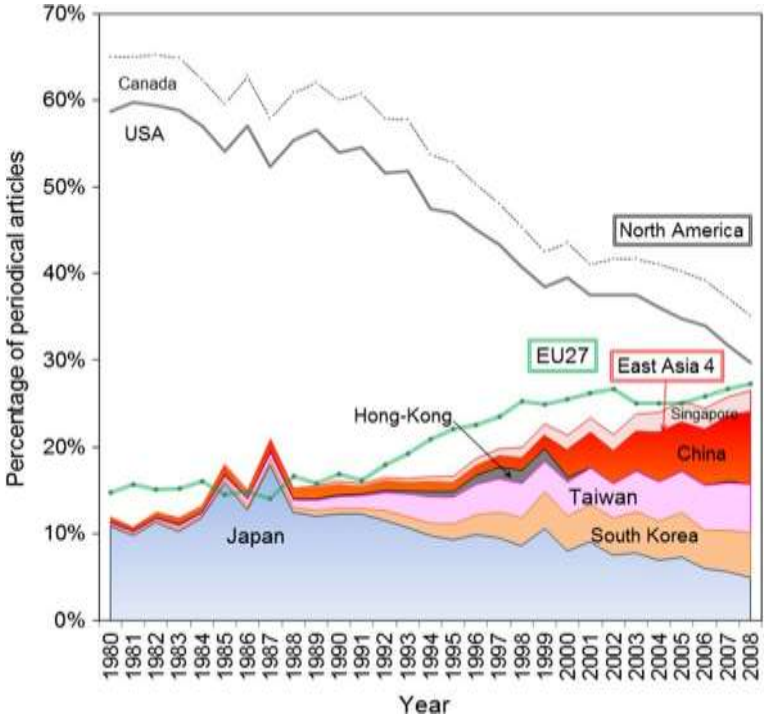

Fig. 8 Percentage of periodical articles by region (China includes Hong Kong after reversion)

in Table 2 we can see. Monopoly, duopoly, internationalization, globalization, and glocalization are the hallmarks of these epochs. The United States was the hub of IEEE during phase I (monopoly), and nuclear science was the dominant technology since it was developed during the cold war. In phase II (duopoly), the spread of magnetic and electron devices polarized the United States and Japan against one another due to Japan's rise to prominence. During Stage III (Internationalization), European nations headed by Italy and Germany expa nded IEEE publications, while photonics, computer science, and communications became the primary technologies. With the expansion of the Internet, East Asian nations like South Korea and Taiwan have flourished throughout phase IV (globalization). Tri-polar regional structure in phase V (glocalisation) with North America, Europe, and East Asia keeps the peace and indicates the ICT wedge is making headway into important technologies underlying mobile communications.

Conclusion

This almost 30-year study of IEEE publications shows that the organization's technical and publishing operations have grown not just internationally, but also domestically. In particular, we discovered that the IEEE's research and publishing activities have undergone incremental structural changes due to the advent of more active international competition, primarily due to the IEEE's support thereof. IEEE has become more international in scope as the primary technologies it studies come and go.

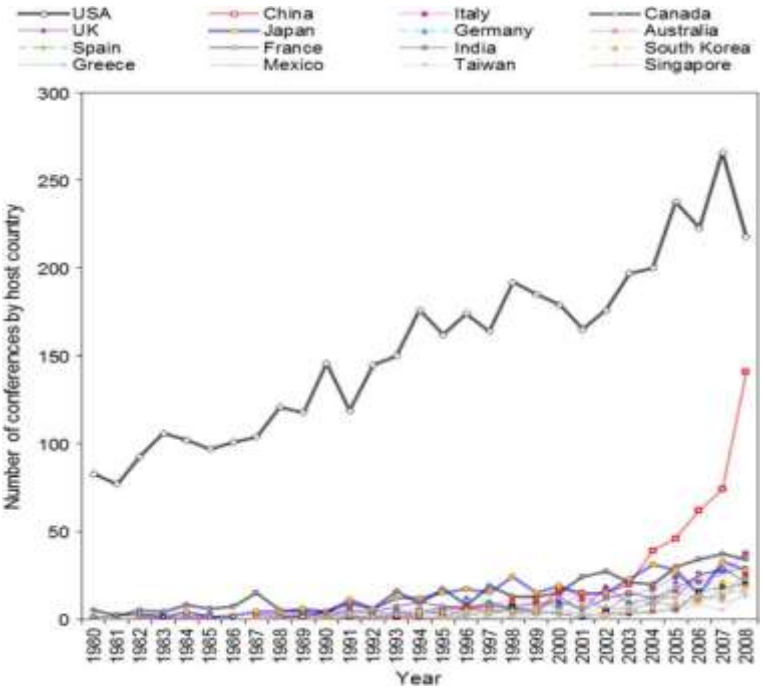

Fig. 9 Number of conferences by host country between 1980 and 2008

Table 2 Transition observed in IEEE publications

Phase	I	II	III	IV	V
Period	1986	1987–1991	1992–1996	1997–2001	2002
Structure	Monopoly North American	Duopoly Cross-border	Internationalization International	Globalisation Transitional	Glocalisation Tri-polar
State	US-centred	Polarized between US and Japan	European participation and the rise of East Asia	Global transition by emergence of China	Tri-polar balanced among North America, Europe and East Asia
Main player	North America	North America, Japan	North America, EU15 and Japan	US, EU15 and East Asia	North America, EU27, East Asia
Major technology	Nuclear science	Magnetics, electron devices	Photonics, Electron devices, Computer, Communications	Computer, Communications, Electron devices	Computer, Communications, Signal processing

Books are sent all over the world and stored in local libraries. The Institute of Electrical and Electronics Engineers (IEEE) is the world's biggest professional engineering society and the industry's preeminent academic publication, and it is undergoing a process of globalization. Here I will detail our particular results and the consequences they have.

• For almost 30 years, IEEE publications have been growing steadily, both internationally and domestically. The IEEE has transitioned from its US-centered roots to actually becoming the 'E&E organization of the globe' as technologically rising nations have increased their contribution to article publishing.

There has been a near 20-fold rise in the publication of conference proceedings since 1980. In example, China's publication of conference proceedings has skyrocketed since 2002, eventually surpassing that of the United States in 2008.

• The amount of articles printed in periodicals multiplied by four between 1980 and 2008.

There is now a more even distribution of papers written by writers in North America, Europe, and East Asia, leading to the emergence of a tri-polar structure in IEEE's technical pursuits.The quantitative examination of IEEE publications indicates five distinct stages of structural change in the form of worldwide rivalry and technical transformation.

This investigation has one major drawback. We were unable to analyze the worldwide cooperation networks that commonly arise among writers from various nations since we only examined the article information relating to the nationality of the first author identified among all the authors in an article. Research in the future should aim to learn more about the composition of these networks and worldwide scientific collaborations. This study's major significance may lie in serving as a springboard to investigate more direct applications of the results because of this limitation. Despite this caveat, we are certain that the results reported here aid in comprehending the international character of E&E and ICT as witnessed via IEEE technical activities and publications.

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