

Current Comments®

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A Citationist Perspective on Science in Taiwan: Most-Cited Papers, Institutions, and Authors, 1981-1992

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Abstract

A citation analysis of current scientific research in Taiwan is presented, based on papers published and cited from 1981 through 1992. The data are drawn from 20,986 papers with at least one author based in Taiwan indexed in the *Science Citation Index*®. The papers, institutions, and authors with the highest citation frequency and impact are identified.

Introduction

A few weeks ago I had the opportunity to tour the island of Taiwan. Dr. Tao-Hsing Ma, director of the Science and Technology Information Center, National Science Council, invited me to participate in the Third Conference of Scientific Editors of the Republic of China as well as the Annual Conference of the Scientific and Technical Interlibrary Cooperation Association. I last visited Taiwan in 1990 to discuss how ISI® selects journals for coverage in its databases.^{1,2}

This essay is based on my presentation, which provided a citation analysis of Pacific Rim science.³ The talk included far more information than can be reprinted in the space available here. For example, eight Pacific Rim nations—Taiwan, Hong Kong, Indonesia, Malaysia, the Philippines, Singapore, South Korea, and Thailand—were compared in terms of trends in the impact of their papers from 1981 through 1992. Comparisons were made for science overall and separately in the life sciences, agriculture and biology, clinical medicine, physics and chemistry, and engineering and technology. This alone could easily be the subject of one or more *Current Contents*® (CC®) essays. However, a brief report based on this data recently appeared in *Science Watch*®.⁴

Data on the Pacific Rim nations is summarized below. Then we focus on Taiwan

in particular, identifying its most-cited papers published from 1981 through 1992. We've also identified the most-cited and highest impact institutions and authors.

Science in the Pacific Rim: A Summary

Over the 12-year period 1981-1992, ISI indexed 62,836 Pacific Rim papers in the *Science Citation Index*® (SCI®). Taiwan accounted for the largest share—33 percent. South Korea followed with 20 percent, Hong Kong with 15 percent, and Singapore with 10 percent. The remaining nations each produced less than 10 percent—Thailand (8 percent), Malaysia (6 percent), the Philippines (4 percent), and Indonesia (3 percent).

In terms of distribution by field, 26 percent of the Pacific Rim papers were in the life sciences, which includes molecular biology, genetics, biochemistry, biophysics, microbiology, cell biology, and so on. Following the CC journal groupings, the physical and chemical sciences include the earth sciences and mathematics. This group was next with 24 percent of the papers, followed by engineering and technology (20 percent), which include materials science, optics, acoustics, mining, etc. Clinical medicine accounted for 17 percent, followed by agricultural and biological sciences (13 percent), which include biotechnology, plant sciences, aquatic, and environmental science.

Table 1: 12-year impact rankings of Pacific Rim nations for papers published and cited from 1981 through 1992. Only those nations accounting for 10 percent of total Pacific Rim papers in all sciences and in each field are included. Impact factors are shown below each nation.

Rank	All Sciences	Agriculture/ Biology	Clinical Medicine	Life Sciences	Physics/ Chemistry	Engineering/ Technology
1.	Hong Kong 3.4	Philippines 2.9	Taiwan 3.9	Thailand 5.8	South Korea 2.5	South Korea 1.6
2.	Taiwan 2.5	Thailand 2.3	Thailand 3.8	Hong Kong 4.5	Taiwan 2.4	Taiwan 1.5
3.	Singapore 2.2	Malaysia 2.1	Hong Kong 3.3	Taiwan 4.3		Singapore 1.2
4.	South Korea 2.2	Taiwan 1.9	Singapore 2.2	Singapore 3.4		
5.			South Korea 1.8	South Korea 3.0		

Table 1 shows how the Pacific Rim nations ranked in science overall and in each field in terms of impact over the 12-year period. These impact factors were calculated as follows: total 1981-1992 citations were divided by the number of papers published by Pacific Rim authors during this period. However, the table includes only those nations that produced at least 10 percent of Pacific Rim papers in each field. Nations producing less were excluded lest their impact was influenced by a small number of highly cited papers.

Among the most productive Pacific Rim nations in science overall, Hong Kong ranked first with a 12-year impact of 3.4. Taiwan followed (2.5), and Singapore and South Korea both had an impact of 2.2.

In agriculture and biology, the Philippines ranked first with a 12-year impact of 2.9. Taiwan was the leader in clinical medicine (3.9), followed closely by Thailand (3.8). In the life sciences, Thailand ranked first with an impact of 5.8. In the physical and chemical sciences, Taiwan and South Korea were the only nations that produced more than 10 percent of Pacific Rim papers. And both had virtually equivalent impacts—South Korea with 2.5 and Taiwan, 2.4. Lastly, in engineering and technology, South Korea had the highest 12-year impact (1.6), followed by Taiwan (1.5) and Singapore (1.2).

Most-Cited Taiwan Papers

Table 2 lists the most-cited 1981-1992 papers with at least one author based in

Taiwan. Twenty-two papers cited more than 75 times are listed. The highest impact paper—with 669 citations—concerns hepatitis B virus and hepatocellular carcinoma. Published in the 1981 *Lancet*, it was authored by R.P. Beasley, University of Washington Medical Research Unit, Taipei, and colleagues at the Government Employees Clinic Center and the National Taiwan University Medical College.

Beasley appears on 7 of the 22 most-cited Taiwan papers, all dealing with hepatitis B virus. Thus, his coauthors also account for several papers—L.Y. Hwang (six), C.C. Lin (five), C.E. Stevens and W. Szmuness (three), and F.J. Hsieh, T.S. Sun, and K.Y. Wang (two each).

Another prolific author is J.C. Wang, Academia Sinica, Taipei, and Harvard University, Cambridge. He accounts for four of the papers listed, all describing DNA studies, with 179, 176, 89, and 76 citations. It is interesting to note that these high impact papers were published recently—three in 1988 and one in 1987.

In terms of institutions, the National Taiwan University, Taipei, appeared on 6 of the 22 highest impact Taiwan papers. Of these, five were from the College of Medicine and one from the Botany Department. Four papers were from the Academia Sinica. The Chang Gung Memorial Hospital, Taipei, and the Veterans General Hospital, Taipei, appeared on three papers each, followed by the Taiwan Provincial Junior College of Nursing, Taipei, and National Yang Ming Medical College, Taipei, with two each.

Table 2: Most-cited Taiwan papers, published and cited from 1981 through 1992.**Cites**

- 669 **Beasley R P, Lin C C, Hwang L Y & Chien C S.** Hepatocellular carcinoma and hepatitis B virus—a prospective study of 22,707 men in Taiwan. *Lancet* 2:1129-33, 1981. Univ. Washington, Med. Res. Unit, Taipei, Taiwan; Govt. Employees Clin. Ctr., Taipei, Taiwan; Natl. Taiwan Univ. Med. Coll., Inst. Public Health, Taipei
- 246 **Beasley R P, Hwang L Y, Lee G C Y, Lin C C, Roan C H, Huang F Y & Chen C L.** Prevention of perinatally transmitted hepatitis B virus infections with hepatitis B immune globulin and hepatitis B vaccine. *Lancet* 2:1099-102, 1983. Univ. Washington, Med. Res. Unit, Taipei, Taiwan; Natl. Taiwan Univ. Hosp., Dept. Pediat., Taipei; Taipei Municipal Women & Children's Hosp., Taipei; Mackay Mem. Hosp., Dept. Obstet. & Pediat., Taipei, Taiwan
- 241 **Key J L, Lin C Y & Chen Y M.** Heat-shock proteins of higher plants. *Proc. Nat. Acad. Sci. USA* 78:3526-30, 1981. Univ. Georgia, Dept. Botany, Athens, US; Natl. Taiwan Univ., Dept. Botany, Taiwan
- 190 **Beasley R P.** Hepatitis B virus as the etiologic agent in hepatocellular carcinoma—epidemiologic considerations. *Hepatology* 2:S21-6, 1982. Univ. Washington, Med. Res. Unit, Taipei, Taiwan
- 179 **Wu H Y, Shyy S, Wang J C & Liu L F.** Transcription generates positively and negatively supercoiled domains in the template. *Cell* 53:433-40, 1988. Johns Hopkins Univ. Sch. Med., Dept. Biol. Chem., Baltimore, MD, US; Acad. Sinica, Inst. Molec. Biol., Taipei, Taiwan; Harvard Univ., Dept. Biochem. & Molec. Biol., Cambridge, MA, US
- 176 **Wang J C.** Recent studies of DNA topoisomerases. *Biochim. Biophys. Acta* 909:1-9, 1987. Harvard Univ., Dept. Biochem. & Molec. Biol., Cambridge, MA, US; Acad. Sinica, Inst. Molec. Biol., Taipei, Taiwan
- 150 **Beasley R P, Lin C C, Wang K Y, Hsieh F J, Hwang L Y, Stevens C E, Sun T S & Szmunes W.** Hepatitis B immune globulin (HBIG) efficacy in the interruption of perinatal transmission of hepatitis B virus carrier state. *Lancet* 2:388-93, 1981. Univ. Washington, Med. Res. Unit, Taipei, Taiwan; Natl. Taiwan Univ. Med. Coll., Inst. Public Health, Taipei; New York Blood Ctr., NY, US; Taiwan Provincial Jr. Coll. Nursing, Ctr. Maternal & Child Health, Taipei; US Navy, Med. Res. Unit, Manila, Philippines
- 123 **Liaw Y F, Chu C M, Su I J, Huang M J, Lin D & Changchien C S.** Clinical and histological events preceding hepatitis B-E antigen seroconversion in chronic type-B hepatitis. *Gastroenterology* 84:216-9, 1983. Chang Gung Mem. Hosp., Liver Unit & Dept. Pathology, Taipei, Taiwan
- 121 **Shen D C, Shieh S M, Fuh M M T, Wu D A, Chen Y D I & Reaven G M.** Resistance to insulin-stimulated glucose uptake in patients with hypertension. *J. Clin. Endocrinol. Metab.* 66:580-3, 1988. Stanford Univ. Sch. Med., Dept. Med., CA, US; Tri-Services Gen. Hosp., Dept. Med. & Clin. Res., Taipei, Taiwan
- 116 **Lu N C C, Gerzberg L, Lu C Y & Meindl J D.** Modeling and optimization of monolithic polycrystalline silicon resistors. *IEEE Trans. Electron Devices* 28:818-30, 1981. Stanford Univ., Integrated Circuits Lab, CA, US; Natl. Chiao Tung Univ., Inst. Electronics, Hsinchu, Taiwan
- 110 **Russell D S, Gherzi R, Johnson E L, Chou C K & Rosen O M.** The protein tyrosine kinase activity of the insulin receptor is necessary for the insulin mediated receptor down regulation. *J. Biol. Chem.* 262:1833-40, 1987. Mem. Sloan Kettering Cancer Ctr., New York, NY, US; Cornell Univ. Med. Sch., New York, NY; Veterans Gen. Hosp., Taipei, Taiwan
- 103 **Ashley J C & Tung C J.** Electron inelastic mean free paths in several solids for 200 eV less than or equal to E less than or equal to 10 keV. *Surf. Interface Anal.* 4:52-5, 1982. Oak Ridge Natl. Lab., Div. Health Safety Res., TN, US; Natl. Tsing Hua Univ., Inst. Nuclear Sci., Hsinchu, Taiwan
- 100 **Chu C M, Karayiannis P, Fowler M J F, Monjardino J, Liaw Y F & Thomas H C.** Natural history of chronic hepatitis B virus infection in Taiwan—studies of hepatitis B virus DNA in serum. *Hepatology* 5:431-4, 1985. Royal Free Hosp. Sch. Med., Depts. Med. & Physiol., London, UK; Chang Gung Mem. Hosp., Liver Unit, Taipei, Taiwan
- 94 **Beasley R P, Hwang L Y, Lin C C, Leu M L, Stevens C E, Szmunes W & Chen K P.** Incidence of hepatitis B virus infections in preschool children in Taiwan. *J. Infect. Dis.* 146:198-204, 1982. Univ. Washington, Med. Res. Unit, Taipei, Taiwan; Natl. Taiwan Univ., Inst. Public Health, Taipei; New York Blood Ctr., NY, US; US Navy, Med. Res. Unit, Manila, Philippines
- 93 **Beasley R P & Hwang L Y.** Postnatal infectivity of hepatitis B surface antigen carrier mothers. *J. Infect. Dis.* 147:185-90, 1983. Univ. Washington, Med. Res. Unit, Taipei, Taiwan; US Navy, Med. Res. Unit, Manila, Philippines
- 92 **Beasley R P, Hwang L Y, Stevens C E, Lin C C, Hsieh F J, Wang K Y, Sun T S & Szmunes W.** Efficacy of hepatitis B immune globulin for prevention of perinatal transmission of the hepatitis B virus carrier state—final report of a randomized double-blind, placebo-controlled trial. *Hepatology* 3:135-41, 1983. Univ. Washington, Med. Res. Unit, Taipei, Taiwan; Taiwan Provincial Jr. Coll. Nursing, Ctr. Maternal & Child Health, Taipei; US Navy, Med. Res. Unit, Manila, Philippines; Natl. Taiwan Univ. Med. Coll., Inst. Public Health, Taipei; New York Blood Ctr., NY, US
- 92 **Wu D, Kou H C & Hung J S.** Exercise-triggered paroxysmal ventricular tachycardia—a repetitive rhythmic activity possibly related to after-depolarization. *Ann. Intern. Med.* 95:410-4, 1981. Chang Gung Mem. Hosp., Dept. Med., Cardiol. Sect., Taipei, Taiwan

Table 2 (continued)

Cites	<p>89 Tsai-Pflugfelder M, Liu L F, Liu A A, Tewey K M, Whangpeng J, Knutsen T, Huebner K, Croce C M & Wang J C. Cloning and sequencing of cDNA encoding human DNA topoisomerase-II and localization of the gene to chromosome region 17Q21-22. <i>Proc. Nat. Acad. Sci. USA</i> 85:7177-81, 1988. Harvard Univ., Dept. Biochem. & Molec. Biol., Cambridge, MA, US; Acad. Sinica, Inst. Molec. Biol., Taipei, Taiwan; Johns Hopkins Univ. Sch. Med., Dept. Biol. Chem., Baltimore, MD, US; Natl. Cancer Inst., Med. Branch, Bethesda, MD, US; Wistar Inst. Anatomy & Biology, Philadelphia, PA, US</p> <p>86 Homma T, Kanki P J, King N W, Hunt R D, O'Connell M J, Letvin N L, Daniel M D, Desrosiers R C, Yang C S & Essex M. Lymphoma in macaques—association with virus of human T-lymphotropic family. <i>Science</i> 225:716-8, 1984. Harvard Univ. Sch. Public Health, Dept. Cancer Biol., Boston, MA, US; New England Regional Primate Res. Ctr., Southborough, MA, US; Natl. Taiwan Univ. Med. Coll., Taipei</p> <p>81 Liebman H A, Furie B C, Tong M J, Blanchard R A, Lo K J, Lee S D, Coleman M S & Furie B. Des-gamma-carboxy (abnormal) prothrombin as a serum marker of primary hepatocellular carcinoma. <i>N. Engl. J. Med.</i> 310:1427-31, 1984. New England Med. Ctr., Div. Hematol. Oncol., Boston, MA, US; Tufts Univ. Sch. Med., Boston; Boston City Hosp., Div. Hematol. Oncol.; Huntington Mem. Hosp., Liver Ctr., Pasadena, CA, US; Veterans Gen. Hosp., Taipei, Taiwan</p> <p>77 Chang C M, Jeng K S, Hu C P, Lo S C J, Su T S, Ting L P, Chou C K, Han S H, Pfaff E, Salfeld J & Schaller H. Production of hepatitis B virus <i>in vitro</i> by transient expression of cloned HBV DNA in a hepatoma cell line. <i>EMBO J.</i> 6:675-80, 1987. Natl. Yang Ming Med. Coll., Inst. Microbiol. & Immunol., Shih Pai, Taiwan; Veterans Gen. Hosp., Dept. Med. Res., Taipei, Taiwan; Univ. Heidelberg, Germany</p> <p>76 Wang J C & Giaever G N. Action at a distance along a DNA. <i>Science</i> 240:300-4, 1988. Harvard Univ., Dept. Biochem. & Molec. Biol., Cambridge, MA, US; Acad. Sinica, Inst. Molec. Biol., Taipei, Taiwan</p>
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The following institutions each appeared on one paper: Government Employees Clinical Center, Taipei; Mackay Memorial Hospital, Taipei; National Chiao Tung University, Hsinchu; National Taiwan University Hospital, Taipei; National Tsing Hua University, Hsinchu; Taipei Municipal Women and Children's Hospital, Taipei; and the Tri-Services General Hospital, Taipei.

In terms of national collaboration, US institutions appeared on 14 of the 22 papers. The Philippines accounted for four papers, but all of these were by researchers at the US Navy Medical Research Unit. The UK and Germany appeared on one paper each.

Most-Cited (and Most-Productive) Institutions

From ISI®'s database of 20,986 1981-1992 papers from Taiwan, it is fairly straightforward to generate lists of institutions and authors ranked by productivity, total citations, impact, and so on. The most-cited Taiwan institutions are shown in Table 3. Twenty-nine institutions with at least 250 citations are listed.

It should be noted that only those institutions that produced at least 25 papers are

included. This effectively "censors" the occasional citation "outliers"—institutions that may have high citation rankings based on just a few highly cited papers. By setting an arbitrary threshold of 25 papers, the list includes consistently productive institutions over the 12-year period.

Twelve institutions received at least 1,000 citations. The National Taiwan University ranks first with more than 11,300 citations. As it turns out, it also is the most productive institution, with almost 3,900 papers published in 1981-1992.

In fact, *all* of the institutions in Table 3 are also the *most productive* in Taiwan. That is, simply by resorting the table by number of papers, you obtain a ranking by output or productivity. Only the China Steel Corp., with 111 papers, would need to be added. Its 131 citations, however, was below the threshold of 250 for inclusion in Table 3.

This near 100 percent overlap deserves comment. It is not surprising that lists of most-cited and most-productive institutions overlap. Depending on the nations or fields being ranked, overlaps can be significant. For example, an analysis of very large fields or nations—such as molecular biology or Europe—might well include thousands of institutions. But an analysis of very spe-

Table 3: Most-cited Taiwan institutions, 1981-1992, which produced at least 25 papers.
A = Citations. B = Papers. C = Impact.

Rank	Institution	A	B	C	Rank	Institution	A	B	C
1.	Natl. Taiwan Univ. Taipei	11,315	3,872	2.9	15.	Indust. Technol. Res. Inst. Hsinchu	946	453	2.1
2.	Natl. Tsing Hua Univ. Hsinchu	8,844	3,244	2.7	16.	Tri-Services General Hosp. Taipei	817	214	3.8
3.	Acad. Sinica Taipei	7,373	2,278	3.2	17.	Chang Gung Med. Coll. Taipei & Taoyuan	547	274	2.0
4.	Natl. Cheng Kung Univ. Tainan	3,890	2,200	1.8	18.	Mackay Memorial Hosp. Taipei	517	119	4.3
5.	Veterans General Hosp. Taipei	3,603	1,109	3.3	19.	Chung Shan Inst. Sci. Tech. Lung-Tan	507	316	1.6
6.	Natl. Chiao Tung Univ. Hsinchu	2,817	1,552	1.8	20.	Tatung Inst. Technol. Taipei	492	314	1.6
7.	Chang Gung Memorial Hosp. Linkou, Taipei & Taoyuan	2,564	682	3.8	21.	Natl. Taiwan Inst. Technol. Taipei	484	369	1.3
8.	Natl. Yang Ming Med. Coll. Taipei	2,346	780	3.0	22.	Natl. Taiwan Normal Univ. Taipei	443	206	2.2
9.	Natl. Taiwan Univ. Hosp. Taipei	2,258	529	4.3	23.	Chia Nan Jr. Coll. Pharm. Tainan	377	99	3.8
10.	Natl. Defense Med. Ctr. Taipei	1,736	547	3.2	24.	Inst. Nuclear Energy Res. Lung-Tan	347	170	2.0
11.	Natl. Chungshing Univ. Taichung	1,067	523	2.0	25.	Providence Univ. Taichung	310	107	2.9
12.	Natl. Sun Yat-Sen Univ. Kaohsiung	1,020	545	1.9	26.	Chung Yuan Christian Univ. Chung Li	309	210	1.5
13.	Kaohsiung Med. Coll. Kaohsiung	987	447	2.2	27.	Tamkang Univ. Tamsui	288	203	1.4
14.	Natl. Central Univ. Chung Li	972	579	1.7	28.	Natl. Taiwan Ocean Univ. Chilung	287	200	1.4
					29.	Chung Cheng Inst. Technol. Taoyuan & Tashi	260	166	1.6

cialized research areas or small nations might include only several hundred or fewer.

This is the case with Taiwan. Of course, the same is true for the Pacific Rim nations and other relatively small research producers. There may be no more than several hundred research centers in each nation. The number publishing in international journals is even smaller. And those accounting for the most papers or citations tend to be even fewer by Bradford-like concentrations.⁵ Thus, when ranking the top 25 or 50 institutions by papers or citations, essentially the same set is being "reshuffled."

Highest Impact Institutions

In contrast to output and total citations, Table 4 shows the highest impact Taiwan institutions. We limited the analysis to those

that produced at least 25 papers. Of these, 27 institutions had a 12-year impact of at least 2.0.

The asterisks indicate 17 institutions that also appeared in Table 3. Thus, the overlap between the highest impact and most-cited lists is 61 percent, compared with the near 100 percent concordance of most-cited and most-productive institutions. This conforms to a typical pattern in citation analyses—impact rankings identify a different set of institutions than do citation or productivity rankings, alone or combined.

Institutional rankings by impact versus total citations was recently discussed by H. Jousma, Center for Bio-Pharmaceutical Sciences, Leiden, The Netherlands, in a letter concerning our analysis of xenobiotics research.⁶ He noted that impact rankings may favor institutions working

Table 4: Highest impact Taiwan institutions, 1981-1992, which produced at least 25 papers. Asterisks indicate institutions which also appear in Table 3. A = Impact. B = Papers. C = Citations.

Rank	Institution	A	B	C	Rank	Institution	A	B	C
1.	Taipei City Psychiat. Ctr. Taipei	5.8	39	227		Taipei Med. Coll. Taipei	2.8	85	234
2.	*Mackay Memorial Hosp. Taipei	4.3	119	517	15.	Changhua Christian Hosp., Changhua	2.7	30	80
	*Nat'l. Taiwan Univ. Hosp. Taipei	4.3	529	2,258		*Nat'l. Tsing Hua Univ. Hsinchu	2.7	3,244	8,844
4.	*Chang Gung Memorial Hosp. Linkou, Taipei & Taoyuan	3.8	682	2,564	17.	Fu Jen Catholic Univ. Taipei	2.6	91	236
	*Chia Nan Jr. Coll. Pharm., Tainan	3.8	99	377	18.	Cathay General Hosp. Taipei	2.4	39	93
	*Tri-Services Gen. Hosp. Taipei	3.8	214	817		Chung Shan Med. & Dental Coll., Taichung	2.4	46	110
7.	Natl. Taiwan Coll. Educ. Changhua	3.4	27	93	20.	China Med. Coll. Taichung	2.3	95	216
8.	*Acad. Sinica Taipei	3.2	2,278	7,373		Soochow Univ. Taipei	2.3	61	141
	*Nat'l. Defense Med. Ctr. Taipei	3.2	547	1,736	23.	*Kaohsiung Med. Coll. Kaohsiung	2.2	447	987
10.	*Nat'l. Yang Ming Med. Coll., Taipei	3.0	780	2,346		*Nat'l. Taiwan Normal Univ., Taipei	2.2	206	443
11.	*Nat'l. Taiwan Univ. Taipei	2.9	3,872	11,315	25.	*Indust. Technol. Res. Inst., Hsinchu	2.1	453	946
	*Providence Univ. Taichung	2.9	107	310	26.	*Chang Gung Med. Coll. Taipei & Taoyuan	2.0	274	547
13.	Food Industry Res. & Dev. Inst., Hsinchu	2.8	61	171		*Inst. Nuclear Energy Res., Lung-Tan	2.0	170	347
						*Nat'l. Chunghsing Univ. Taichung	2.0	523	1,067

in "hot" research areas. He said, "I would like to recommend to always publish a...list of most-cited institutions next to a highest impact list. This seems to me only fair to those institutions who elect to have more broadly based research, with some areas not directly at the forefront of research."⁷ He suggests that in evaluating an institution as a whole, it is arguable whether impact is more significant than absolute citation frequency.

The answer is not either-or but both: Impact and citation rankings each have advantages and disadvantages. For example, citation frequency may be influenced by sheer output. That is, an institution may rank high on total citations by virtue of high productivity, even though its papers are cited at or below the average for the specialty, nation, or whatever. On the other hand, as Jousma stated, impact factors may be influenced by especially "hot" research

topics. That is, an institution may rank high on impact because of a few labs working on genetic disease markers, superconductivity, AIDS, or other "super-cited" areas. Although these hypothetical situations probably are rare, institutions have been ranked here both by citations and impact in the interest of balance.

Author Rankings—Will the Real C.C. Chen Please Stand Up?

From the 1981-1992 database of about 21,000 Taiwan papers, publication, citation, and impact data were aggregated and ranked for *all* authors in the byline. More than 62,000 names were identified. These include not only authors based in Taiwan, but also coauthors from other nations. In addition, homographs were included—that is, two or more authors with the same surname and initials.

Table 5: Most-cited Taiwan authors, 1981-1992, who published at least 20 papers. Asterisks indicate those who also rank among the 30 most-productive authors. A = Citations. B = Papers. C = Impact.

Rank	Author	A	B	C	Rank	Author	A	B	C
1.	*Chen D S Natl. Taiwan Univ. Med. Internal Med. Dept. Taipei	1,369	145	9.4	15.	*Huang T F Natl. Taiwan Univ. Med. Pharmacology Inst. Taipei	380	62	6.1
2.	*Liaw Y F Chang Gung Mem. Hosp. Liver Unit Taipei	1,129	134	8.4	16.	Yang P M Natl. Taiwan Univ. Med. Pathology Dept. Taipei	374	34	11.0
3.	*Sung J L Natl. Taiwan Univ. Med. Internal Med. Dept. Taipei	1,008	76	13.3	17.	*Chung C S Natl. Tsing Hua Univ. Chemistry Dept. Hsinchu	373	93	4.0
4.	*Chu C M Chang Gung Mem. Hosp. Liver Unit Taipei	839	75	11.2	18.	*Chiou S H Acad. Sinica Biol. Chemistry Inst. Taipei	353	56	6.3
5.	*Sheu J C Natl. Taiwan Univ. Med. Internal Med. Dept. Taipei	814	55	14.8		*Wu P T Indust. Technol. Res. Inst. Materials Res. Labs Hsinchu	353	89	4.0
6.	*Lee S D Veterans Gen. Hosp. Gastroenterol. Div. Taipei	745	128	5.8	20.	*Peng S M Natl. Taiwan Univ. Chemistry Dept. Taipei	351	104	3.4
7.	*Lin M T Natl. Cheng Kung Univ. Med. Internal Med. Dept. Tainan	658	115	5.7	21.	Sheen I S Chang Gung Mem. Hosp. Liver Unit Taipei	331	39	8.5
8.	Lai M Y Natl. Taiwan Univ. Med. Hepatitis Res. Ctr. Taipei	632	48	13.2	22.	*Teng C M Natl. Taiwan Univ. Med. Pharmacology Inst. Taipei	330	98	3.4
9.	*Tsai Y T Veterans Gen. Hosp. Gastroenterol. Div. Taipei	627	114	5.5	23.	Wu D Chang Gung Med. Coll. Cardiology Sect. Taipei	328	27	12.2
10.	*Lo K J Veterans Gen. Hosp. Gastroenterol. Div. Taipei	621	81	7.7	24.	Hsieh F J Natl. Taiwan Univ. Med. Obstet./Gynecol. Dept. Taipei	317	25	12.7
11.	Su I J Natl. Taiwan Univ. Med. Pathology Dept. Taipei	528	53	10.0	25.	Pao C C Chang Gung Med. Coll. Biochemistry Dept. Taipei	313	36	8.7
12.	*Han S H Veterans Gen. Hosp. Medical Res. Dept. Taipei	443	61	7.3		*Wang S L Natl. Tsing Hua Univ. Chemistry Dept. Hsinchu	313	88	3.6
13.	*Hwang C Natl. Cheng Kung Univ. Chem. Engineering Dept. Tainan	416	73	5.7	27.	*Chang M H Natl. Taiwan Univ. Med. Pediatrics Dept. Taipei	311	57	5.5
14.	Shih Y P Natl. Taiwan Inst. Technol. Chem. Engineering Dept. Taipei	409	39	10.5	28.	Hu C P Natl. Yang Ming Med. Coll. Microbiol./Immunol. Inst. Taipei	309	34	9.1

Table 5 (continued)

Rank	Author	A	B	C
29.	Hung J S Chang Gung Med. Coll. Cardiology Sect. Taipei	308	38	8.1
30.	*Lee G H Natl. Taiwan Univ. Chemistry Dept. Taipei	306	74	4.1
31.	Ting L P Natl. Yang Ming. Med. Coll. Microbiol./Immunol. Inst. Taipei	297	31	9.6
32.	Lu C Y Indust. Technol. Res. Inst. Electr. Res./Serv. Org. Hsinchu	280	28	10.0

Homographs are particularly troublesome with Oriental surnames.⁸ A small number of common names account for the majority of Oriental surnames. For example, there are only about 200 common Chinese surnames.⁹ Similarly, there are about 300 common Korean surnames but only three—Kim, Pak, and Lee—account for the great majority.⁹

Not surprisingly, we encountered a large number of homographs in our rankings of Taiwan authors. For example, under the name "C.C. Chen" there are 193 papers for 1981-1992. In the 1991 *SCI*® CD-ROM edition alone, at least 15 different authors appear under that heading. Six are based at the National Taiwan University in various departments—chemistry, chemical engineering, electrical engineering, materials engineering, mathematics, and medicine. One each is at the Academia Sinica, Food Industry Research and Development Institute, National Defense Medical Center, National Sun Yat-Sen University, National Taiwan Institute of Technology, National Tsing Hua University, Veteran Affairs Medical Center, and Veterans General Hospital. In the lists that follow, we eliminated any names that would require extensive analysis and verification. Of course, it is possible to differentiate the various homographs. But one would need the CVs of each individual to compile accurate publication, citation, and impact data.

Most-Cited Authors

Table 5 lists 32 authors with at least 280 citations. Only those who produced at least 20 papers are included. Asterisks indicate 20 authors who also rank among the 30 most-productive authors.

The most-cited author is D.S. Chen, National Taiwan University Medical College, with 1,369 citations to 145 papers, giving an impact of 9.4. He also ranks first in terms of productivity. Two other authors were cited over 1,000 times—Y.F. Liaw (1,129), Chang Gung Memorial Hospital, Taipei, and J.L. Sung (1,008), National Taiwan University Medical College. Liaw ranks second on productivity and Sung, thirteenth.

Table 5 also shows the 1991 institutional affiliation for each author. The National Taiwan University accounts for 12 authors—10 based at the medical college and 2 at the chemistry department. Four authors were based at the Veterans General Hospital, and three each were from the Chang Gung Medical College and Chang Gung Memorial Hospital. The following each accounts for two authors: Industrial Technology Research Institute; National Cheng Kung University; National Tsing Hua University; and National Yang Ming Medical College. One author each was based at the Academia Sinica and National Taiwan Institute of Technology.

Highest Impact Authors

Table 6 ranks authors in terms of average impact rather than absolute citations. It includes only those authors who published at least 20 papers. Thirty-two authors with an impact of at least 7.0 are listed. Thus, their impact was between three and six times the 12-year impact average for Taiwan (2.5). They also rank among the 99.95th percentile of all author names in the 1981-1992 Taiwan database.

The highest impact author is J.C. Sheu of the National Taiwan University Medical College, with 55 papers that received 814 citations. This gives an overall impact of 14.8. The next two authors, both from the same institution, have virtually the same impact—J.L. Sung (13.3) and M.Y. Lai (13.2). All three also ranked among the most-cited

Table 6: Highest impact Taiwan authors, 1981-1992, who published at least 20 papers. Asterisks indicate authors who appear in Table 5. A= Impact. B = Papers. C = Citations.

Rank	Author	A	B	C	Rank	Author	A	B	C
1.	*Sheu J C Nat. Taiwan Univ. Med. Internal Med. Dept. Taipei	14.8	55	814	15.	Shen D C Nat. Defense Med. Ctr. Endocrinology Div. Taipei	9.6	20	192
2.	*Sung J L Nat. Taiwan Univ. Med. Internal Med. Dept. Taipei	13.3	76	1,008		*Ting L P Nat. Yang Ming Med. Coll. Microbiol./Immunol. Inst. Taipei	9.6	31	297
3.	*Lai M Y Nat. Taiwan Univ. Med. Hepatitis Res. Ctr. Taipei	13.2	48	632	17.	*Chen D S Nat. Taiwan Univ. Med. Internal Med. Dept. Taipei	9.4	145	1,369
4.	*Hsieh F J Nat. Taiwan Univ. Med. Obstet./Gynecol. Dept. Taipei	12.7	25	317		How S W Nat. Taiwan Univ. Hosp. Pathology Dept. Taipei	9.4	22	206
5.	*Wu D Chang Gung Med. Coll. Cardiology Sect. Taipei	12.2	27	328	19.	Liu M Y Nat. Taiwan Univ. Med. Microbiol. Inst. Taipei	9.3	20	186
6.	Sun C N Nat. Chungshing Univ. Entomology Dept. Taichung	11.8	20	235	20.	*Hu C P Nat. Yang Ming Med. Coll. Microbiol./Immunol. Inst. Taipei	9.1	34	309
7.	*Chu C M Chang Gung Mem. Hosp. Liver Unit Taipei	11.2	75	839	21.	*Pao C C Chang Gung Med. Coll. Biochemistry Dept. Taipei	8.7	36	313
8.	*Yang P M Nat. Taiwan Univ. Med. Pathology Dept. Taipei	11.0	34	374		Shieh S M Nat. Defense Med. Ctr. Endocrinology Div. Taipei	8.7	29	253
9.	Su T S Veterans Gen. Hosp. Medical Res. Dept. Taipei	10.8	24	260	23.	*Sheen I S Chang Gung Mem. Hosp. Liver Unit Taipei	8.5	39	331
10.	Lien M H Nat. Chungshing Univ. Chemistry Dept. Taichung	10.5	21	220	24.	*Liaw Y F Chang Gung Mem. Hosp. Liver Unit Taipei	8.4	134	1,129
	*Shih Y P Nat. Taiwan Inst. Technol. Chem. Engineering Dept. Taipei	10.5	39	409		Lo T B Nat. Taiwan Univ. Biochemistry Inst. Taipei	8.4	28	236
12.	*Lu C Y Indust. Technol. Res. Inst. Electr. Res. & Serv. Org. Hsinchu	10.0	28	280		Yang S D Nat. Tsing Hua Univ. Med. Biomedical Sci. Inst. Hsinchu	8.4	26	217
	*Su I J Nat. Taiwan Univ. Med. Pathology Dept. Taipei	10.0	53	528	27.	Choo K B Veterans Gen. Hosp. Medical Res. Dept. Taipei	8.2	27	221
14.	Changchien C S Chang Gung Mem. Hosp. Gastroenterology Div. Taipei	9.7	20	194		Yeh E K Nat. Taiwan Univ. Med. Psychiatry Dept. Taipei	8.2	23	189

Table 6 (continued)

Rank	Author	A	B	C
29.	*Hung J S Chang Gung Med. Coll. Cardiology Sect. Taipei	8.1	38	308
30.	*Lo K J Veterans Gen. Hosp. Gastroenterol. Div. Taipei	7.7	81	621
31.	*Han S H Veterans Gen. Hosp. Medical Res. Dept. Taipei	7.3	61	443
32.	Lay C S Veterans Gen. Hosp. Gastroenterol Div. Taipei	7.0	20	139

authors in Table 5. In total, 19 of the highest impact authors also appeared on the list of most-cited authors in Table 5, and they are indicated by asterisks.

Conclusion

This analysis of science in Taiwan illustrates how citation data can be used to provide a unique perspective on national re-

search performance. Of course, citation-based indicators enable more detailed analyses that go well beyond rankings of the highest impact papers, institutions, and authors. These include comparisons with other nations over different time periods by various criteria—e.g., trends in output, citation frequency, impact, percent citedness, etc.—for science overall and in particular fields, specialties, and subspecialties. In addition, through *co-citation* analysis it is possible to identify and map research fronts in which a nation or group of nations is particularly active.¹⁰

While citation data offer new tools for analyses of research performance, it should be stressed that they *complement* rather than replace other quantitative—and qualitative—indicators. And like other indicators, their appropriate and balanced interpretation requires the input of information specialists working with knowledgeable scientists.

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