Global Research Report – South and East Asia

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Institute for Scientific Information

Web of Science Group

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Author biographies

Jonathan Adams is Director of the Institute for Scientific Information, a part of the Web of Science Group. He is also a Visiting Professor at King's College London, Policy Institute, and was awarded an Honorary D.Sc. in 2017 by the University of Exeter, for his work in higher education and research policy.

Gordon Rogers is a Senior Data Scientist at the Institute for Scientific Information He has worked in the fields of bibliometrics and data analysis for the past 10 years, supporting clients around the world in evaluating their research portfolio and strategy.

Martin Szomszor is Head of Research Analytics at the Institute for Scientific Information. He joined from Digital Science where, as Chief Data Scientist he applied his extensive knowledge of machine learning, data integration and visualization techniques to found the Global Research Identifier Database. He was named a 2015 top-50 UK Information Age data leader for his work in creating the REF2014 impact case studies database for the Higher Education Funding Council for England (HEFCE).

David Pendlebury is Head of Research Analysis at the Institute for Scientific Information, a part of Clarivate Analytics. Since 1983 he has used *Web of Science* data to study the structure and dynamics of research. He worked for many years with ISI founder Eugene Garfield. With Henry Small, David developed ISI's *Essential Science Indicators*.

Foundational past, visionary future

The Institute for Scientific Information

ISI builds on the work of Dr. Eugene Garfield – the original founder and a pioneer of information science. Named after the company he founded – the forerunner of the Web of Science Group – ISI was re-established in 2018 and serves as a home for analytic expertise, guided by his legacy and adapted to respond to technological advancements.

Our global team of industry-recognized experts focus on the development of existing and new bibliometric and analytical approaches, whilst fostering collaborations with partners and academic colleagues across the global research community.

Today, as the 'university' of the Web of Science Group, ISI both:

- Maintains the foundational knowledge and editorial rigor upon which the *Web of Science* index and its related products and services are built. Our robust evaluation and curation have been informed by research use and objective analysis for almost half a century. Selective, structured and complete data in the *Web of Science* provide rich insights into the contribution and value of the world's most impactful scientific and research journals. These expert insights enable researchers, publishers, editors, librarians and funders to explore the key drivers of a journal's value for diverse audiences, making better use of the wide body of data and metrics available.
- Carries out research to sustain, extend and improve the knowledge base and disseminates that knowledge to our colleagues, partners and all those who deal with research in academia, corporations, funders, publishers and governments via our reports and publications and at events and conferences.

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Global Research Report – S&E Asia

In the development of our series of Global Research Reports, it has been our intention for some time to describe the state of the research base in Asia beyond the growing and well researched Asia-Pacific group that covers China, Japan and South Korea.

This Global Research Report surveys an area described as South and East Asia (S&E Asia), which includes the ASEAN group of nations and extends to a wider network.

The 14 countries examined here, from West to East, are:
Pakistan, India, Sri Lanka, Bangladesh plus the ASEAN states of Myanmar, Laos, Vietnam, Thailand, Cambodia, Malaysia, Singapore, Indonesia, Brunei Darussalam, and the Philippines.

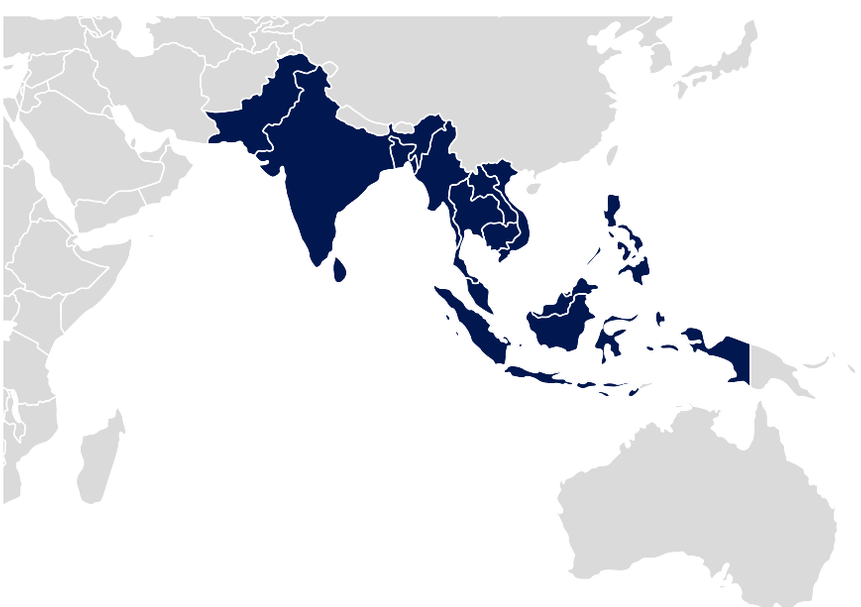
The ASEAN regional forum includes 27 member states, including the EU and the USA, which are partners with but not embedded in the region. We recognize that definitions of regions differ and change and apologize to those who find ours unduly restrictive or too broad.

S&E Asia countries differ markedly in geographical size, in population and in their economies. They nonetheless form an evident global region. They have historical relationships with former colonial powers in the European Union (EU) and contemporary alliances with states further North and South in the Pacific. They have deep roots in learning, culture and technology over millennia – Singapore has been recognized for 200 years as a crossroads in commerce and in ideas between the Indian and Pacific oceans.

For some of the S&E Asia region, it is evident that many recent research achievements have been dependent on international links. Now, these countries are in an increasingly strong position to benefit from their own potential to grow through their national investments, through the emergence of a regional network and through their collaboration with partners in neighbouring regions. This report looks at all these characteristics.

These countries are in an increasingly strong position to benefit from their own potential to grow

Map 1.
The South and East Asia countries under examination.



There have been few in-depth bibliometric studies of national activity and performance in S&E Asia. Papers published over the past decade have focused on the ASEAN members as a group or individual ASEAN member nations in specific research areas.

Individual scientists from countries in S&E Asia have made significant contributions to research – but often while working in other countries. Historical levels of research investment have generally been lower than in Europe and the relative size of the researcher workforce has been small. In fact, the economic potential of the region is massive and could underpin a research network with global impact. India has been spoken of as a 'sleeping giant' of research and the opportunities that might be realized in Indonesia are also huge, as it too turns towards building greater capacity and improving quality in higher education and research. Already at hand, Singapore (with two of the world's 50 leading research universities) and Malaysia have well established research economies and Pakistan, Thailand and Vietnam already have rapidly growing research profiles. (Table 1)

Table 1.
Descriptive statistics by country, ranked by annual publication output. CNCI is an index of research publication impact (where world average = 1.0, see text) and is expressed as gross (for the country as a whole) and domestic (for publications with only national authors)

Source	World Bank 2017		UNESCO Institute for Statistics, 2017		Web of Science average for 2014-18		
	Population Thousands	GDP current $US million	GERD as % GDP	Researchers per million population	Publication output	CNCI gross	CNCI domestic
Laos	7,169	18,131	0.04	16 [1]	179	1.23	0.44
Myanmar	54,045	71,215	0.16	15	203	2.13	0.61
Brunei	433	13,567	0.04	283 [1]	207	1.30	0.67
Cambodia	16,486	24,572	0.12	30	300	1.34	0.45
Sri Lanka	21,323	88,901	0.11	107	931	1.86	0.44
Philippines	108,117	330,910	0.14	188 [1]	1,438	1.46	0.39
Bangladesh	163,046	274,025	n/a	n/a	2,092	1.27	0.55
Indonesia	270,626	1,042,173	0.08	89 [1]	2,462	1.19	0.52
Vietnam	96,462	244,948	0.44	672	3,766	1.20	0.67
Thailand	69,626	504,993	0.78	1,210	8,261	0.95	0.56
Pakistan	216,565	312,570	0.25	294	10,112	1.03	0.56
Malaysia	31,950	354,348	1.30	2,274	11,924	1.06	0.76
Singapore	5,804	364,157	2.16	6,730	13,916	1.64	1.28
India	1,366,420	2,726,323	0.62	216	66,400	0.86	0.68

GDP = gross domestic product, GERD = gross expenditure on research and development
CNCI = average category normalised citation impact
[1] = Researcher data for these countries is from sources more than five years old

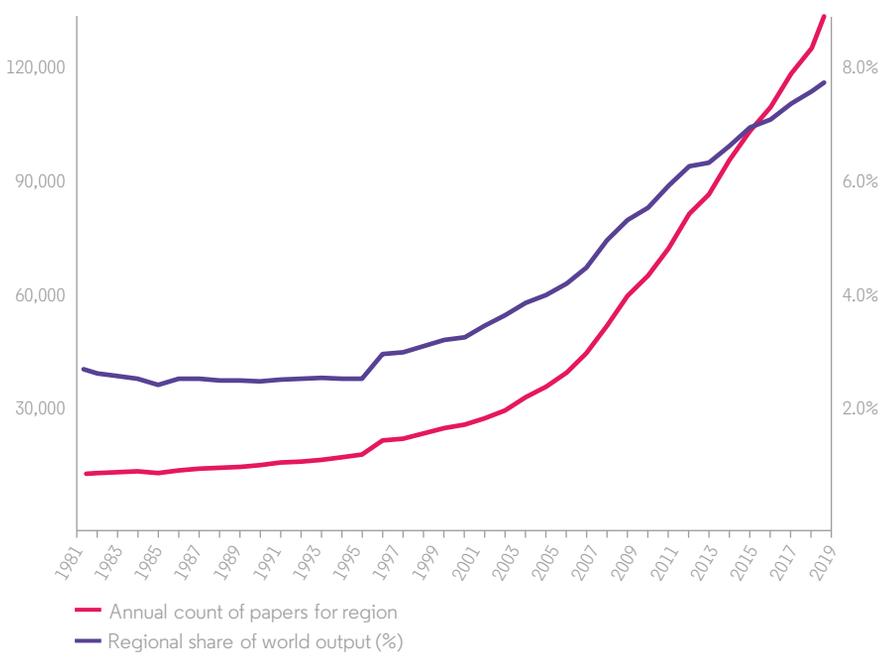
It is important to note data for Category-Normalised Citation Impact (CNCI) in Table 1. This is an index that reflects a publication's academic impact using the number of times it is subsequently cited by later work. Because citation counts rise over time at a rate that is discipline-dependent, these counts are 'normalised' for the appropriate subject category and year of publication, and then an average is taken. The world average, as a reference benchmark, is always 1.0. Two figures are quoted in Table 1: CNCI-gross and CNCI-domestic. CNCI-gross refers to all the publications with at least one national address while CNCI-domestic is the data pool from which all publications with international co-authorship have been removed. This enables a comparison for the research impact of a country in its partnerships and standing alone. All countries, including the G7, have higher collaborative than domestic impact.

For the S&E Asia nations, with the exception of Singapore, the impact gained through international collaboration is very substantial and it is this activity that lifts their average citation impact above world average. Moed (Moed and Halevi, 2015; Moed, 2016) has drawn attention to the need to interpret national scientometric indicators in the context of their evolving research development. This region contains very different stages of research development. For Singapore, international collaboration is just a part of national strategy: the outcome of researchers elsewhere collaborating with scientists in world leading institutions.
For the smaller ASEAN nations, international collaboration forms the bulk of their high-performance research activity as their domestic research base builds up.

Research capacity

Research activity in South and East Asia has grown rapidly since 2000. From an annual regional total of about 12,000 papers (articles and reviews), output has risen ten-fold and now accounts for more than 8% of global publications every year.

Figure 1.
Regional growth of research in S&E Asia in numbers of publications (articles and reviews) and share of world output.



Vietnam has increased its indexed publication volume more than five-fold since 2009

This regional growth is reflected at national level and it is pervasive. The region might best be considered as three groups plus India.
The major research producers are India (around 75,000 papers per year) plus Singapore, Pakistan, Malaysia, Thailand and Vietnam (more than 5,000 papers per year). These countries have roughly doubled in research output over the last decade.

By far the fastest rate of growth in this group is that of Vietnam which has increased its indexed publication volume more than five-fold since 2009 and shows every sign of continuing expansion. Research growth for Thailand, which has the second largest economy in this group, has slowed compared to the others. (Figure 2)

The medium-sized research economies are Indonesia, Bangladesh, the Philippines and Sri Lanka, with 1,000-5,000 papers per year. The four nations with fewer than 500 papers per year are Cambodia, Myanmar, Laos and Brunei.

The indicators for the smaller research economies remain very dependent on their involvement in international collaborations, but they too are expanding and all of these countries have more than doubled its output since 2009, which is a welcome sign. Myanmar which had been producing very little earlier in the 2000s demonstrates the fastest rate of growth. Indonesia – which surely has the resource capacity to become a major research nation – has increased its output nearly four-fold in ten years. Its location, increasing economic power and vast human resources give it the potential to become a significant regional research and technology hub.It is not by chance that the ASEAN group headquarters was established in Jakarta.

These data demonstrate the extent of research development across the region but the disparities between population, wealth and research intensity shown in Table 1 also reflect unrealised potential for further development in many areas. That development must drive the infra-structure for higher education and research that is expected to lead to sustained growth in national knowledge capacity, reduce dependency on international partnerships and underpin technology innovation and economic competitiveness. Data later in this report will demonstrate that such dependency remains a worrying factor in some instances.

Further development will require some re-iteration of research already performed elsewhere, in order to build training, understanding and capability. This may appear redundant, but without this recapitulation it will not be feasible to realise latent capacity and build a useful technological infrastructure for wholly independent research in the future.

Figure 2.
Annual publication output (articles and reviews) for major research producers in S&E Asia.

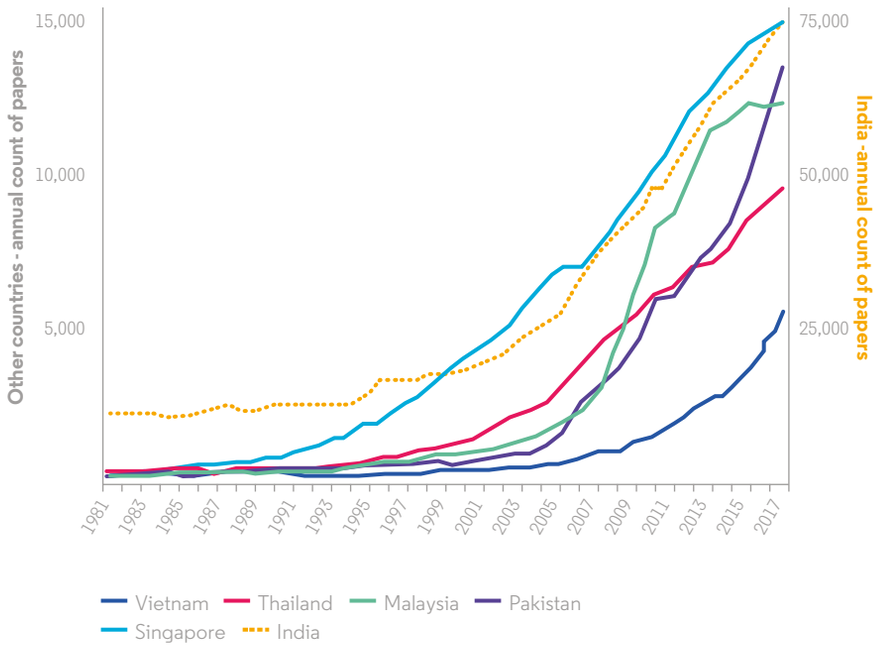
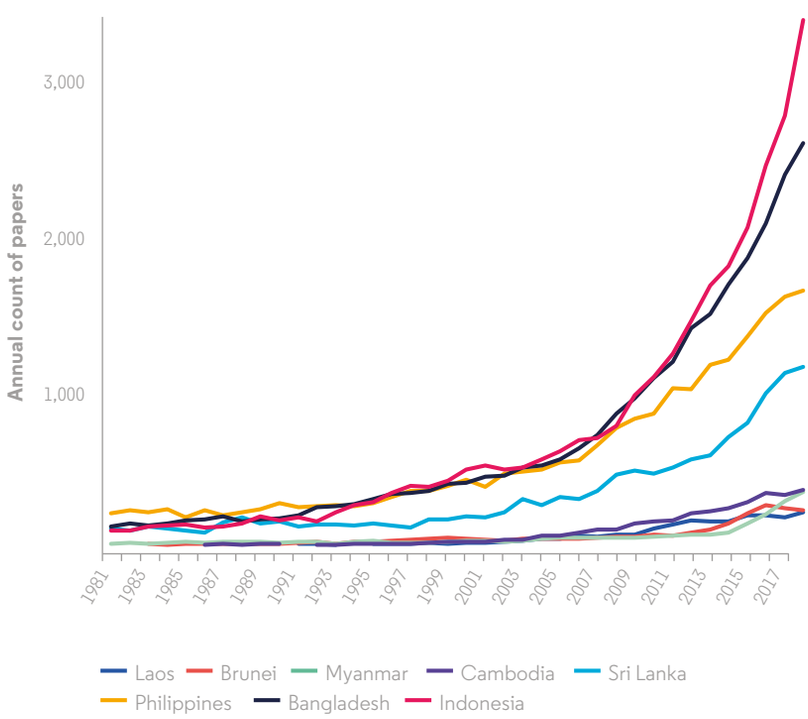


Figure 3.
Annual publication output (articles and reviews) for medium-sized and smaller research producers in S&E Asia.



International collaboration

To visualize the regional collaboration network, we present two complementary views of the data that illustrate the strongest ties between nations, both within S&E Asia countries, and beyond.

Collaboration is measured as the percentage of co-authored research papers (articles and reviews) indexed in the *Web of Science*, 2009-18 and is shown in two forms: as a collaboration network (Figure 4), and as a collaboration heat-map (Figure 5).

The network gives an overall sense of the topology, with key external collaborators (USA, China and the UK) in the centre, linking the smaller nations to the largest research producing countries (India, Singapore, Malaysia and Pakistan) in the outer ring. The heat-map supplies more granular information and highlights similarities and differences in the collaboration patterns. For example, by looking at rows (countries that collaborate with S&E Asia) it is possible to identify that the UK and Australia have similar profiles, and that China and Japan are collaborating with different groups.

Two S&E Asia countries stand apart from the main group in terms of their collaboration profile:

India

- India (left column, Figure 5) produces far fewer papers with international collaborators as a percentage of its total research output when compared to others.

Sri Lanka

- Sri Lanka (right column, Figure 5) has a much higher percentage of collaboration with many partners.

This is due to a large number of massively co-authored papers published in High Energy Physics through participation in the Compact Muon Solenoid (CMS) detector collaboration and international groups that utilise data from the ATLAS project at CERN's Large Hadron Collider. Given Sri Lanka's total research output is relatively small otherwise, these publications have a substantial impact on the overall collaboration profile.

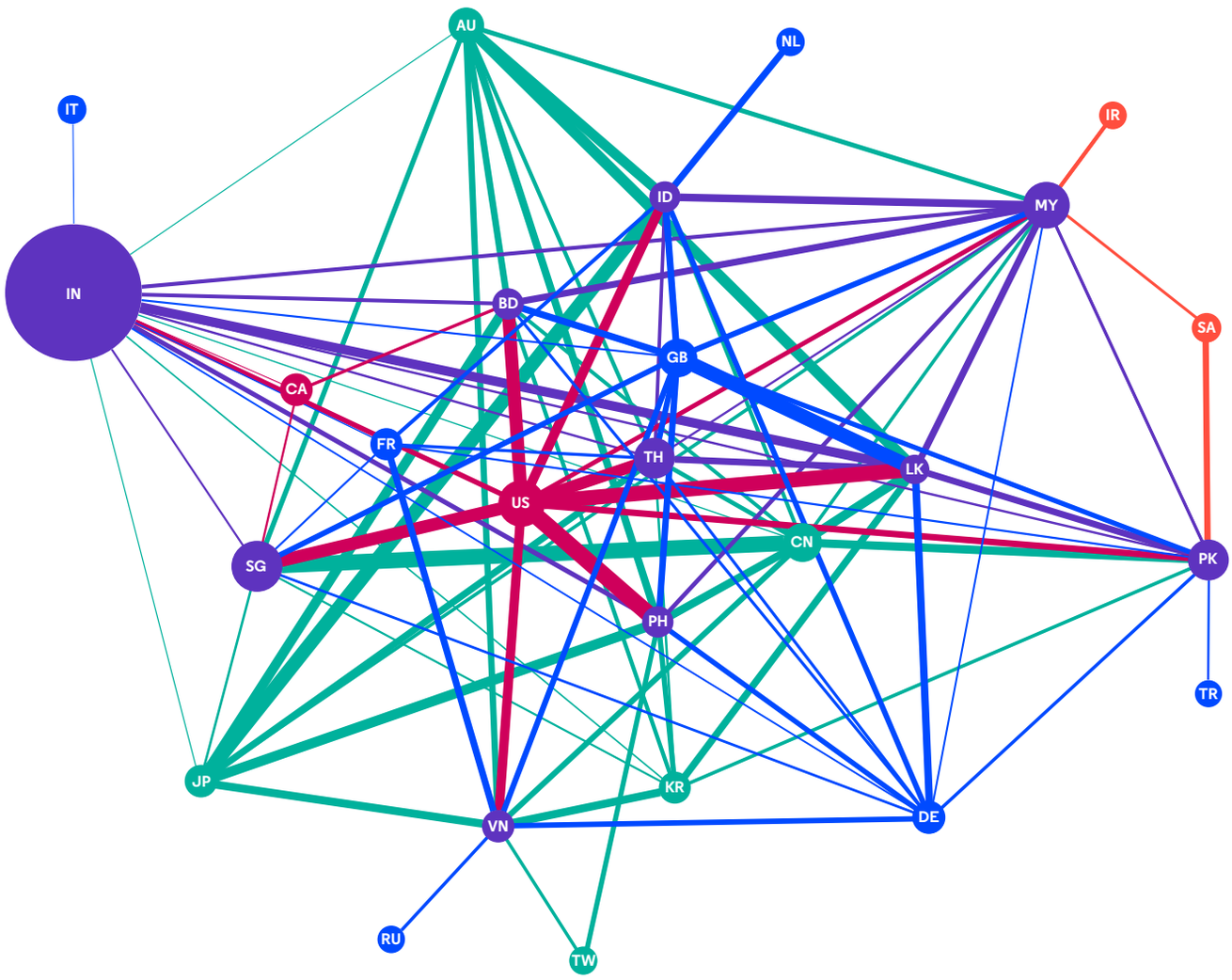
International research links have become rich and complex. The research base in some S&E Asia countries has a long history of association with former colonial economies. They established higher education systems in the region and remain prominent research partners today. Examples are the UK's links to Malaysia, the Netherlands' links to Indonesia, and France's links to Vietnam, Cambodia and Laos.

The growth of collaboration is driven partly by the opportunity to use information networks and travel more easily to international conferences, partly by the number of international programmes and major international projects – notably in health, the environment and natural resources, and physics – and partly by the nature of contemporary research challenges that need to draw on global intellectual resources. A consequence of international collaboration is that the average domestic CNCI is less, and in these cases often much less, than the apparent national average CNCI (Table 1). A particular problem arises where there are highly multinational papers, such as epidemiology studies in medicine and fundamental particle physics. Authorship can run across dozens of countries in these instances as well as including scientists and practitioners in S&E Asia.

There is as yet only limited evidence to demonstrate the regional network. The UK and Germany are linked to many of the countries and are at the centre of the network while the USA has very strong ties to all the larger research economies, though somewhat less to India than might be expected. A key feature is the role of neighbouring regional partners of which China is most central and where Australia, Japan and South Korea are evidently playing an important role. This suggests that a broader network combining S&E Asia, Asia-Pacific and Australasia is emerging. This will be a powerful counter-balance to the trans-Atlantic axis which has dominated global research for centuries.

A broader network combining S&E Asia, Asia-Pacific and Australasia is emerging. This will be a powerful counter-balance to the trans-Atlantic axis

Figure 4.
Network diagram of most frequent research collaborations for countries and regions in S&E Asia.
Collaboration is indexed by the number of co-authored research papers (articles and reviews) indexed in the *Web of Science*, 2009-18. Each node represents a country and node size is proportional to the number of publications. Edges joining these nodes link a country to its ten most frequent collaborators. Edge thickness is proportional to the percentage of publications co-authored by the two countries. No data are shown for four small research economies (Cambodia, Myanmar, Laos and Brunei). Colors are used to group countries by region, as described in the figure legend.



South and East Asia
Bangladesh (BD), India (IN), Indonesia (ID), Malaysia (MY), Pakistan (PK), Philippines (PH), Sri Lanka (LK), Singapore (SG), Thailand (TH), Vietnam (VN)

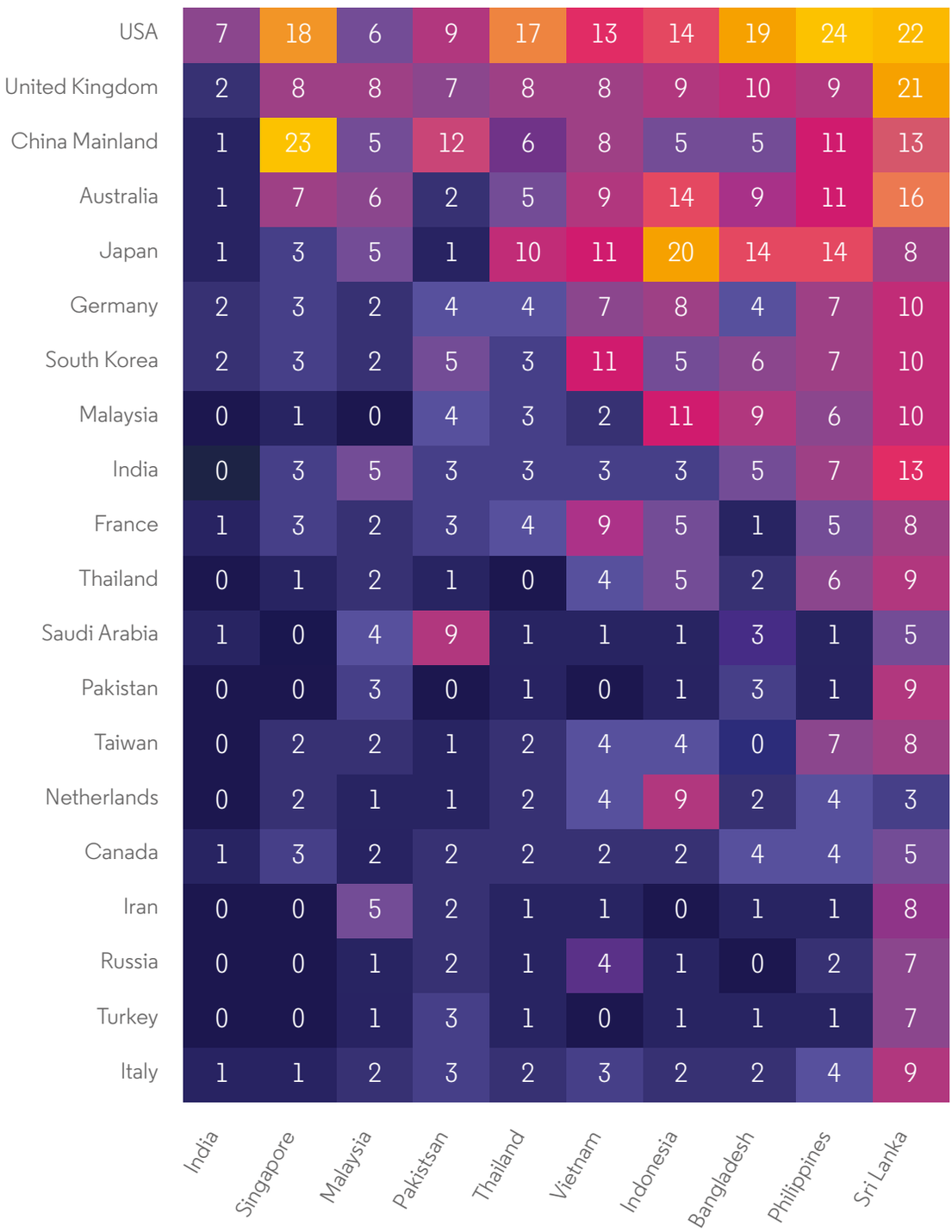
Continental Europe
France (FR), Germany (DE), Italy (IT), Netherlands (NL), Russia (RU), Turkey (TR), United Kingdom (GB)

Asia and Pacific
Australia (AU), China Mainland (CN), Japan (JP), South Korea (KR), Taiwan (TW)

North America
Canada (CA), USA (US)

Arab States
Iran (IR), Saudi, Arabia (SA)

Figure 5.
Heat-map of research collaboration for countries or regions in S&E Asia highlighting most frequent bilateral co-authorship for papers (articles and reviews) indexed in the Web of Science, 2009-18. The horizontal axis is ordered by publication output of the country in the region. The most frequent collaborators are listed on the vertical axis and ordered by volume of their total collaboration with countries in the region. Values in each cell display the percentage of papers for which there is co-authorship for the two relevant countries or regions.



Impact Profiles

Impact Profiles display the distribution of CNCI values of journal papers

Research activity needs to be seen in the light of research quality.

A widely-used indicator of research quality has been the CNCI index (Table 1). This is a quick reference guideline but, like all simple metrics, it necessarily absorbs and hides a great deal of information. To reveal that information we use Impact Profiles (see page 16, GRRI:Profiles, not metrics).

Impact Profiles display the distribution of CNCI values of journal papers (here, for the ten-year window 2009-18). Papers are assigned to categories as either uncited, or cited less often than world average (down to half, less than half to one-quarter and so on), or cited more often (up to 2 times, 2-4 times and so on) than world average (Adams et al., 2007).

In Figures 6 below, the uncited papers are shown as blocks and the cited papers as a smoothed curve from low to highly cited.

Each country's data are shown in three curves plus a table.

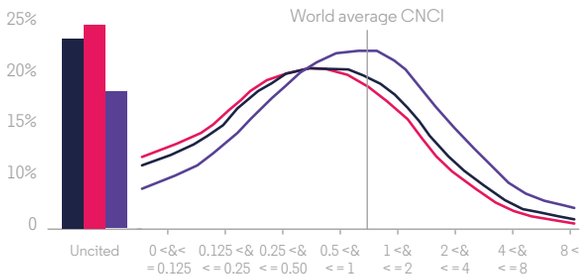
The three curves track:

- The Impact Profile for all papers with at least one national address
- The Impact Profile for the purely domestic papers with only national authors
- The Impact Profile for those papers with one or more international co-authors.

The table summarizes the numbers of papers used to calculate the curves and the total for the most recent full year. The average CNCI across the period and the CNCI for 2018 are also given for each set of papers.

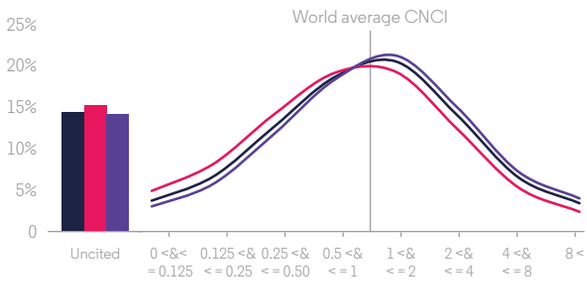
Figure 6.
Impact Profiles for papers (articles and reviews) published during 2009-2018 by countries in S&E Asia. Papers in each analysis have at least one author address for the given country and are shown as national totals, papers with only national authors and papers with an international co-author. In reviewing an Impact Profile, attention should be paid to: the proportion of papers that remain uncited (even by their authors); the balance of papers cited less often than world average; the height and position of the peak of the curve; the balance of papers cited more often than world average; and the proportion of papers that are in the most highly-cited categories more than four and more than eight times world average. For detailed methodology see text.

India



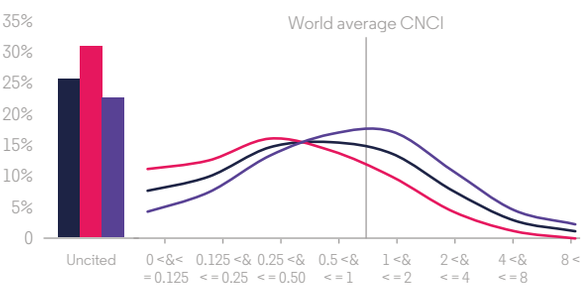
	Total papers	2018 papers	Average CNCI	2018 CNCI
India Total	565,873	73,951	0.82	0.85
India Domestic	429,967	53,577	0.67	0.68
India International	135,907	20,375	1.30	1.32
International as a %	24	28		

Singapore



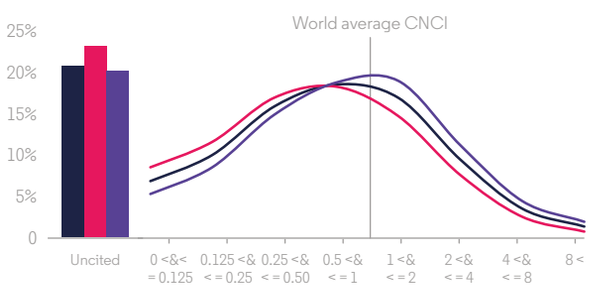
	Total papers	2018 papers	Average CNCI	2018 CNCI
Singapore Total	120,185	14,918	1.61	1.59
Singapore Domestic	43,946	4,153	1.29	1.26
Singapore International	76,239	10,765	1.80	1.72
International as a %	63	72		

Pakistan



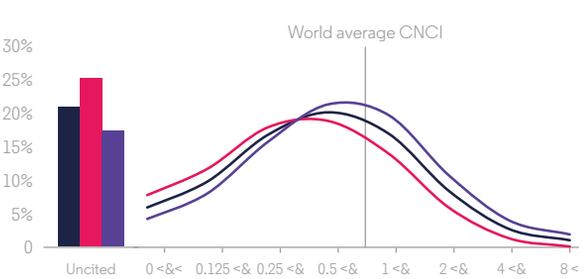
	Total papers	2018 papers	Average CNCI	2018 CNCI
Pakistan Total	77,527	13,393	0.89	1.04
Pakistan Domestic	38,004	5,246	0.51	0.60
Pakistan International	39,523	8,147	1.28	1.32
International as a %	51	61		

Malaysia



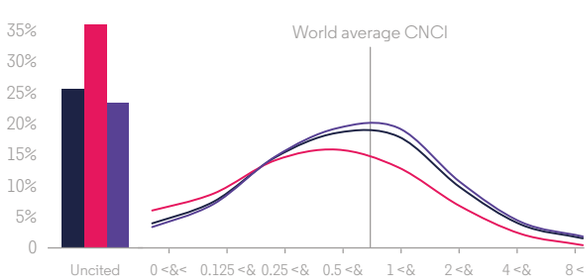
	Total papers	2018 papers	Average CNCI	2018 CNCI
Malaysia Total	97,152	12,193	0.94	1.04
Malaysia Domestic	46,867	4,848	0.74	0.66
Malaysia International	50,285	7,345	1.12	1.28
International as a %	52	60		

Thailand



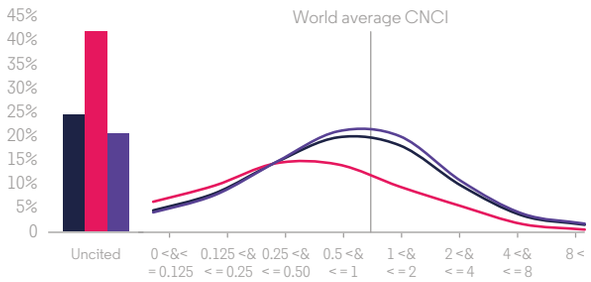
	Total papers	2018 papers	Average CNCI	2018 CNCI
Thailand Total	70,937	9,448	0.93	0.94
Thailand Domestic	34,162	4,356	0.62	0.53
Thailand International	36,775	5,092	1.23	1.29
International as a %	52	54		

Vietnam



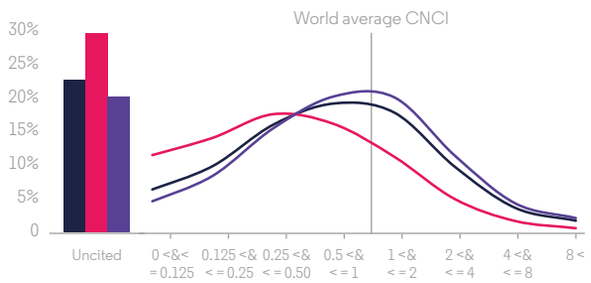
	Total papers	2018 papers	Average CNCI	2018 CNCI
Vietnam Total	26,742	5,457	1.09	1.09
Vietnam Domestic	5,859	1,155	0.62	0.68
Vietnam International	20,883	4,302	1.22	1.19
International as a %	78	79		

Indonesia



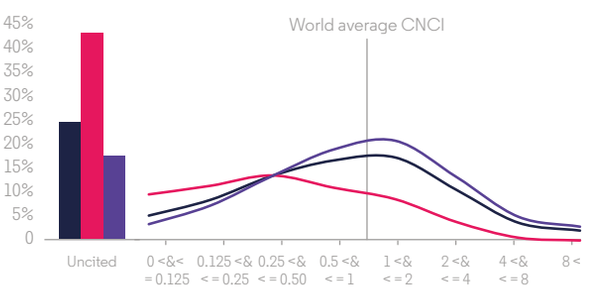
	Total papers	2018 papers	Average CNCI	2018 CNCI
Indonesia Total	18,625	3,350	1.11	0.87
Indonesia Domestic	3,411	791	0.52	0.45
Indonesia International	15,214	2,559	1.23	1.00
International as a %	82	76		

Bangladesh



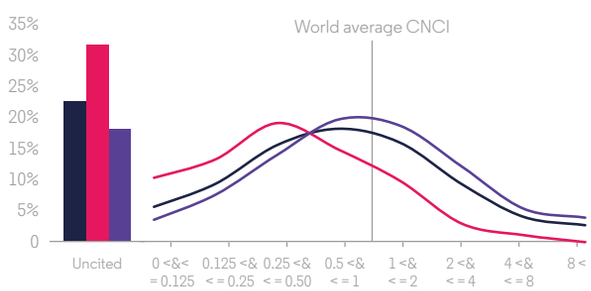
	Total papers	2018 papers	Average CNCI	2018 CNCI
Bangladesh Total	16,477	2,559	1.06	1.06
Bangladesh Domestic	4,221	531	0.50	0.48
Bangladesh International	12,256	2,028	1.25	1.21
International as a %	74	79		

Philippines



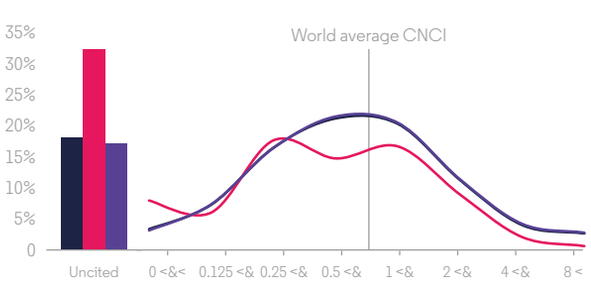
	Total papers	2018 papers	Average CNCI	2018 CNCI
Philippines Total	11,964	1,622	1.31	1.40
Philippines Domestic	3,432	413	0.38	0.44
Philippines International	8,532	1,209	1.69	1.73
International as a %	71	75		

Sri Lanka



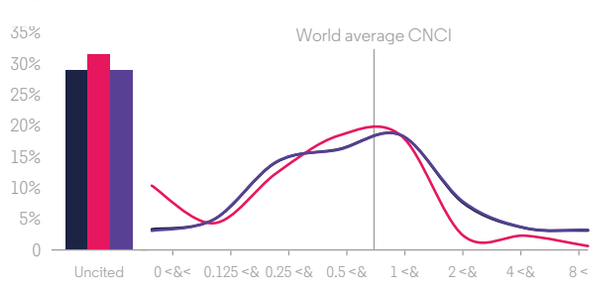
	Total papers	2018 papers	Average CNCI	2018 CNCI
Sri Lanka Total	7,178	1,132	1.49	1.20
Sri Lanka Domestic	2,216	306	0.43	0.42
Sri Lanka International	4,962	826	1.96	1.49
International as a %	69	73		

Cambodia



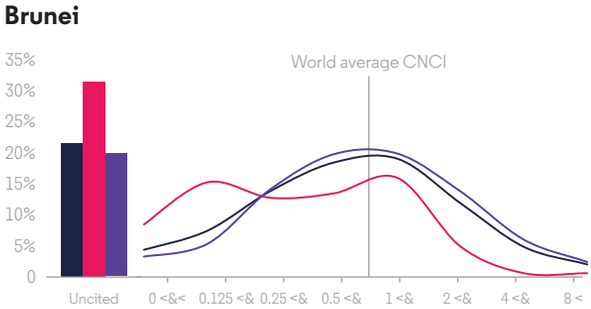
	Total papers	2018 papers	Average CNCI	2018 CNCI
Cambodia Total	2,351	350	1.38	0.93
Cambodia Domestic	106	12	0.56	0.00
Cambodia International	2,245	338	1.42	0.97
International as a %	95	97		

Myanmar



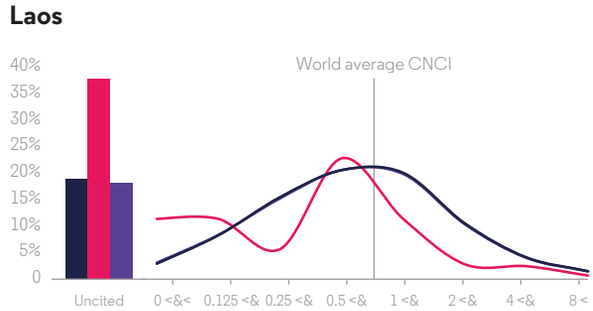
	Total papers	2018 papers	Average CNCI	2018 CNCI
Myanmar Total	1,292	337	1.45	1.22
Myanmar Domestic	48	9	0.58	0.39
Myanmar International	1,244	328	1.48	1.24
International as a %	96	97		

Brunei



	Total papers	2018 papers	Average CNCI	2018 CNCI
Brunei Total	1,376	218	1.04	1.60
Brunei Domestic	294	37	0.55	1.00
Brunei International	1,082	181	1.19	1.72
International as a %	79	83		

Laos



	Total papers	2018 papers	Average CNCI	2018 CNCI
Laos Total	1,493	204	1.12	0.90
Laos Domestic	36	6	0.38	0.62
Laos International	1,457	198	1.14	0.91
International as a %	98	97		

Research activity and performance data are skewed, exhibiting many low and only a few high values. The benefits of Impact Profiles are that they show the distribution underpinning the average values and explain the balance between uncited, less well cited and more highly cited outputs. With the exception of India, (where about one-quarter of papers have an international co-author,) every other country in S&E Asia has at least 50% international co-authorship. For Cambodia, Myanmar and Laos this is over 95%. By separating the domestic and international components, we can see how reliant each country is on its partnerships for its overall profile as well as its capacity.

Singapore stands out. Singapore National University, Nanyang Technological University and the National Research Foundation's A* research agency are recognised as world-leading institutions. Its Impact Profile peak is above world average and it has a substantial percentage of publications in the highest two categories. India is notable for a strong domestic research base but despite its volume it has yet to sustain high citation impact across the breadth of its research portfolio and its international collaborative output is visibly more highly-cited than the domestic output. The other larger research economies (see Figure 2) have domestic profiles that broadly overlap with their overall profile (including international papers) and while left-shifted (towards lower impact) are similarly bell-shaped.

For the four medium-sized economies (see figure 3), the domestic Impact Profile is less symmetrical and is more evidently shifted towards low impact categories and a relatively high proportion of uncited papers. The domestic pattern for the four smallest economies loses the standard 'bell-shape' and the overall Impact Profile is clearly driven primarily by international collaboration. As noted earlier, it is a universal truth that international collaboration boosts the citation rates for research publications. In the case of the smaller research economies, the total and international Impact Profiles are almost indistinguishable because the innate domestic research capacity remains small.

The Impact Profiles demonstrate that – whatever the average CNCI – there are excellent research papers produced by researchers in all these countries. What is less immediately evident is the research base tackling research that addresses local and regional policy and economic concerns. This is often because such research is close to application and transferred directly to users or published in non-journal formats not indexed in the Web of Science. Regional citation indexes that capture this local research are now making the information available to regional researchers. These include the Malaysian Citation Index (http://www.mycite.my/) established by the Ministry of Education in 2011 and the Thai Journal Citation Index (http://www.kmutt.ac.th/jif/public_html/). Indonesia does not have its own citation database but it lists and tiers journals for assessment (http://sinta2.ristekdikti.go.id/journals).

Impact Profiles demonstrate that there are excellent research papers produced by researchers in all these countries.

Summary

Institutional growth and development will surely turn emerging strengths into a new reality

Historically, Asia is recognized as having contributed to the foundation of much of the world's understanding of science.

However, S&E Asia has generally featured less prominently during the modern era, with the exception of some outstanding individuals and the exceptional performance of Singapore's universities and research institutions, built on the vision of Lee Kuan Yew.

The data reported here show a region where research generally still lags significantly on its European associates and more established Asian neighbours (China, Japan, South Korea) but which is nonetheless growing steadily.

There are three essential ingredients that would address the gap in performance and the development.

- Human capital is the first of these. The relative number of researchers in the workforce is still very small for many S&E Asia countries and that must be linked to the funding and development of higher education.

- A research environment strongly promoted through universities free to pursue their own programs of thought and innovation will be critical to change in this regard.

- The resources that the region could deploy are enormous and the potential for achievement and innovation is vast. If only to keep pace with others prospering through expanding their knowledge economies, S&E Asia nations cannot afford to underinvest in scientific and technology education and research.

The analysis in this report presents a complex picture, and contrasts are marked. Some nations have experienced very rapid growth. Conversely these are continuing low levels of research activity and output elsewhere.

The possibility of a truly effective regional network of collaborative endeavour is not yet fully realized, because there is simply insufficient capacity in some countries to engage even locally. Levels of collaboration are, for most of the region, substantial but there is much still to be put in place in translating this into the growth of domestic capacity.

Partnerships are a route to development – not only regional partnerships but links to the rest of the world. This need not be about diffuse aid – an issue of concern – because the rest of the world should be able to identify emerging centres of excellence. Although national average citation impact may lag behind world averages, the Impact Profiles demonstrate a growing volume of excellence that will hopefully enable further growth of high-quality capacity.

It is difficult, and perhaps unnecessary, to provide any simple summary of the current state of the research environment across S&E Asia. Institutional growth and development will surely turn emerging strengths into a new reality. It is essential that this should not only deliver top-end research but also create more robust educational and social transformation through human resource capacity. How widespread that change becomes and how it translates into different research fields will be an interesting narrative to follow. Given the rich human capacity and available resources, as well as the clear evidence of improvement presented here, one may hope to see further advances in science and technology for the region in the future.

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