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Author(s): J. Webb
T. Spurling
A. Finch

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Australia, Innovation and International Collaboration: Australia's collaboration with countries of Asia, with particular focus on Pakistan

Webb, J.*[1], Spurling, T. [1] and Finch, A.[2]
[1]Centre for Transformative Innovation, Swinburne University of Technology, Melbourne, Victoria Australia
[2]CSIRO, Adelaide, South Australia

*jmwebb@swin.edu.au

Abstract

Australia's path to innovation began with the very early use of tools and cultivation by aboriginal communities. With the arrival of Europeans from 1788, innovation focused on supporting agricultural production and mineral extraction. More recently, Australian innovation has extended to include high technology products such as the Cochlea Ear and the production of plastic bank notes, developed through a strong foundation in fundamental science. Looking to the future, Australia has greatly expanded its international cooperation. Bibliometric data show strong growth in collaborative chemical research papers between chemists in Australia and those in China, greatly exceeding those with Japan and India, the next strongest partners in collaboration. The most productive areas of chemistry for international collaboration are physical chemistry and chemical engineering. Concerning Pakistan, bibliometric data show a dramatic growth in collaboration between Australian and Pakistani scientists. Data analysis support the benefits of international collaboration.

Keywords: *international science collaborations, bibliometrics, science and diplomacy, Australia, Pakistan*

1. Introduction

In a radical reassessment of reports and letters written by early European settlers about the aboriginal communities they encountered, Bruce Pascoe [1] has highlighted the many innovations within indigenous communities and practices. The arrival of mainly English and Irish convicts and settlers led to the dispossession of aboriginal people and a simplistic characterization of their way of life as that of 'hunters and gatherers'. Pascoe's compelling argument calls for Are consideration of the hunter-gatherer label for pre-colonial Aboriginal Australians. The evidence insists that Aboriginal people right across the continent were using domesticated plants, sowing, harvesting, irrigating and storing – behaviours inconsistent with the hunter-gatherer tag.

European innovations focused on agricultural research necessary for survival as well as minerals extraction as colonies began to prosper. In her history of science in colonial Australia, Ann Moyal noted the good record of practical innovations directed to solving such problems in agriculture, mining and also animal husbandry [2]. As we have noted elsewhere, much of the countries scientific output concerned Australia's unique flora and fauna, astronomical observations, geological mapping and metrology [3]. While the constraints and unavailability of key materials during World War One led to governmental initiatives to stimulate scientific research and innovation, it was only after the end of World War Two that Australia began to realise the necessity of recognising and taking the opportunities provided by its geography, close to Asia. As the then Minister for External Affairs, Percy Spender emphasized (quoted in ref [4]):

"No nation can escape its geography. There is an axiom that should be written deep in the mind of every Australian

Australians were initially not inclined to take this advice. As Daniel Oakman, historian of the development assistance and scholarship scheme known as the Colombo Plan, observed [4]:

> For most of their history, Australians have seen themselves as a beleaguered white outpost of the British Empire, perched precariously between the hordes of Asia and the edge of the world. They looked north with a mixture of ignorance, wonder and fear and always through the prism of imperial design and racism

Certainly, Australia's history reveals a troubled relationship with Asia. Although cameleers from north-west Asia, nowadays Pakistan and Afghanistan, were the earliest migrants to Australia, bringing their camels to establish trading routes around the sparsely populated countryside, much of which was desert land. The more recent recognition of this 21st century as the Asian Century, with much commercial and geo-political focus on Asia, is a significant development for the Australian view of the world. Innovation in Australia now has high technology exemplars such as the introduction of polymer bank notes in 1988 [5] (and subsequently in various countries around the world) and the Cochlear ear implant to treat deafness. From the first implant in 1978, there were 10,000 recipients by 1984 and over 300,000 by 2012 [6].

2. Materials and Methods

In the context of chemistry, we have initiated a systematic analysis of collaboration between Australia and countries of Asia. Two of the authors (TS and JW) have PhDs in this field. We have used membership of the regional Federation of Asian Chemical Societies (FACS) to define the scope of these studies. The FACS began in August 1979 at a gathering of representatives of eleven chemical societies. Listed in alphabetical order in English they were Australia, Hong Kong, India, Indonesia,

Iraq, Korea, Malaysia, Philippines, Singapore, Sri Lanka and Thailand. By 2017, there were thirty member societies, covering almost all of Asia, including Pakistan. The current President, for the period 2017-2019, is Dr Dave Winkler of Australia (drdavewinklet@gmail.com).

We have employed bibliometric analysis of data from the Thomson-Reuters Web of Science to identify collaborative papers between chemists in Australia and chemists in the member countries of the FACS.

3. Results

The data in figure 1 clearly illustrates the dominant role of China in international collaboration in chemistry with Australia. The second ranked collaborator country, Japan, is just ahead of India whose collaborative output is increasing more rapidly than is Japan's. Many other countries of the FACS show appreciable collaborations with Australia but their scale is dwarfed by that of China where there were close to 700 collaborative publications in 2015. For many FACS countries, though, chemistry collaboration with Australia is increasing. We have considered this aspect in more detail elsewhere [7] reporting that collaboration in both physical chemistry and chemical engineering are most frequent. In the case of Pakistan, there were only 13 collaborative publications with Australia in 2015, with a total over the period from 1981 to 2015 of 82. Clearly, there is an opportunity here for greater collaboration in chemistry between Pakistan and Australia.

A feature of chemistry research collaboration in the 1970s and later was the strong interest in the chemistry of natural products, with UNESCO providing support for regional cooperation through networks with several national governments also supporting this area of research. Natural products chemists in Pakistan were strongly involved in these efforts. The interests of organic chemists have moved recently from the isolation and characterisation of biologically active ingredients of plants and spices to now focus more on the synthesis of such compounds of interest.

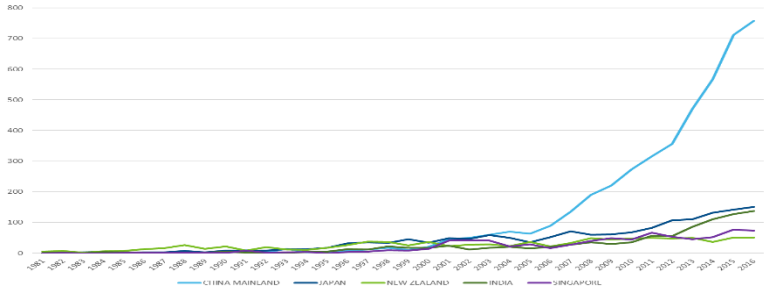

Figure 1: The number of papers of international collaboration over the period 1981-2016 for the five countries that have the largest number of collaborative

chemistry publications with Australia: China (mainland), Japan, New Zealand, India and Singapore.

For the present paper, we have widened the scope of our analysis to include the entire database of the Web of Science across pure and applied science to analyze collaborative links between Australia and Pakistan. Data are presented in several graphs, starting with figure 2.

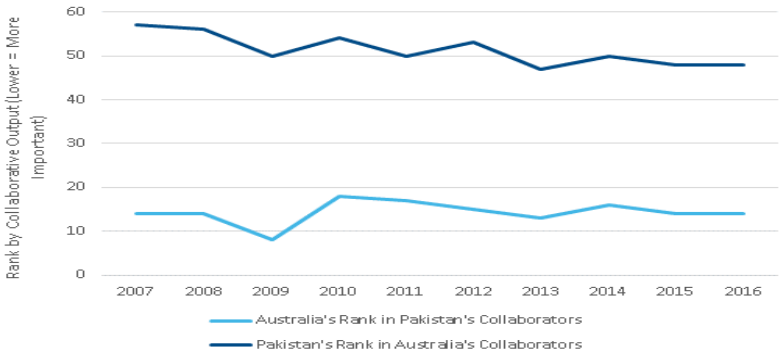

Figure 2: The position in rank order of the Australia-Pakistan collaboration over time

Over the period 2007-2016, Pakistan has become increasingly important to Australia as an international collaborator, moving from just under 60th in 2007 to now being just under 50th. Over the same period, Australia has remained around the 13th or 14th important collaborator for Pakistan.

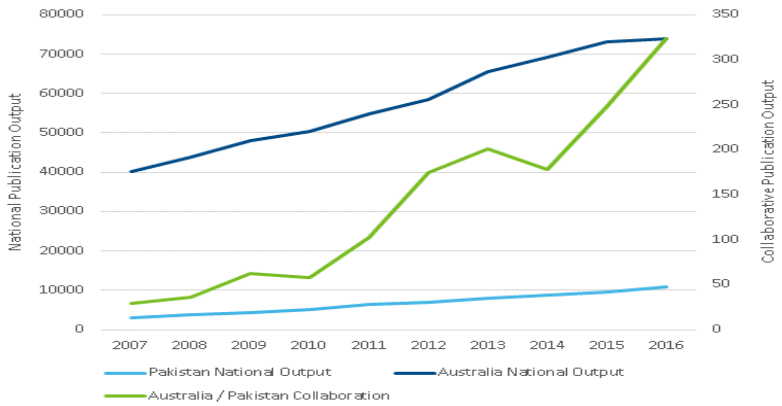

Figure 3: Research outputs of Australia, Pakistan and Australia/Pakistan collaboration over the period 2007-2016

Looking at the publication data from both countries, figure 3 shows the significance of Australia-Pakistan collaborations. The research output of both countries has grown steadily over this decade, but the Australia-Pakistan

collaboration has grown dramatically, from less than 30 in 2007 to over 300 in 2016. This is growth of an order of magnitude, quite remarkable. This rate of growth greatly exceeds that of the national growth rates: overall 2.7 for Australia, overall 5.9 for Pakistan, though from a lower base than Australia.

Not surprisingly, both countries have increased their international collaboration, a feature of contemporary science noted by the OECD in their 2015 Science Technology and Innovation Scoreboard [8]. "The proportion of documents involving international collaboration in some form has doubled since 1996, reaching close to 20% in 2013, although most scientific collaborations are still of a domestic nature".

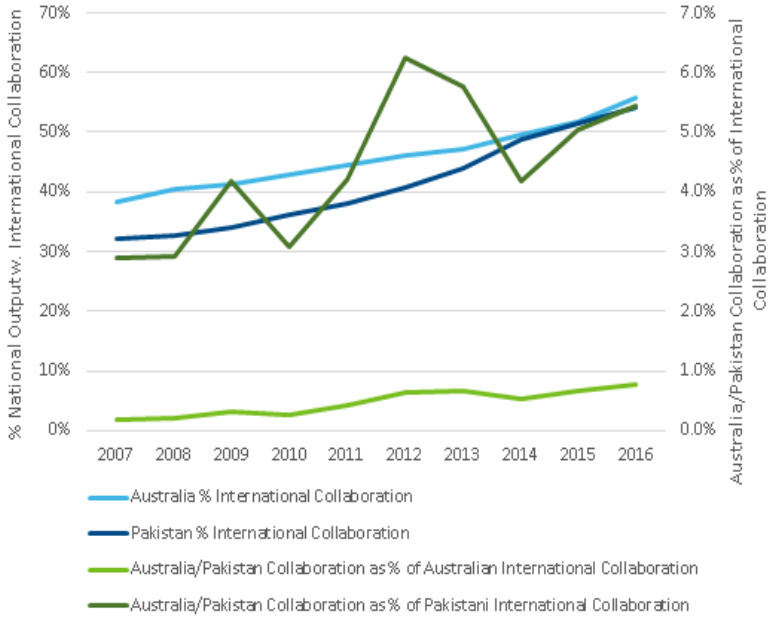

Figure 4: Australia-Pakistan collaboration in comparison with Australia's international collaboration and Pakistan's international collaboration over the period 2007-2016

Over the study period, the data of figure 4 show that Australia is still collaborating more frequently than Pakistan as a share of its national output, but Pakistan has caught Australia up in the last decade (the two blue graphs). Collaboration between Australia and Pakistan, as a percentage of Pakistan's international collaborations has fluctuated quite a bit, while as a percentage of Australia's international collaborations, it is steady and growing, though at far lower levels (the two green graphs).

We have also taken a closer look at the various fields of study, as employed by the Web of Science database.

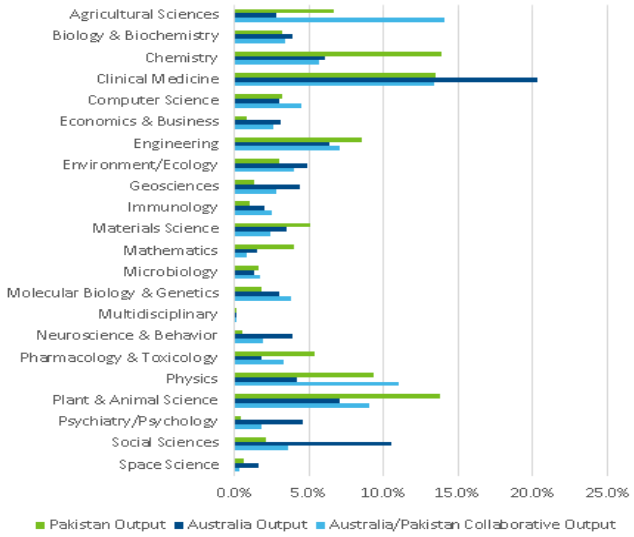

Figure 5: Australia's output, Pakistan's output and the collaborative output between Australia and Pakistan for various fields of research (Web of Science classifications)

Considering 10% as a cut-off point, the data for several of these fields merit further comment. The data reveal a range of comparisons. In some cases, the collaboration follows the Australian focus (light blue line close to size of dark blue line), in others, the Pakistan (light blue line follows the green line in length) while in other case, collaboration follows neither national data. In agricultural science, the two countries work far more together as a share of output than they do individually (the light blue line exceeds both the others). This is clearly a relative focus for Australia-Pakistan collaboration. Collaboration is also strong in the field of physics.

Looking at chemistry, where Australia's total output exceeds that of Pakistan, Pakistan produces far more chemistry publications (as % of national output) than does Australia, relatively speaking, and far more than the collaborative research papers which, however, follow Australia's (as % of national output) quite closely. The data suggest there is real potential for Australia and Pakistan to collaborate more in chemical sciences. Similar comments can be made concerning the field of plant and animal science.

In clinical medicine, an area of strength for Australia as shown by the dominant blue line, Pakistan's national output parallels its collaborative output with

Australia. Social sciences is also an area of strength for Australia but not yet for Pakistan or for Australia-Pakistan collaboration. Clearly, the data in figure 5 provides much 'food for thought' as particular fields are considered.

A question that arises from these data concerns which institutions in Australia and Pakistan are involved in creating this collaborative output.

Table 1: Data for the collaborations involving the top three institutions in Australia and in Pakistan for Australia/Pakistan (A/P) collaborations as well as Normalized Citation Impact (NCI) data

Institution	2007-2016 output	% A/P collaboration	Collaborative. NCI	Overall institution NCI
University of Sydney	296	21.0	9.01	1.51
University of Western Australia	200	14.2	11.65	1.52
University of Queensland	174	12.3	13.76	1.51
University of Agriculture Faisalabad	229	16.2	1.19	0.75
Quaid-i-Azam University	175	12.4	3.54	1.16
Aga Khan University	132	9.3	17.12	1.57

On the Australian side, nine universities, namely the Group of Eight research-intensive universities, together with Curtin University in Western Australia, account for 86.5% of the 2007-2016 collaborative output. The largest number of collaborative papers originate from the University of Sydney (296 or 21.0% of all collaborative papers).

The list of Pakistan institutions collaborating with Australia is headed by the University of Agriculture Faisalabad, accounting for 229 or 16.2% of collaborative output over the 2007-2016 period. The next listed institution is the Quaid-i-Azam University (175 or 12.4%). All others contribute individually less than 10% of the collaborative output.

The publication data in Figures 1-5 based on the number of publications provides considerable insight into the scale and fields of collaboration as well as how these have developed with time. In table 1 we have gathered the data for the top three institutions in each country with respect to their collaborations with institutions in the other country, including the normalized citation impact (NCI) measurements. The Table provides strong evidence for the benefits of

collaboration. For example, the University of Sydney has an overall institutional NCI of 1.51 but in the papers published in collaboration with Pakistan institutions, this increases to 9.01. For the Aga Khan University, its institutional NCI of 1.57 is close to that of the three Australian universities listed but in its collaborations with Australia, this rises to a remarkable 17.12. Clearly, some collaborative papers are attracting very wide attention and citation frequency. A closer look at individual papers that are highly cited reveals that such papers are multi-country collaborations not just Australia-Pakistan collaborations. They involve collaborations with researchers in Europe and North America, and appear in highly ranked journals such as Nature and Lancet. Hence, they receive a large number of citations leading to high NCI values shown in Table 1.

4. Discussion and Conclusion

The data and analysis presented here provide much 'food for thought' in considering international collaborations between Australia and Pakistan across the broad field of science. Bibliometric data are valuable in this regard. It is not, of course, the whole story. The social aspects of collaborations, the bonds of trust that form to enable collaboration and the flow of shared information, are crucial human aspects of collaboration. Further, on a broader scale, such international collaboration can be seen as a form of soft diplomacy and can attract specific funding for diplomatic initiatives. In the case of Australia, that has occurred in the early years of the 21st century for collaboration with India and with China. This diplomatic aspect is further reflected with the launch recently by the American Association for the Advancement of Science (AAAS), publishers of the highly rated journal Science, of the new journal Science & Diplomacy.

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