Asia-Pacific
Economic Cooperation

Mapping Researcher Mobility

Measuring research collaboration among APEC economies

APEC Human Resources Development Working Group

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Executive summary

Measuring researcher mobility

Researcher mobility is an important form of cross-border education (CBE). It has the potential to generate significant benefits for economies as expert scholars and scientists come together to solve some of the most pressing challenges in the contemporary world. Among members of the Asia-Pacific Economic Community (APEC) researcher mobility can strengthen ties between economies and enable the minimisation of barriers to economic growth and sustainability.

There are not currently any comparable or rigorous data available on researcher mobility among APEC economies. Proxy measures are needed to gain a sense of the extent to which researchers in APEC economies are collaborating with their peers. In this report, research collaboration, measured through data on joint publications, is analysed to identify patterns of collaboration among researchers in APEC economies. Although this approach does not encapsulate the outcomes of all forms of researcher mobility it provides an illustration of the strength of patterns of research collaboration within, and among, the 21 economies that comprise APEC.

Data were extracted from the Scopus database, encompassing all those documents published between 2011 and 2015. More than 38 per cent of these publications were written by researchers affiliated with China or the United States, or both, and researchers affiliated with the APEC economies of Australia; Canada; Japan; and the Republic of Korea also well represented.

Collaborative publications

More than half of all publications indexed by Scopus were affiliated with researchers from APEC economies. In addition to making a considerable contribution to overall publications, researchers from APEC economies were also active in collaborating with their peers in other APEC economies. Nine per cent of all publications affiliated with APEC economies included co-authors from researchers in another APEC economy.

- In six APEC economies – Hong Kong, China; Papua New Guinea; Peru; the Philippines; Singapore; and Viet Nam – more than 40 per cent of all publications were co-authored with researchers in another APEC economy.
- In thirteen further APEC economies the proportion of publications co-authored with researchers in other APEC economies was between 15 and 40 per cent.
- Just China and Russia had fewer than 15 per cent of all publications co-authored with researchers in other APEC economies.

The number of peer-reviewed publications involving collaboration by researchers from different APEC economies is increasing every year. Between 2011 and 2015, the number of papers with co-authors from two or more APEC economies has increased by around a quarter.

Most collaboration on publications between researchers in APEC economies involved researchers in just two APEC economies – only 10 per cent of papers were co-authored by researchers from more than two APEC economies. A total of 230 papers included authors from ten or more APEC economies.

Researchers in the fields of decision sciences, earth and planetary sciences and multidisciplinary fields appear to be most engaged in collaborative publications among APEC economies, with researchers in the arts and humanities appearing to be least active in collaboration.

Patterns of collaboration

In almost all economies there were significant increases in both the number of publications produced and the proportion that were written in collaboration with researchers in other APEC economies. Perhaps most marked was the very rapid increase in the number of publications produced by researchers in many economies in recent years.

Table 1 summarises the number of all documents published by researchers from each APEC economy between 2011 and 2015. It also gives the proportion of publications that researchers from each economy have co-authored with researchers from other APEC economies and the top three economies with which they collaborate. It also includes the per cent increase in the number of papers co-authored with researchers from other APEC economies between 2011 and 2015, and the discipline in which the largest proportion of all papers involved collaboration with researchers from other APEC economies that had at least 10 co-authored publications.

Table 1: Summary of cross-border collaboration in the period between 2011 and 2015

Economy	Total publications (2011-2015)	Publications co-authored with other APEC economies (%)	Top three APEC economies for collaboration	Increase in publications co-authored with other APEC economies (%)	Discipline with greatest proportion of collaboration with other APEC economies
Australia	407 239	29%	United States People's Republic of China Canada	34%	Multidisciplinary
Brunei Darussalam	1 426	36%	Malaysia Australia United States	310%	Chemistry
Canada	472 090	30%	United States People's Republic of China Australia	13%	Multidisciplinary
Chile	46 605	28%	United States Canada Australia	50%	Earth and planetary sciences
People's Republic of China	2 134 251	13%	United States Hong Kong, China Australia	51%	Psychology
Hong Kong, China	76 890	58%	People's Republic of China United States Australia	18%	Multidisciplinary
Indonesia	24 609	36%	Japan Malaysia Australia	36%	Neuroscience
Japan	623 636	18%	United States People's Republic of China Republic of Korea	-1%	Earth and planetary sciences
Republic of Korea	362 378	21%	United States People's Republic of China Japan	10%	Psychology

Economy	Total publications (2011-2015)	Publications co-authored with other APEC economies (%)	Top three APEC economies for collaboration	Increase in publications co-authored with other APEC economies (%)	Discipline with greatest proportion of collaboration with other APEC economies
Malaysia	119 671	16%	Australia United States Japan	51%	Neuroscience
Mexico	92 833	21%	United States Canada People's Republic of China	12%	Multidisciplinary
New Zealand	68 328	36%	United States Australia Canada	16%	Multidisciplinary
Papua New Guinea	734	78%	Australia United States Japan	15%	Chemistry
Peru	7 511	45%	United States Mexico Chile	60%	Multidisciplinary
Philippines	9 316	47%	United States Japan Australia	38%	Immunology and microbiology
Russia	249 316	11%	United States People's Republic of China Japan	32%	Psychology
Singapore	89 860	44%	People's Republic of China United States Australia	32%	Multidisciplinary
Chinese Taipei	204 842	19%	United States People's Republic of China Japan	12%	Earth and planetary sciences
Thailand	59 644	29%	United States Japan People's Republic of China	26%	Psychology

Economy	Total publications (2011-2015)	Publications co-authored with other APEC economies (%)	Top three APEC economies for collaboration	Increase in publications co-authored with other APEC economies (%)	Discipline with greatest proportion of collaboration with other APEC economies
United States	3 041 225	15%	People's Republic of China Canada Australia	23%	Multidisciplinary
Viet Nam	17 163	48%	United States Japan Republic of Korea	79%	Psychology

Introduction

Project background

This report forms part of the Mapping Researcher Mobility project commissioned by the Australian Government Department of Education and Training in early 2016 as part of a broader APEC Researcher Mobility Project. This project builds on work from a number of previous activities that have explored cross-border education cooperation, researcher mobility and institutional mobility in the APEC region.

The Mapping Researcher Mobility Project was an outcome of the APEC Researcher Mobility Workshop, held in Jakarta in December 2015. Specifically, this project responds to discussions and recommendations for more data on research collaboration and mobility in the region.

To date, there has been little quantitative information published about the scale and scope of cross-border collaboration and mobility of researchers in APEC economies. Information on research collaboration and researcher mobility will provide policy makers and other stakeholders with a more complete understanding of the current level of research collaboration in the Asia-Pacific. This can be used to inform future approaches to increasing and supporting researcher mobility and research collaboration in the region.

Researcher mobility and research collaboration are closely related concepts that often occur together. Researcher mobility relates to the physical mobility of researchers, while cross-border research collaboration does not always require researchers to physically move in order for collaboration to occur. This project will focus specifically on cross-border research collaboration. This report provides initial insights into the scale, scope and trends in research collaboration in the APEC region.

Measuring cross-border research collaboration

Cross-border research collaboration has become increasingly important in recent years. There is clear evidence that academic journal articles that include international authors have higher impact factors (The Royal Society, 2011; Wagner, 2005) and that cross-border collaboration leads to higher quality research output (Liao, 2011).

Research collaboration occurs ‘when two or more investigators work together on a project and contribute resources and effort, both intellectual and physical’ (Subramanyam, 1983, p. 34). Although this definition initially looks to be quite simple, it can be difficult to clearly define the boundaries of what activities constitute research collaboration (Katz & Martin, 1997). Collaboration can occur at different levels, and may range from sharing ideas and information with colleagues at a conference to working together in the same laboratory on the same research project for several years (Subramanyam, 1983).

There are several ways in which cross-border research collaboration may take place. Junior researchers may move abroad to undertake research as part of their doctoral studies or postdoctoral fellowship. Their research may also be supervised or co-supervised by a researcher based at a university in a different country. Researchers may join cross-border disciplinary or interdisciplinary research groups. Researchers from more than one economy may collaborate on research projects or publish research findings as co-authors.

Cross-border research collaboration can be difficult to measure for a number of reasons. These include that there are many different levels and types of research collaboration, no clear boundaries of what constitutes a research collaboration, and that many aspects of collaboration are intangible (Katz & Martin, 1997; Subramanyam, 1983).

Attempts at understanding research collaboration have used a number of different approaches. These include observation, interviews, surveys, social network analysis and bibliometric approaches (Otte & Rousseau, 2002; Subramanyam, 1983).

Observational studies would elicit deep insights into the research collaboration process, and could capture information about many aspects of research collaboration that other methodologies may miss. However, this methodology requires a large amount of time and effort to implement and as a result would only be able to focus on the activities of a limited number of researchers. Because of this, observation was not the best approach to use to gain a broad understanding of the scale and scope of cross-border research collaboration in the APEC region.

Interview or survey methodologies could also be used to collect information from researchers about the number and nature of their research collaborations, as well as their experience and perspectives on collaboration. However, it would be very difficult to select a random and representative sample of researchers to include in such a study, and it would be difficult to gain a broad understanding of cross-border research collaboration at a regional level.

Social network analysis aims to understand the social structures of communities and the relationships between individuals and groups (Otte & Rousseau, 2002). It could be used to explore the relationships between individual researchers or groups of researchers and understand the strength and nature of these relationships, such as in Wagner and Leydesdorff (2005). Social network analysis could aid understanding of the nature of cross-border research collaboration in the APEC region, but was not considered to be an appropriate first step in achieving a broad understanding of the size, scale and scope of research collaboration.

This project uses a bibliometric approach to measuring research collaboration, and uses measures of cross-border co-authorship as a proxy for research collaboration. This approach has several benefits. First, it can use data sources that already exist, and that are reliable, comprehensive and frequently updated. Co-authorship is quantifiable and one of the most tangible ways of measuring research collaboration. It is also widely accepted as an appropriate way to measure research collaboration (Katz & Martin, 1997; Melin & Persson, 1996; Subramanyam, 1983).

Although a common approach, measuring collaboration through co-authorship has some limitations. Not all research collaborations will lead to a published document or other tangible, measurable object, and the level of publication differs by discipline. It is not possible to use co-authorship alone to understand the extent or type of collaboration – if any – that has occurred between the authors.

Finally, not all collaborators may be named as authors of a document. The choice of who to list as an author differs between disciplines and institutions, with some papers only listing one or two primary researchers as authors, and others listing everyone in a research laboratory or department (Subramanyam, 1983).

Despite these limitations, co-authorship is a common and widely accepted measure of research collaboration (Melin & Persson, 1996). This project uses cross-border co-authorship as a proxy measure for cross-border research collaboration, and this is in turn used to represent researcher mobility. An existing bibliometric database is used to explore patterns of publication of peer-reviewed documents with authors listed from two or more APEC economies.

Research objectives

As outlined above, this project aims to explore the scale and scope of co-authorship between researchers in APEC economies in order to further understanding of research collaboration in the region. More specifically, this project aims to:

- identify the number of peer-reviewed documents, including journal articles, books, book chapters and conference papers, that have been co-authored by researchers in two or more APEC economies;
- explore differences in the level of cross-border co-authorship in the APEC region by economies;
- explore differences in the level of cross-border co-authorship in the APEC region by subject area;
- explore trends in cross-border co-authorship in the APEC region over time; and
- identify examples of successful cross-border research collaborations.

Report structure

This report first provides an overview of the research approach used in this project. It then moves to the research findings. These include a broad overview of patterns in publication, including trends in overall publication at a global level, trends in collaboration among researchers in APEC economies, and the number of documents being published in different subject areas. An overview of the scale and scope of cross-border collaboration among researchers from different APEC economies is then given.

The report then focuses on each individual APEC economy in turn. A summary of the patterns of overall publication and co-authorship with other APEC economies is given for each APEC economy.

The report also includes a few brief case studies illustrating examples of successful research collaboration among researchers in the APEC region. It then concludes and presents some recommendations for future work to further our understanding of research collaboration and researcher mobility in the region.

Because of the large number of figures and tables included in this report, a list of these is included in Appendix A. Another appendix, Appendix B, includes a summary of how the data file was built. Another appendix includes a summary of how the data were extracted, cleaned and prepared for analyses.

Research Approach

Overview

The research approach used in this project involved several steps. Broadly, the methodology included a brief review of literature on research collaboration; extracting bibliometric data from an existing abstract and citation database; and analysing this data to explore the scale and scope of cross-border co-authorship in the APEC region.

The broad research approach and the methodological details, outlined below, were designed in close consultation with expert librarians, software developers and researchers from the Australian Council for Educational Research (ACER). The approach was chosen as it was both appropriate to the research objectives and achievable given the relatively tight timelines and budget available.

Database selection

A number of different databases were considered for selection in this project, including Web of Knowledge, Google Scholar and Scopus. Scopus was identified as the most appropriate abstract and citation database for this project for a number of reasons.

The main reason for its selection was because it is currently the largest database of peer-reviewed literature, with over 60 million documents, and more than 21 500 peer-reviewed journals across all fields of study included in the database. The database also includes other types of documents including articles published in trade publications, books, book chapters, and conference proceedings (Elsevier, 2016b).

Scopus also has several other features that made it ideal for use in this project. Scopus indexes information about the economy that authors are affiliated with. It allows users to easily extract bibliometric data into a data file. Finally, Scopus also allows users to conduct simple descriptive analyses of search results within the database.

Although Scopus was identified as the best data source for this project, it is important to note that it does have some limitations. Although it is the largest abstract and citation database worldwide, it does not index all research. Like other abstract and citation databases, it excludes grey literature and other research that has not been peer-reviewed, but could still be considered research outputs. In addition, Scopus has strict quality and coverage requirements.

Scopus has a Content Selection and Advisory Board that decides which peer-reviewed journals and other sources meet specific coverage and quality requirements to be included in Scopus's index (Elsevier, 2016c). In addition, in order to be indexed, sources need to be regularly published and include an English-language abstract and reference list (Elsevier, 2016c).

While around a fifth of all titles indexed by Scopus are published in languages other than English and there are a greater number of publications indexed from regions other than Western Europe and North America than other databases (Elsevier, 2016c), the English language requirements may mean that many documents published in languages other than English are excluded.

In other words, although around three million new records are added into the database each year (Elsevier, 2016c), this does not capture all of the research literature published worldwide.

One other potential limitation of using Scopus, is that it is not a static database. Thousands of documents published in the current year and from previous years are added to the index every day (Elsevier, 2016c). This means that any analyses of cross-border co-authorship will be impossible to replicate exactly.

Data from Scopus were extracted into a data file that was used as the basis for many of the analyses presented in this report. Further details about how the data were extracted, and how the data file was built is included in Appendix B: Building the data file.

Research Findings

Global patterns of research publication

The level of publication has increased dramatically in the past decades. As shown in Figure 1, since 1960 the number of peer-reviewed documents being published annually (and indexed by Scopus) has grown from around 150 000 in the 1960s to over 2.5 million in the current decade. This growth is mirrored in the level of publication among authors affiliated with one or more APEC economies. The number of peer-reviewed documents published annually by authors affiliated with an APEC economy has grown from around 30 000 documents to approximately 1.5 million in recent years.

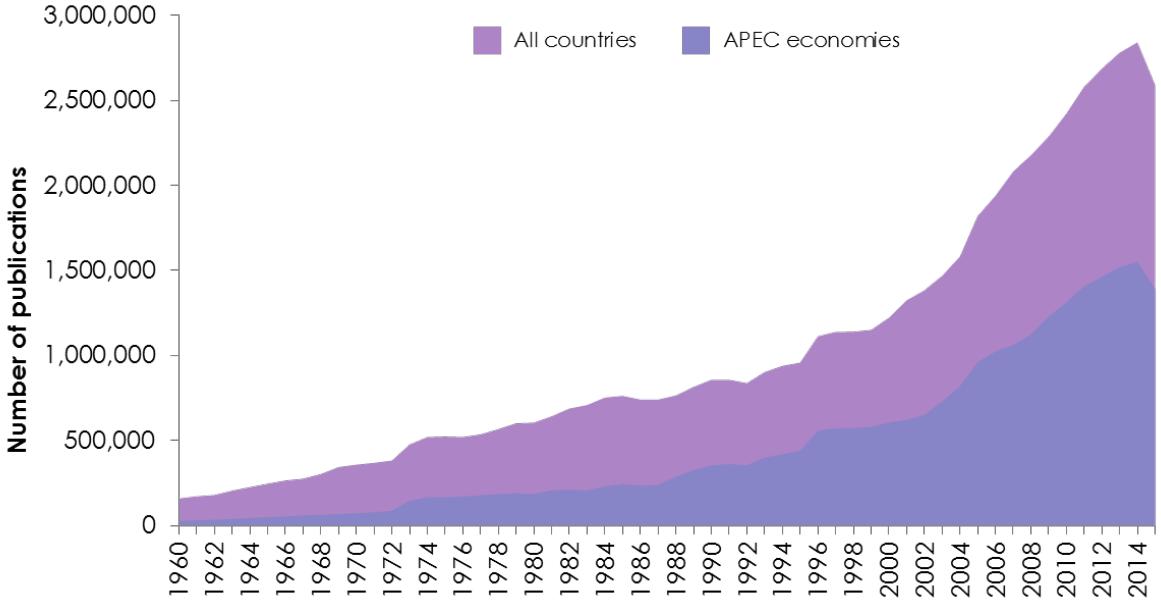

Figure 1: Total number of documents published and number published by researchers from APEC economies

Note that although Figure 1 suggests that there has been a decrease in the number of documents published in 2015, this is most likely only due to a lag in the indexing by Scopus of some of the documents that were published in recent years. More than 13,000 documents published in 2015 across all subject areas were added to Scopus's index in the past week alone. A large proportion of these documents were book chapters, conference papers and books. Although the vast majority of

publications are indexed very quickly by Scopus – taking an on average two or three weeks to process and index journal articles – a number of publications take a longer time to appear in Scopus's index.

Given the huge level of growth in the number of articles, books, book chapters, conference papers and other types of peer-reviewed literature being published, and the very large number of publications indexed by Scopus, this report will mostly focus on documents published in a recent five year period, from 2011 to 2015.

Scopus's index includes documents by authors who are affiliated with over 200 different economies.

Table 2 lists the economies that published the most peer-reviewed documents – representing at least 1 per cent of all publications – between 2011 and 2015. A number of APEC economies are included in this list. These economies are shown in bold text in this table. The most notable of these are the United States and China, who are both very active producers of research literature. Publications affiliated with the United States accounted for more than a fifth of all publications in this time period. Publications associated with China accounted for around 16 per cent of all documents published between 2011 and 2015.

Table 2: Number and proportion of all publications by affiliated economy (2011-2015)

Economy	Publications	
	#	%
United States	3 041 265	22.6
China	2 134 252	15.8
United Kingdom	891 882	6.6
Germany	789 719	5.9
Japan	623 631	4.6
India	566 254	4.2
France	559 656	4.2
Italy	481 924	3.6
Canada	472 085	3.5
Spain	411 403	3.1
Australia	407 219	3.0
Korea	362 375	2.7
Brazil	303 053	2.2
Netherlands	268 302	2.0
Russia	249 291	1.8
Chinese Taipei	204 837	1.5
Iran	204 348	1.5
Switzerland	200 059	1.5
Turkey	189 086	1.4
Poland	181 426	1.3

Economy	Publications	
	#	%
Sweden	174 887	1.3
Belgium	149 869	1.1

Patterns of research publication in APEC economies

Between 1960 and 2015, more than 26 million peer-reviewed documents were published by researchers affiliated with APEC economies. Table 3 summarises the number of documents published by APEC economies for period between 2011 and 2015, and the proportion of all documents that this represents. This shows that documents published affiliated with one or more APEC economies accounted for more than half of all publications indexed by Scopus during this period.

Table 3: Number and proportion of publications affiliated with APEC economies (2011-2015)

APEC economies	Publications	
	#	%
Australia	407 219	3.0
Brunei Darussalam	1 426	0.0
Canada	472 085	3.5
Chile	46 603	0.3
China	2 134 252	15.8
Hong Kong, China	76 891	0.6
Indonesia	24 609	0.2
Japan	623 631	4.6
Korea	362 375	2.7
Malaysia	119 670	0.9
Mexico	92 831	0.7
New Zealand	68 320	0.5
Papua New Guinea	734	0.0
Peru	7 512	0.1
Philippines	9 316	0.1
Russia	249 291	1.8
Singapore	89 861	0.7
Chinese Taipei	204 837	1.5
Thailand	59 647	0.4
United States	3 041 265	22.6
Viet Nam	17 163	0.1
All APEC Economies	**7 330 920**	**54.4**

Looking in more detail at the types of documents published that are affiliated with one or more APEC economies indicates that articles are the most common type of document indexed by Scopus. Articles represent 67 per cent of all documents published by authors from APEC economies between 2011 and

2015, or close to 5 million documents. Other types of documents published by authors affiliated with APEC economies include conference papers (19%), reviews (5%), book chapters (3%), and editorials (1%).

Authors from APEC economies published in a number of different subject areas. Table 4 shows the number of documents published between 2011 and 2015 in each of the narrow subject areas by authors affiliated with APEC economies and the overall number of publications indexed in each of these subject areas. Figure 2 shows the per cent of documents that were published in each narrow subject area.

This indicates that medicine is the subject area with the highest rate of publication. More than a quarter of documents produced by authors affiliated with APEC economies were in this subject area, and around 30 per cent of all publications were in the subject area of medicine in this time period. Other large subject areas include engineering; physics and astronomy; biochemistry, genetics and molecular biology; computer science; and materials science.

Table 4: Number of publications by subject area (2011-2015)

Broad subject area	Narrow subject area	APEC economies	All economies
Life Sciences	Agricultural and Biological Sciences	534 008	1 016 517
	Biochemistry, Genetics and Molecular Biology	935 155	1 557 139
	Immunology and Microbiology	205 649	365 204
	Neuroscience	191 062	323 624
	Pharmacology, Toxicology and Pharmaceutics	224 755	442 324
Social Sciences	Arts and Humanities	253 012	616 040
	Business, Management and Accounting	155 917	339 638
	Decision Sciences	65 649	123 804
	Economics, Econometrics and Finance	111 302	251 143
	Psychology	176 071	308 920
	Social Sciences	562 119	1 158 324
Physical Sciences	Chemical Engineering	338 591	561 880
	Chemistry	649 640	1 094 921
	Computer Science	884 099	1 525 768
	Earth and Planetary Sciences	346 380	558 678
	Energy	246 044	409 502
	Engineering	1 697 477	2 644 828
	Environmental Science	350 650	640 616
	Materials Science	798 825	1 262 876
	Mathematics	477 695	847 392
	Physics and Astronomy	938 845	1 490 955
Health Sciences	Medicine	1 954 742	4 056 447
	Nursing	113 128	224 341
	Veterinary	45 512	113 821

Broad subject area	Narrow subject area	APEC economies	All economies
	Dentistry	33 024	80 348
	Health Professions	84 277	157 556
General	Multidisciplinary	82 697	139 441

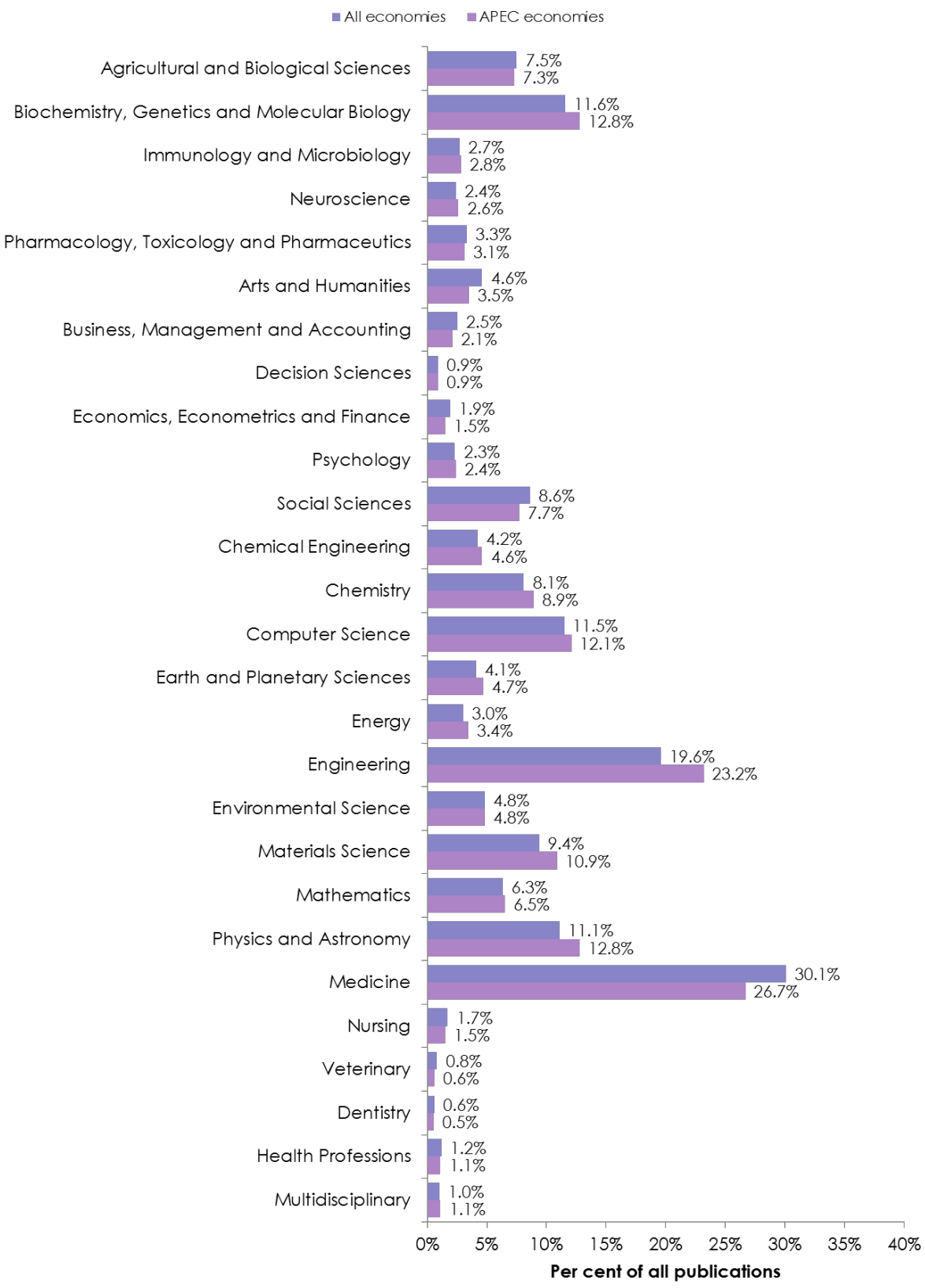

Figure 2: Proportion of publications in each subject area (2011-2015)

Research collaboration among APEC economies

Overall, in the period between 2011 and 2015, 685 906 papers were co-authored by researchers from two or more APEC economies. This represents around nine per cent of all publications written by researchers from APEC economies. The number of papers published by researchers from two or more APEC economies is increasing every year. Between 2011 and 2015, the number of papers being published annually increased by 24 per cent.

As shown in Table 5, when looking at individual economies, the highest level of cross-border collaboration with researchers from APEC economies – as measured by the proportion of all papers co-authored with researchers from another APEC economy – was shown for researchers from Papua New Guinea and Hong Kong, China. 78 per cent of papers affiliated with researchers from Papua New Guinea, and 58 per cent of papers affiliated with researchers from Hong Kong, China were co-authored with researchers from at least one other APEC economy.

Table 5: overall number of publications and publications co-authored with another APEC economy by APEC economy (2011-2015)

APEC economies	Total publications	Publications co-authored with another APEC economy	
	#	#	%
Australia	407 219	119 506	29.3
Brunei Darussalam	1 426	519	36.4
Canada	472 085	143 323	30.4
Chile	46 603	13 055	28.0
China	2 134 252	282 681	13.2
Hong Kong, China	76 891	44 326	57.6
Indonesia	24 609	8 910	36.2
Japan	623 631	111 999	18.0
Korea	362 375	76 422	21.1
Malaysia	119 670	18 618	15.6
Mexico	92 831	19 617	21.1
New Zealand	68 320	24 427	35.8
Papua New Guinea	734	572	77.9
Peru	7 512	3 391	45.1
Philippines	9 316	4 366	46.9
Russia	249 291	28 123	11.3
Singapore	89 861	39 305	43.7
Chinese Taipei	204 837	39 907	19.5
Thailand	59 647	17 278	29.0
United States	3 041 265	457 031	15.0
Viet Nam	17 163	8 251	48.1
All APEC Economies	**7 330 920**	**685 906**	**9.4**

The level of cross-border collaboration can also be measured by the total number of papers co-authored with researchers from other APEC economies. Using this measure, researchers from the United States and China displayed the greatest level of cross-border collaboration. However, only 13 per cent of all papers affiliated with China and only 15 per cent of all papers affiliated with the United States were co-authored with researchers from other APEC economies.

As shown in Figure 3, around three-quarters of all publications co-authored by researchers from two or more APEC economies were articles. Other publications included conference papers (13%), reviews (4%), book chapters (2%) and editorials (2%). The remaining three per cent of publications included letters, articles in press, notes, errata, and whole books.

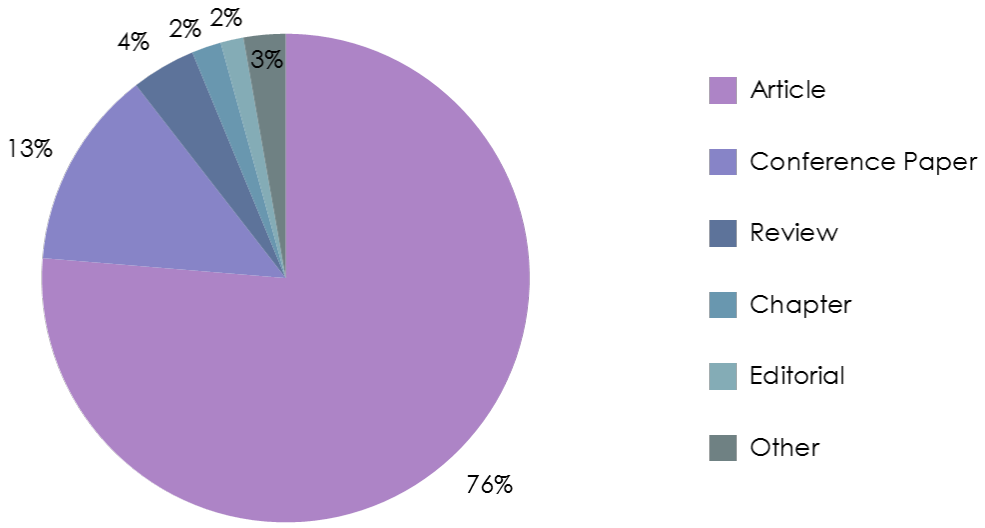

Figure 3: Types of publications co-authored by two or more APEC economies (2011-2015)

Eleven per cent of articles published by APEC economies were co-authored by researchers from two or more APEC economies. A smaller proportion of conference papers (6%), reviews (8%), and book chapters (6%) involved collaboration between researchers from APEC economies.

Most cross-border collaboration appears to be taking place by researchers from just two different APEC economies, with 90 per cent of all papers co-authored by researchers from multiple APEC economies affiliated with two different APEC economies.

Eight per cent have affiliations with three different APEC economies and two per cent have affiliations with four or more different APEC economies. Around 230 papers have affiliations with 10 or more different APEC economies. Around one-fifth of all papers affiliated with researchers from at least two APEC economies also includes researchers from non-APEC economies.

Every journal, book and conference proceeding indexed by Scopus is classified using the All Science Journal Classification (ASJC). (Elsevier, 2016b). The ASJC includes 26 narrow subject areas which are grouped into four broad areas – life sciences, social sciences, physical sciences and health sciences. The classification also includes a general or multidisciplinary subject area. Each publication may be classified in one or more than one of these narrow subject areas.

The rate of cross-border co-authorship among researchers from different APEC economies varies by subject area. Figure 2 shows the proportion of all papers published within a particular subject area that involved collaboration between researchers from two or more APEC economies. This shows that the highest level of cross-border co-authorship seems to be occurring in research in the decision sciences, earth and planetary sciences and multidisciplinary fields. The lowest rate of collaboration appears to be occurring in the arts and humanities.

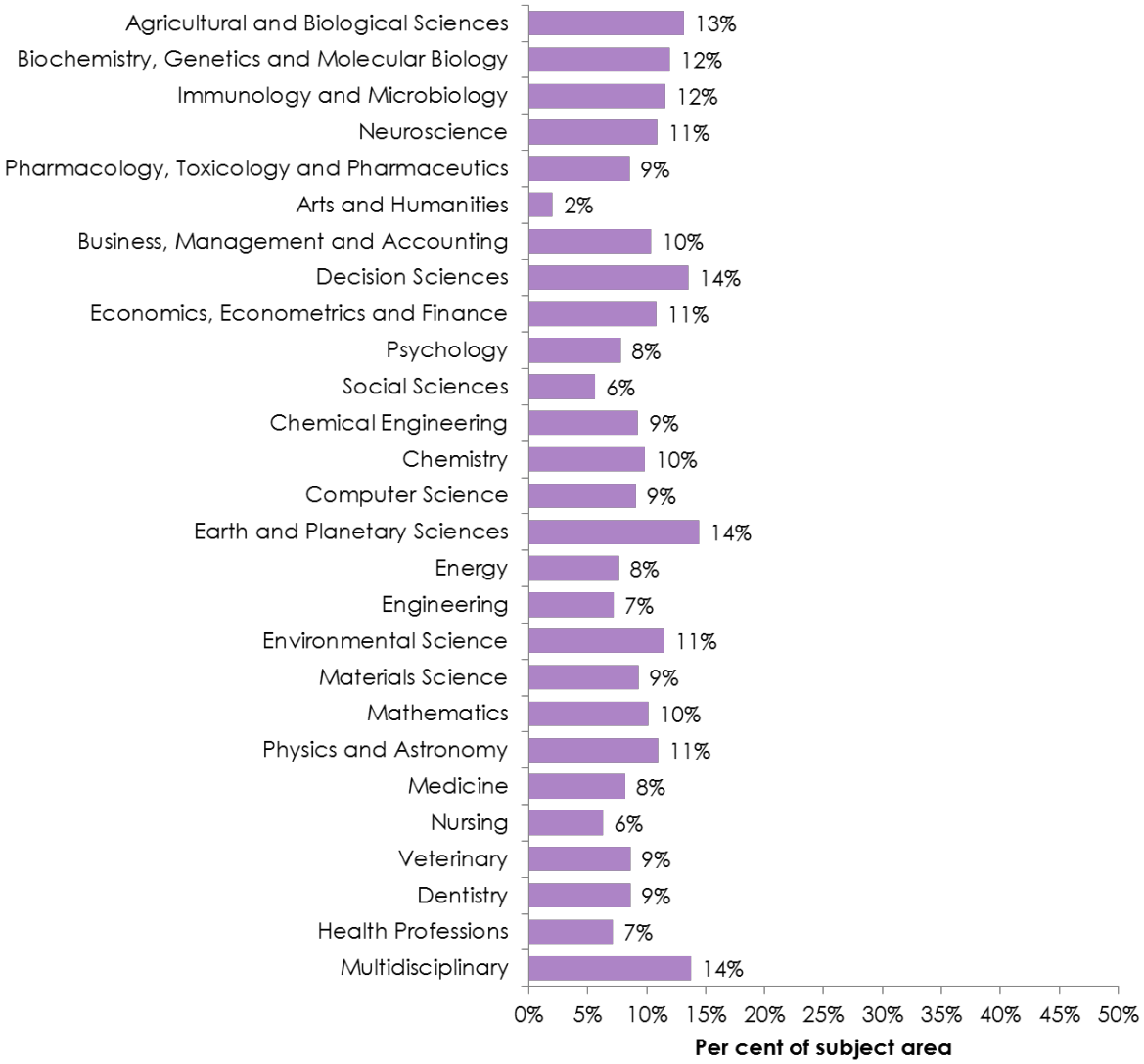

Figure 4: Rates of cross-border collaboration with researchers from other APEC economies by subject area (2011-2015)

Australia

In the period from 1960 to 2015, more than 1.2 million documents affiliated with an Australian author were published and included in Scopus's index. Figure 5 shows the number of documents published during this period and highlights the huge growth in publication in Australia, which is mirrored globally. This also shows that the proportion of documents published by Australian authors has also increased

substantially in recent decades. Between 2011 and 2015, more than 400 000 documents had an Australian affiliation, representing three per cent of all documents indexed by Scopus.

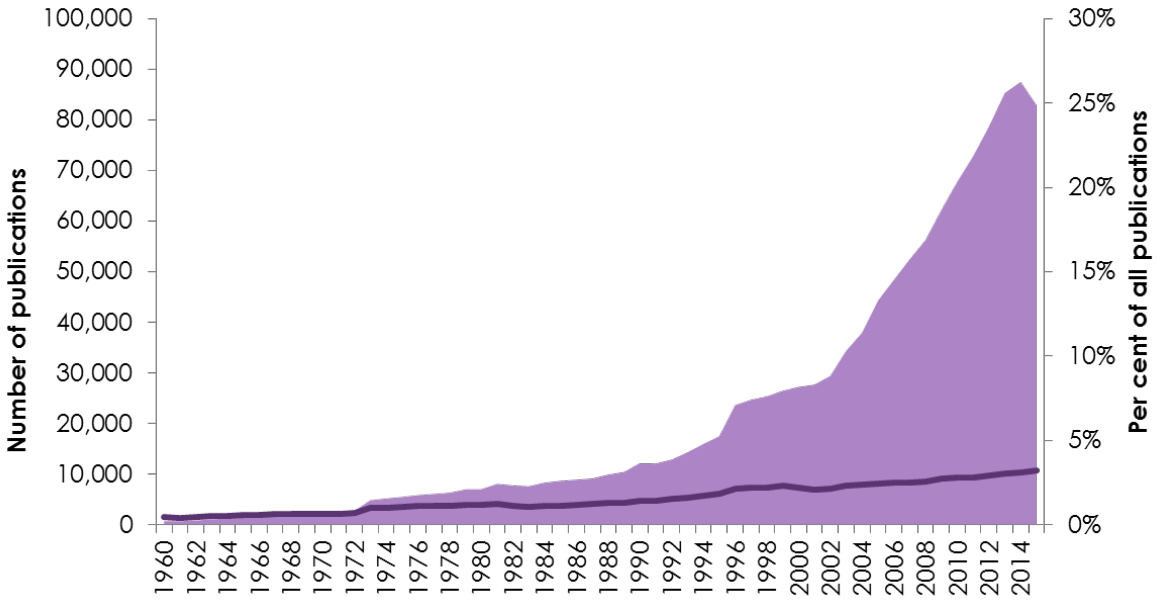

Figure 5: Number and proportion of publications affiliated with Australia

According to analyses conducted by SCImago (2016a), in 2014 almost half of all documents written by Australian researchers were co-authored with researchers from other economies. As shown in Figure 6, in the period between 2011 and 2015, 13 per cent of all Australian publications were co-authored with researchers from the United States, and 10 per cent with researchers from the United Kingdom.

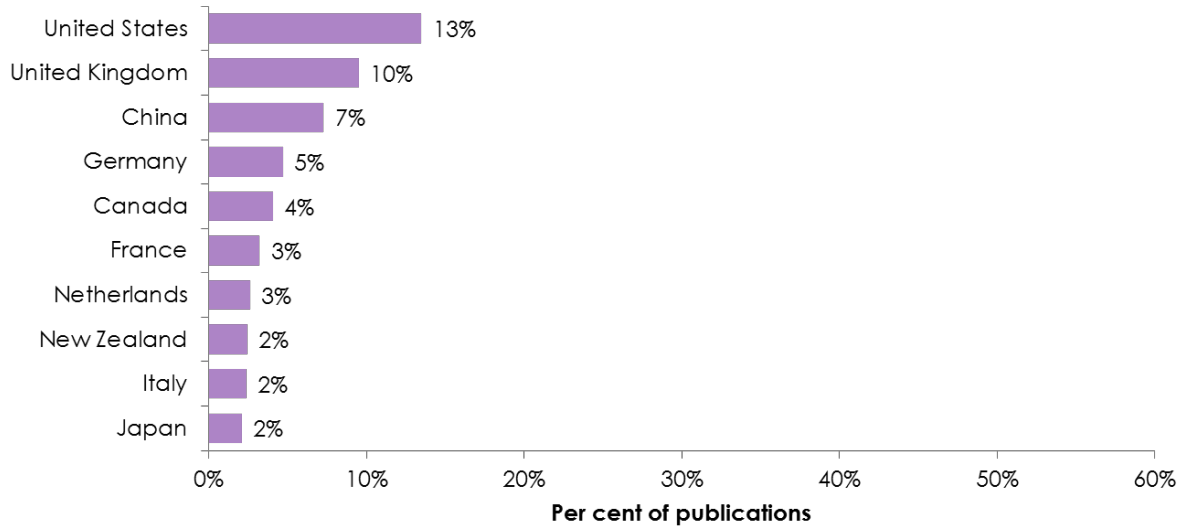

Figure 6: Most common cross-border co-authorship for Australian publications (2011-2015)

Mirroring the huge growth in publication over the previous decades is the growth in cross-border co-authorship. In addition to the huge growth in the number of documents co-authored by researchers from Australia and other APEC economies, the proportion of all Australian documents that this represents

has also grown substantially. Between 2011 and 2015, a total of 119 506 documents included co-authors from Australia and other APEC economies. This represents 29 per cent of all documents published by Australian researchers during this period.

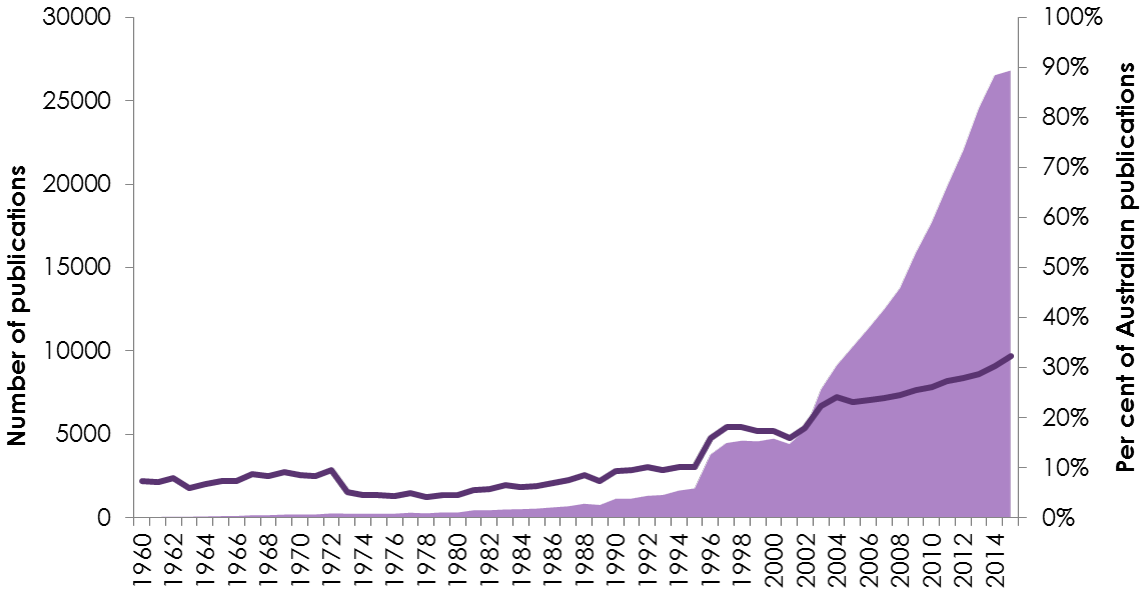

Figure 7: Number and proportion of Australian publications co-authored with other APEC economies

Table 6 lists the number of publications that Australian researchers have co-authored with researchers from each APEC economy between 2011 and 2015. It also shows the proportion of all Australian documents that this number represents. This shows that the most frequent cross-border co-authorship occurs with the United States; China; and Canada.

Table 6: Number and proportion of Australian publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Brunei Darussalam	109	0
Canada	16 582	4
Chile	2 203	1
China	29 600	7
Hong Kong, China	4 238	1
Indonesia	1 824	0
Japan	8 669	2
Korea	4 046	1
Malaysia	4 754	1
Mexico	1 585	0
New Zealand	9 930	2
Papua New Guinea	421	0
Peru	249	0
Philippines	759	0

Russia	2 876	1
Singapore	5 552	1
Chinese Taipei	2 940	1
Thailand	2 429	1
United States	54 934	13
Viet Nam	1 232	0

Figure 8 shows that the number of documents being published by Australian authors is increasing year-on-year, with a small decrease in 2015. This increase is also reflected in the number of publications co-authored by researchers from Australia with researchers from other APEC economies. Between 2011 and 2015, the number of publications co-authored with researchers from other APEC economies has increased by 34 per cent.

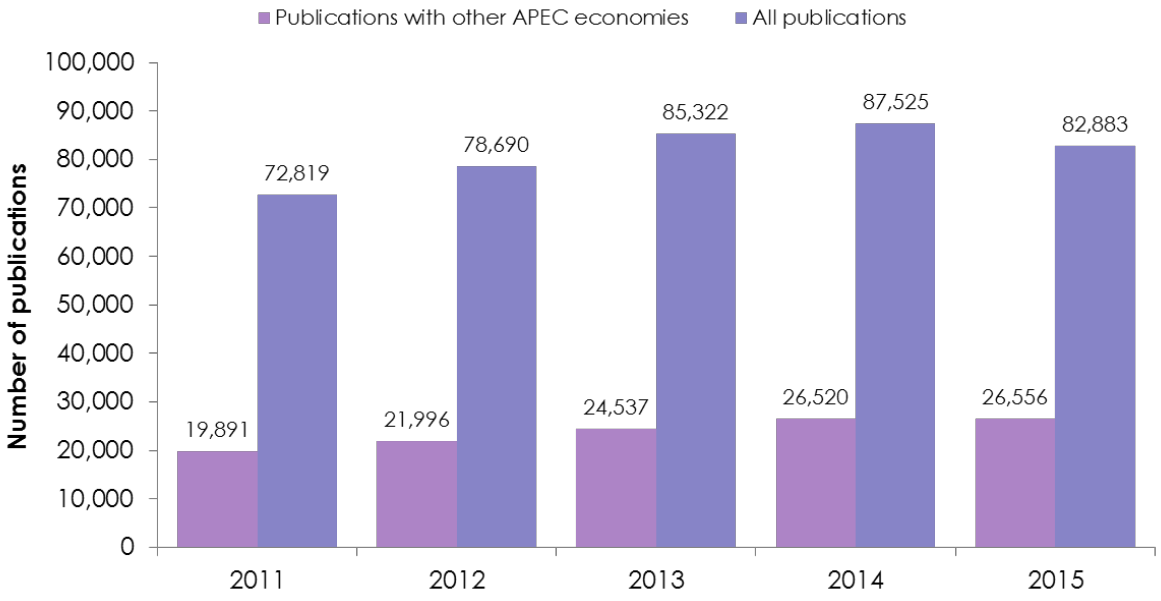

Figure 8: All Australian publications and Australian publications co-authored with another APEC economy

As shown in Figure 9, 71 per cent of all Australian publications did not include a co-author from another APEC economy. Around a quarter were co-authored with researchers from just one other APEC economy, and six per cent included co-authors from two or more other APEC economies.

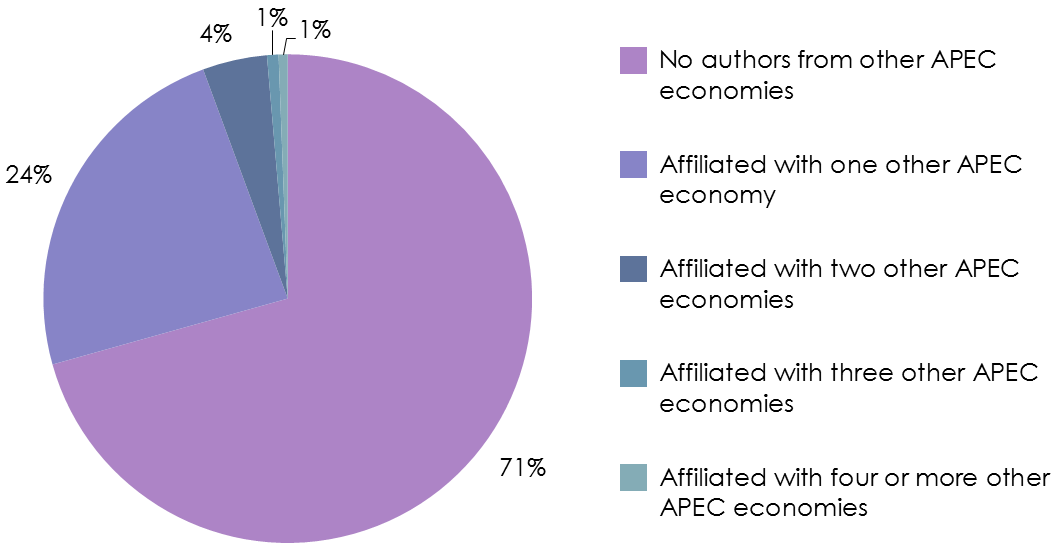

Figure 9: Proportion of all Australian publications co-authored with one or more other APEC economies (2011-2015)

The level of cross-border co-authorship with researchers from other APEC economies varies by subject area. As shown in Figure 10, more than 40 per cent of all peer-reviewed research literature in multidisciplinary, physics and astronomy, or earth and planetary science subject areas were co-authored with researchers from other APEC economies. The level of cross-border co-authorship was lowest for arts and humanities, and social sciences.

Figure 10: Proportion of Australian publications co-authored with another APEC economy by subject area (2011-2015)

Brunei Darussalam

Between 1960 and 2015, researchers from Brunei Darussalam published around 2 500 peer-reviewed documents. Figure 11 shows the number of documents published by Bruneian authors during this period and the proportion of all publications that this represents. Although only a relatively small number of documents have been published by Bruneian authors – representing less than 0.1 per cent of all research literature globally – recent years have seen a rapid increase in number of papers being published by Bruneian researchers.

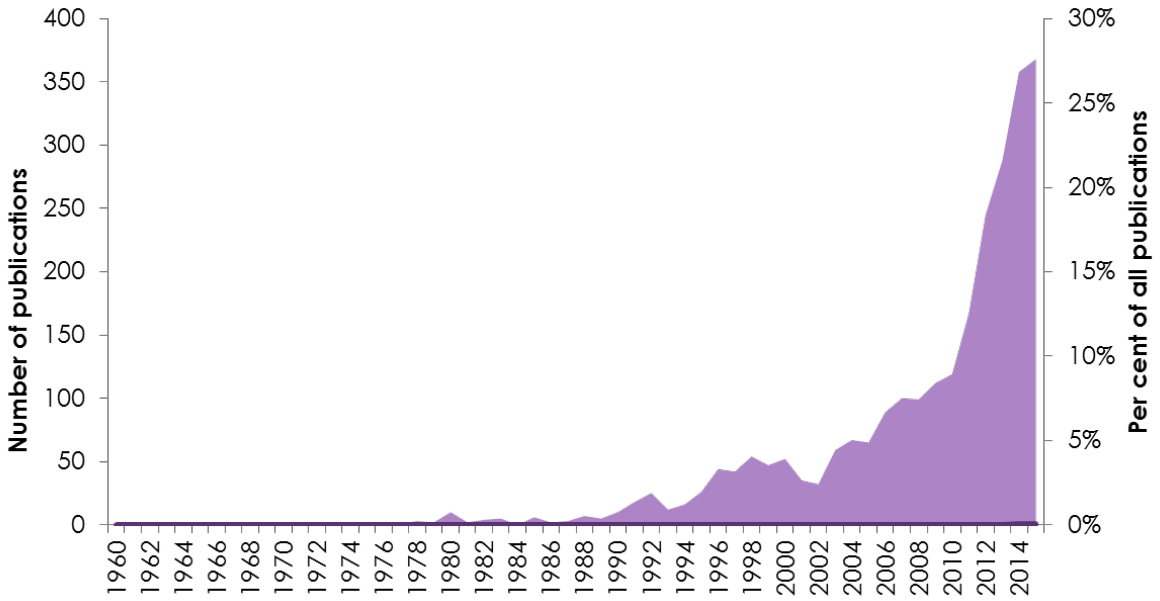

Figure 11: Number and proportion of publications affiliated with Brunei Darussalam

In 2014, 56 per cent of all papers by Bruneian researchers included cross-border co-authors (SCImago, 2016b). As shown in Figure 12, between 2011 and 2015, 14 per cent of all Bruneian publications were co-authored with researchers from Malaysia.

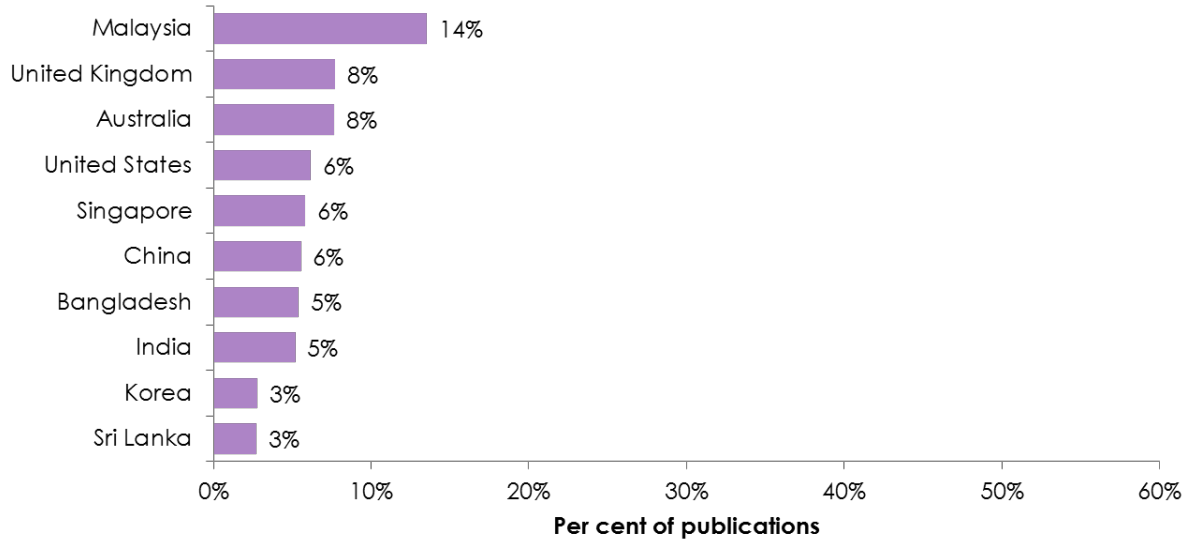

Figure 12: Most common cross-border co-authorship for Bruneian publications (2011-2015)

As well as growth in the number of papers published by Bruneian researchers, recent years have seen growth in the number of papers co-authored by researchers from Brunei Darussalam and other APEC economies (Figure 13). During this period, a total of 519 documents were co-authored by researchers from Brunei Darussalam and other APEC economies. The proportion of all Bruneian documents that co-authored papers represent also appears to be on the rise. Between 2011 and 2015, 36 per cent of all

documents published by Bruneian researchers were co-authored with researchers from other APEC economies.

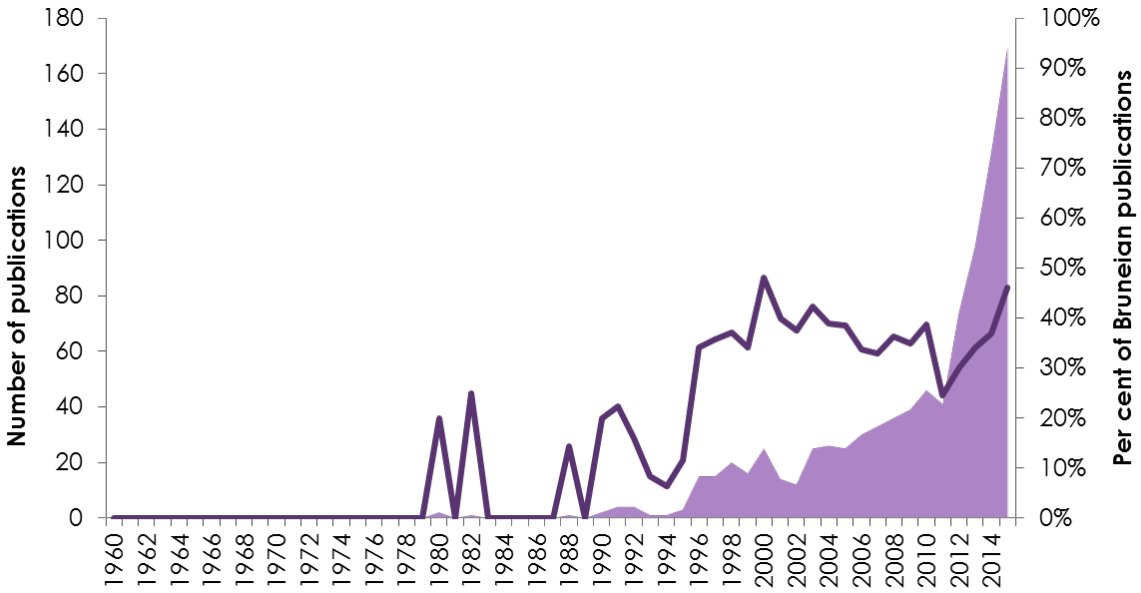

Figure 13: Number and proportion of Brunei Darussalam publications co-authored with other APEC economies

Table 7 shows the number of publications that Bruneian researchers have co-authored with researchers from each of the other APEC economies between 2011 and 2015. It also indicates the proportion of all Bruneian publications that these numbers represent. This shows that collaboration occurs most frequently with Malaysia and Australia.

Table 7: Number and proportion of Bruneian publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	109	8
Canada	31	2
Chile	3	0
China	79	6
Hong Kong, China	19	1
Indonesia	21	1
Japan	37	3
Korea	41	3
Malaysia	196	14
Mexico	6	0
New Zealand	18	1
Papua New Guinea	3	0
Peru	2	0
Philippines	15	1

Other APEC Economies	Publications	
	#	%
Russia	11	1
Singapore	84	6
Chinese Taipei	23	2
Thailand	15	1
United States	91	6
Viet Nam	10	1

Figure 14 shows that the number of documents being published by Bruneian authors is increasing each year. At the same time the number of papers being co-authored with researchers from other APEC economies is also increasing. Between 2011 and 2015, although only a modest number of documents have been published by Bruneian researchers, the number of publications co-authored by researchers from Brunei Darussalam and at least one other APEC economy has more than tripled.

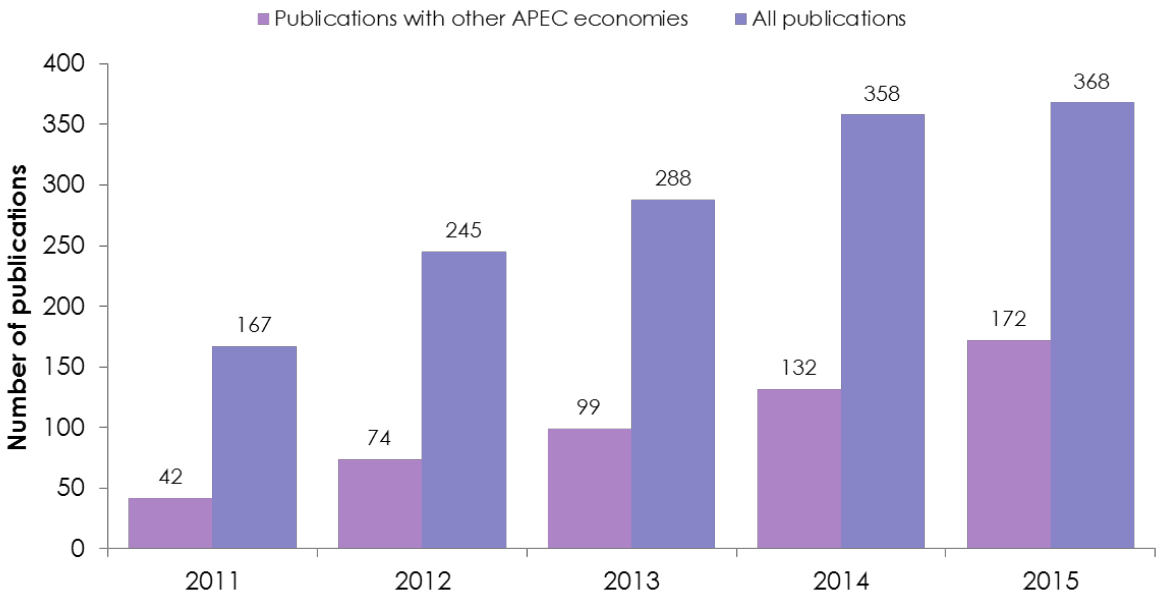

Figure 14: All Bruneian publications and Bruneian publications co-authored with another APEC economy

As shown in Figure 15, 64 per cent of all Bruneian publications did not include a co-author from another APEC economy. Around 28 per cent were co-authored with researchers from just one other APEC economy, and around nine per cent were co-authored with researchers from two or more other APEC economies.

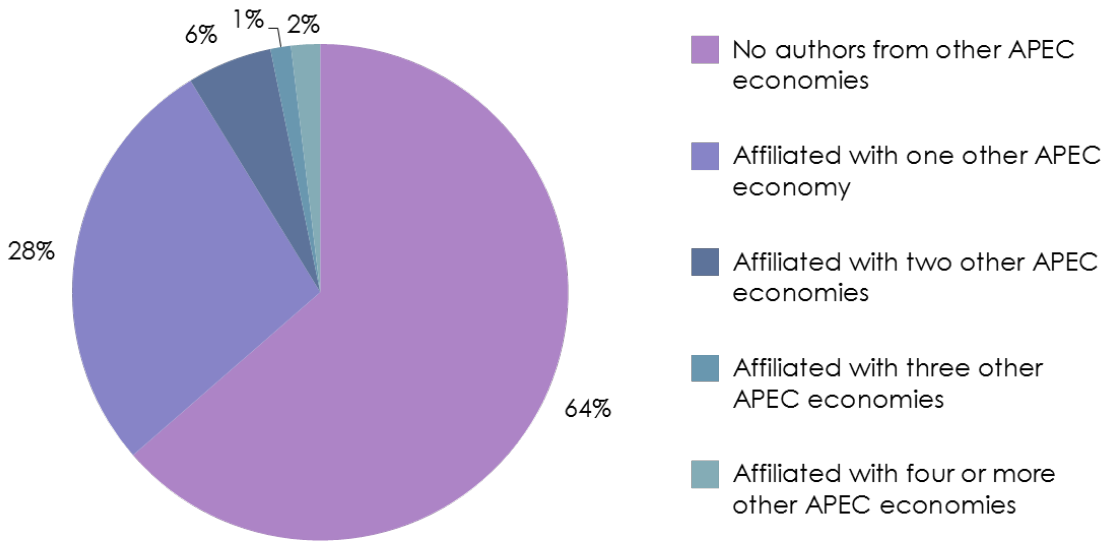

Figure 15: Proportion of all Bruneian publications co-authored with one or more other APEC economies (2011-2015)

The level of cross-border co-authorship with researchers from other APEC economies varies by subject area. Figure 16 shows the proportion of Bruneian publications that are affiliated with one or more APEC economies. Because of the relatively small number of publications by Bruneian researchers, although some of these subject areas appear to have very high levels of cross-border co-authorship, this should be interpreted with caution.

Of the 100 papers published by Bruneian researchers in the field of chemistry, 82 were co-authored with researchers from other APEC economies. 45 papers in the field of chemical engineering were co-authored with researchers from other APEC economies, representing 78 per cent of all research publications in this field.

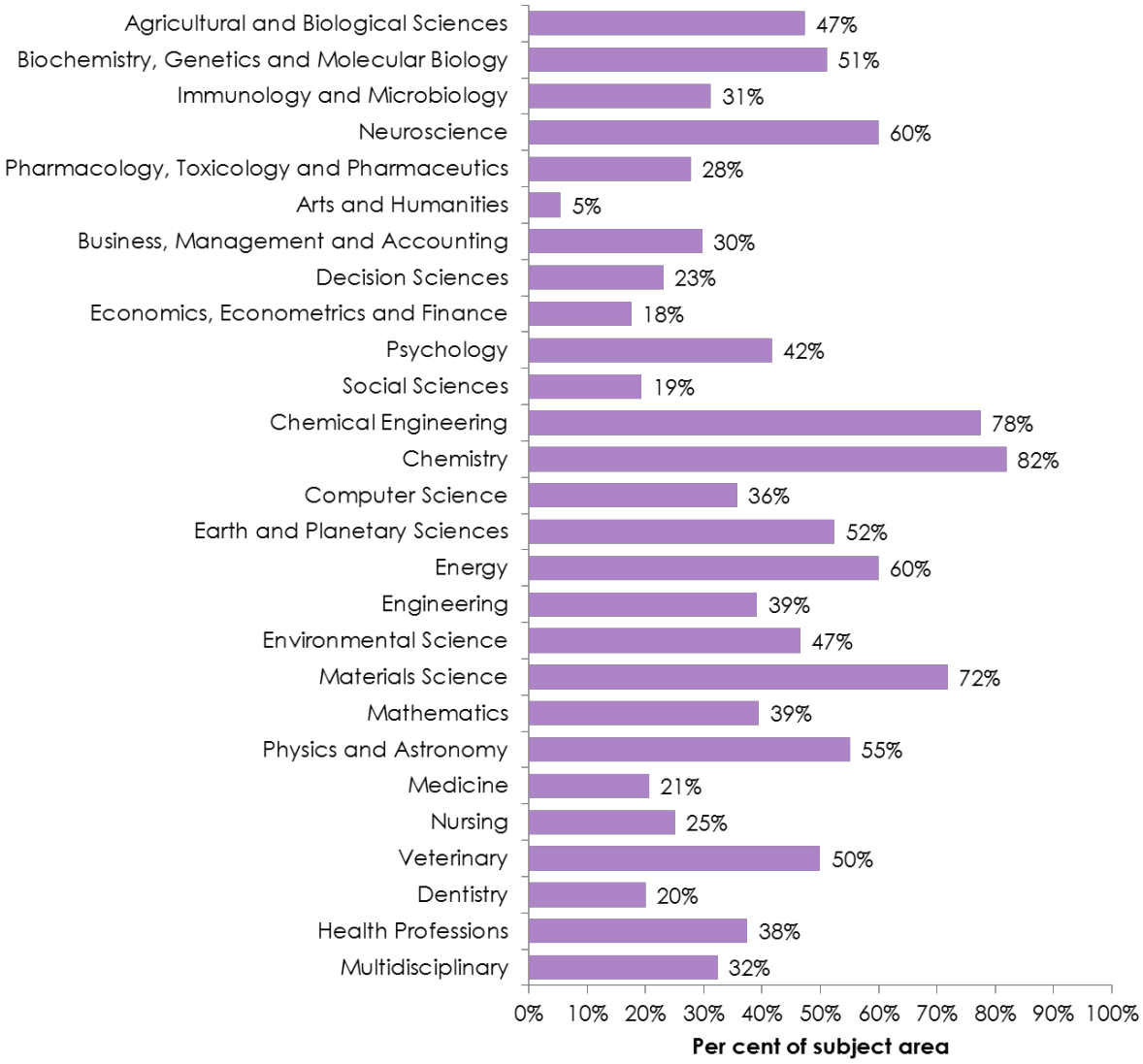

Figure 16: Proportion of documents co-authored with other APEC economies by narrow subject area (2011-2015)

Canada

Canadian researchers publish a very large amount of peer-reviewed research literature. Between 1960 and 2015, more than 1.7 million documents affiliated with Canada were published and included in Scopus's index. Figure 17 shows the number of documents published during this period and highlights the tremendous growth in publication in Canada, which mirrors that seen globally. This also shows that the proportion of all documents published by Canadian researchers has increased in recent decades. Between 2011 and 2015, more than 470 000 peer-reviewed documents were written by Canadian researchers. This represents 3.5 per cent of all documents published between 2011 and 2015.

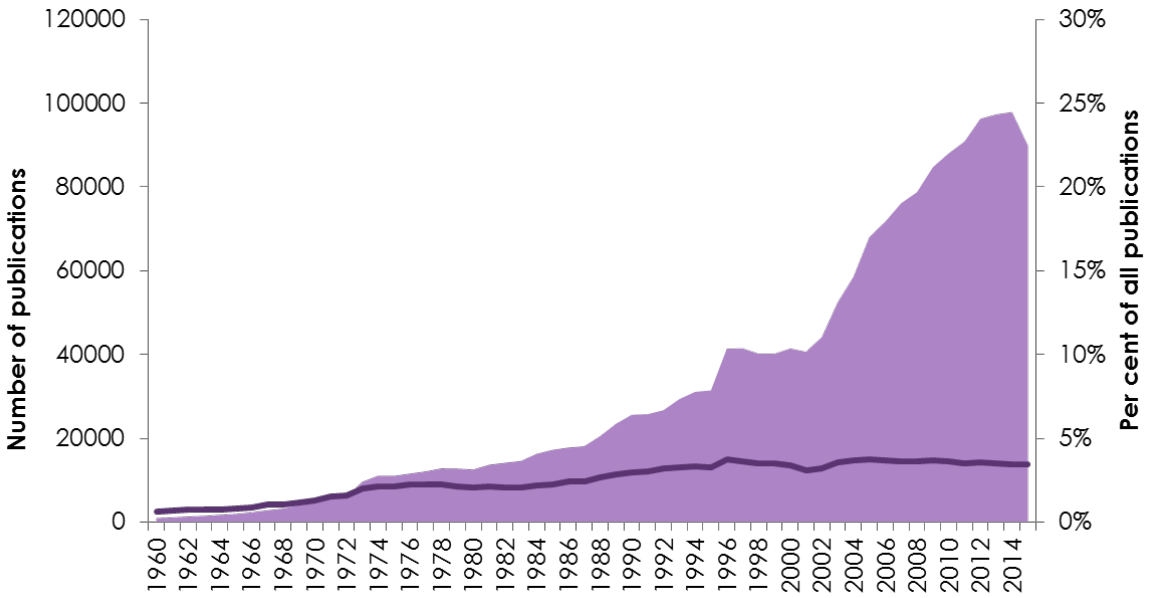

Figure 17: Number and proportion of publications affiliated with Canada

In 2014, around half of all peer-reviewed literature written by Canadian researchers had cross-border co-authors (SCImago, 2016c). As shown in Figure 18, between 2011 and 2015, the most frequent cross-border collaboration occurred with researchers from the United States. Close to 100 000 papers were co-authored by researchers from Canada and the United States in this time period.

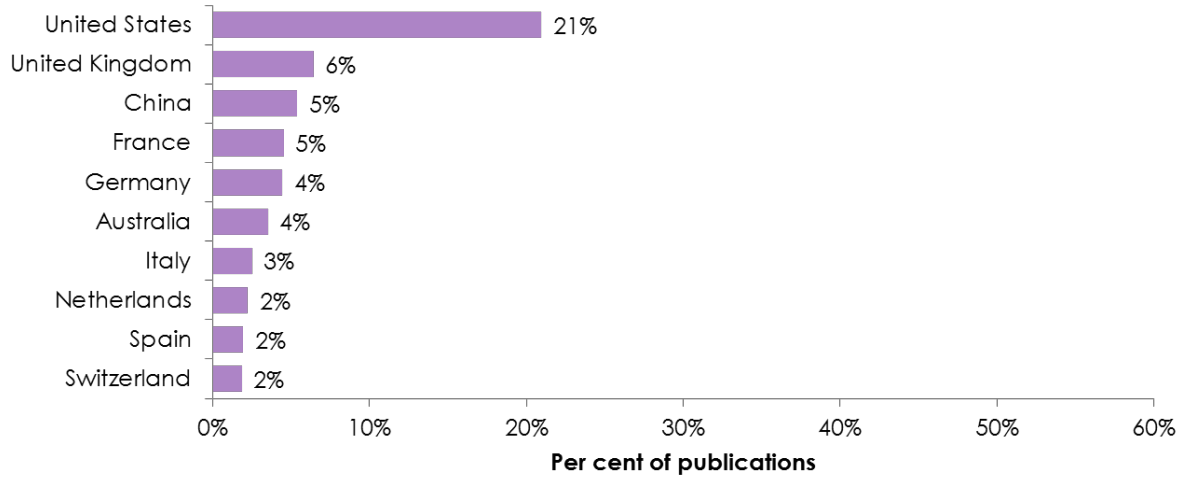

Figure 18: Most common cross-border co-authorship for Canadian publications (2011-2015)

Figure 19 clearly shows that there has been very strong growth recently in the number of publications co-authored by researchers from Canada and other APEC economies. Between 2011 and 2015, a total of 143 323 documents were co-authored by researchers from Canada and another APEC economy. Figure 19 also indicates the proportion of all Canadian publications that included a co-author from another APEC economy. This shows that recent years have also seen growth in the proportion of all Canadian publications that are co-authored with researchers affiliated with other APEC economies.

Between 2011 and 2015, 30 per cent of all documents published by Canadian researchers were co-authored with researchers from other APEC economies.

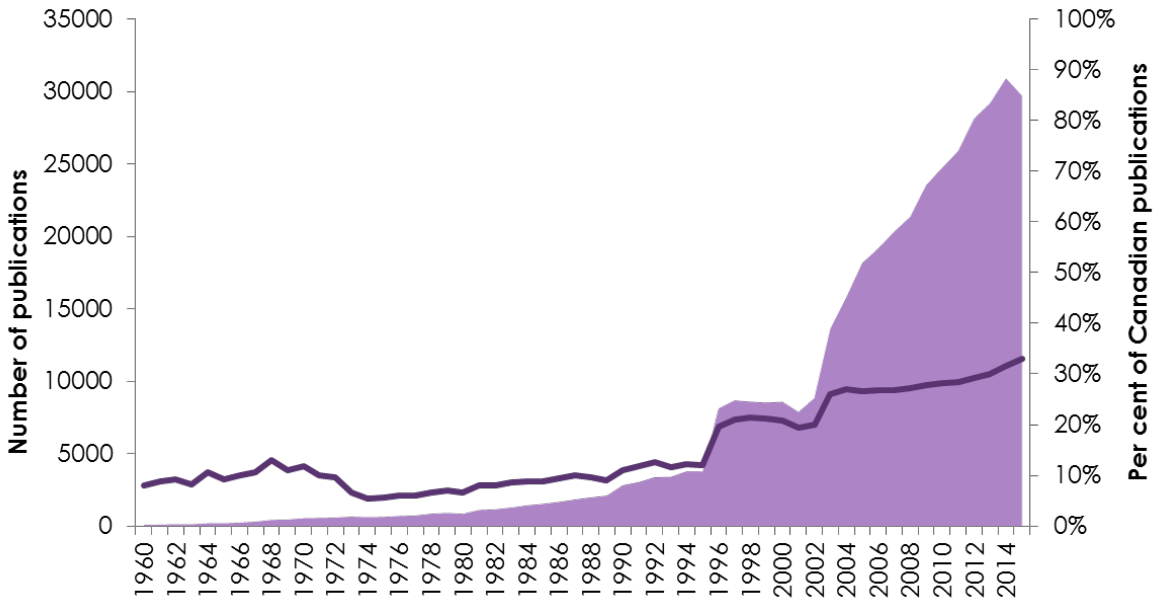

Figure 19: Number and proportion of Canadian publications co-authored with other APEC economies

Table 8 lists the number of publications that Canadian researchers have co-authored with researchers from other APEC economies between 2011 and 2015. It also shows the proportion of all Canadian documents that this number represents. This indicates that the most frequent cross-border co-authorship occurs with the United States; China; and Australia.

Table 8: Number and proportion of Canadian publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	16 582	4
Brunei Darussalam	31	0
Chile	2 555	1
China	25 345	5
Hong Kong, China	2 434	1
Indonesia	251	0
Japan	8 677	2
Korea	4 641	1
Malaysia	1 322	0
Mexico	2 740	1
New Zealand	3 155	1
Papua New Guinea	25	0
Peru	322	0
Philippines	232	0

Other APEC Economies	Publications	
	#	%
Russia	3 433	1
Singapore	2 350	0
Chinese Taipei	2 787	1
Thailand	1 027	0
United States	98 642	21
Viet Nam	340	0

As shown in Figure 20, the number of documents being published by Canadian researchers seems to be trending slightly upwards, with a small decrease in 2015. The same pattern is mirrored in the number of documents being co-authored by Canadian researchers and researchers from other APEC economies. Between 2011 and 2015, the number of publications co-authored by Canadian researchers and researchers from at least one other APEC economy has grown by 13 per cent.

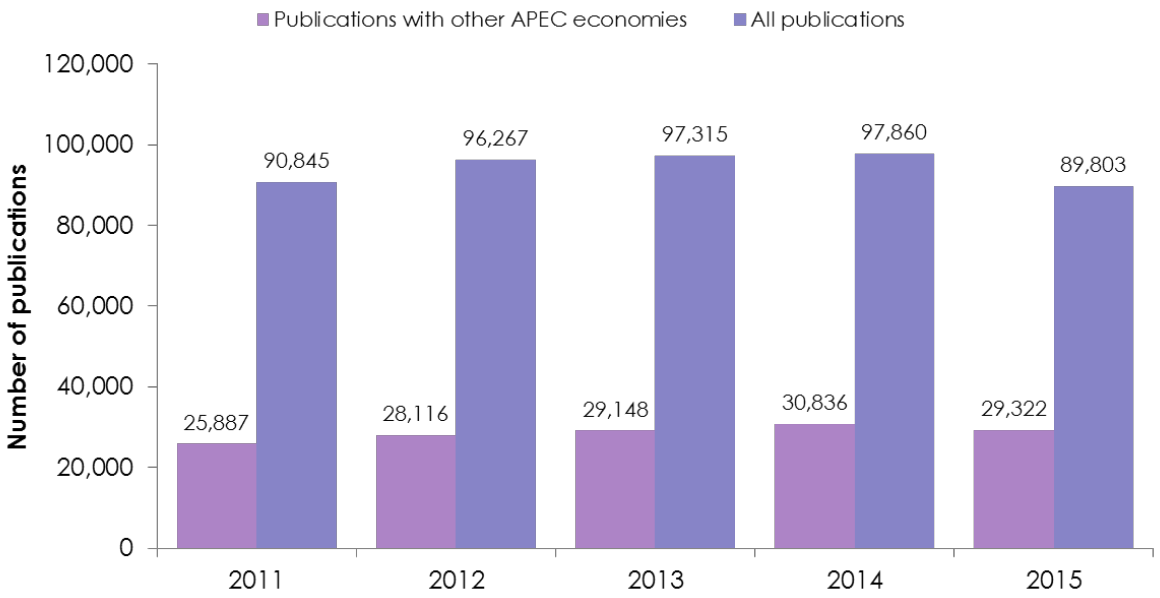

Figure 20: All Canadian publications and Canadian publications co-authored with another APEC economy

Figure 21 shows the proportion of all Canadian documents that were co-authored with researchers in one or more other APEC economy. This shows that 70 per cent of all publications written by Canadian researchers did not include any co-authors from APEC economies. Around a quarter were co-authored with researchers from just one other APEC economy, and around five per cent were affiliated with two or more other APEC economies.

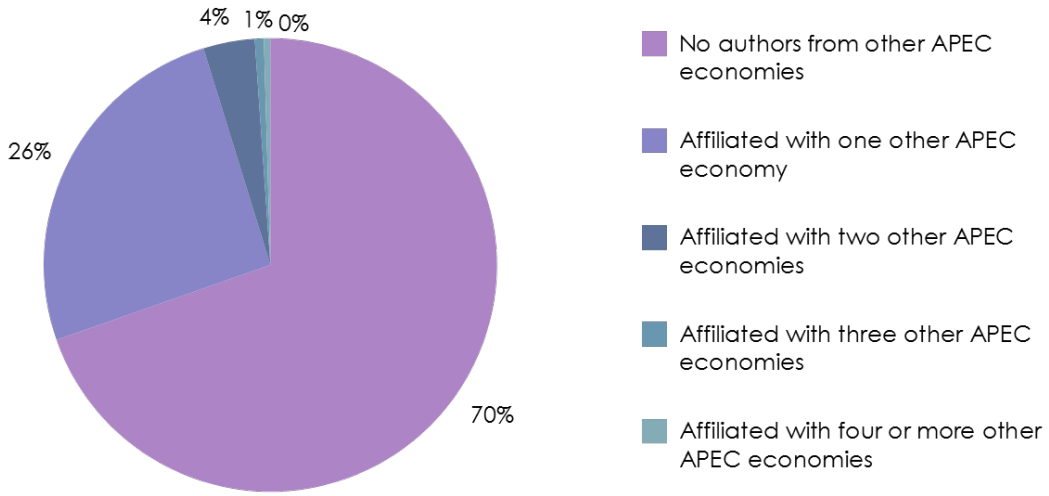

Figure 21: Proportion of all Canadian publications co-authored with one or more other APEC economies (2011-2015)

The level of cross-border co-authorship between researchers from Canada and other APEC economies varies by subject area. As shown in Figure 22, more than 40 per cent of peer-reviewed literature published by Canadian researchers in the multidisciplinary, and earth and planetary sciences subject areas were co-authored with researchers in at least one other APEC economy. The level of cross-border collaboration was lowest in the subject areas of arts and humanities and social sciences.

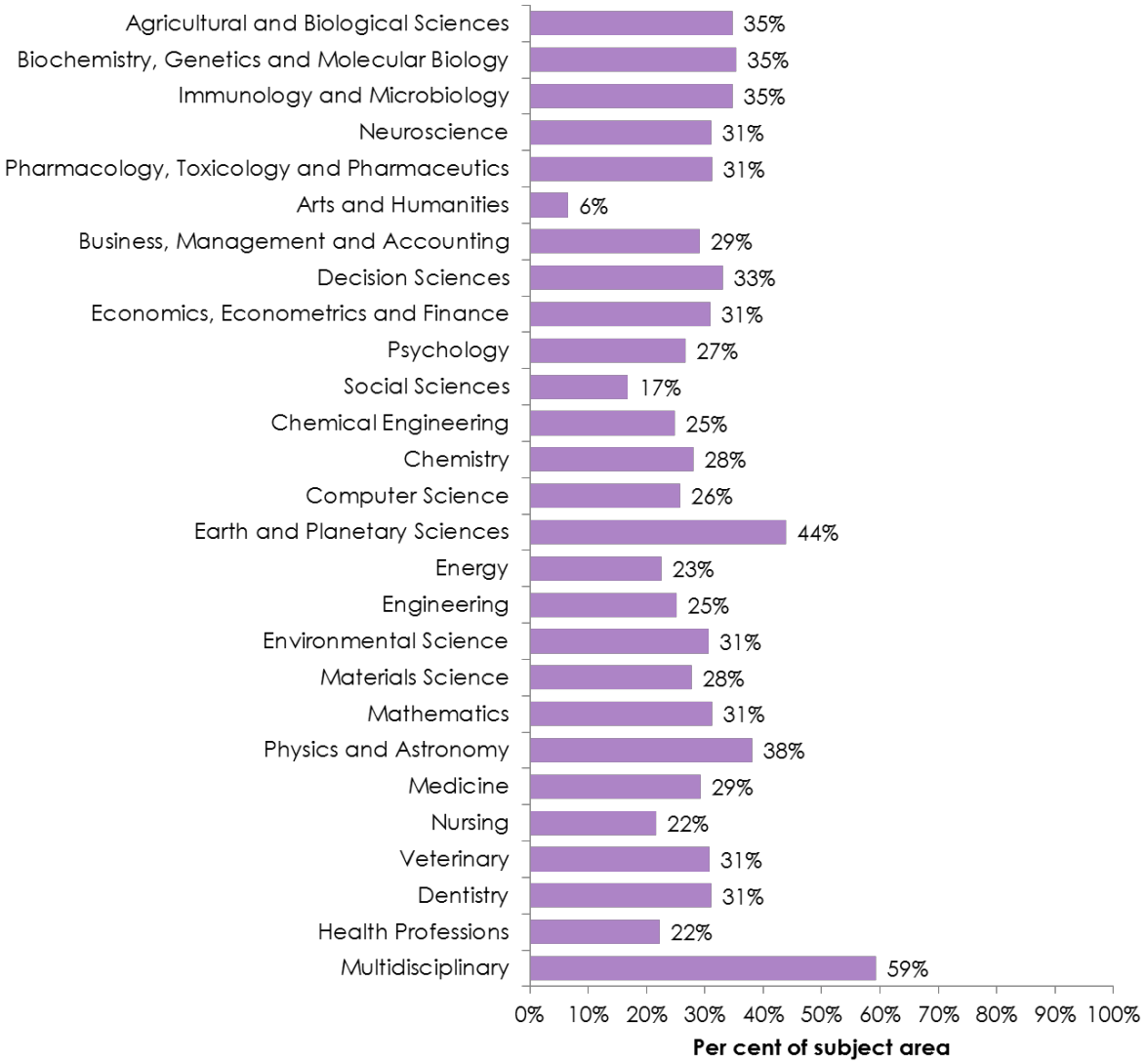

Figure 22: Proportion of Canadian publications co-authored with another APEC economy by subject area (2011-2015)

Chile

Between 1960 and 2015, more than 110 000 documents written by researchers affiliated with Chile were published and included in the Scopus index. Figure 23 shows the strong growth in the number of documents published by researchers from Chile. In the past two decades the number of documents published by Chilean researchers has increased tenfold. Figure 23 also shows the proportion of all documents that Chilean publications represent, which has increased slightly in recent years. Between 2011 and 2015, more than 45 000 documents indexed by Scopus were affiliated with Chile. This represents around 0.3 per cent of all research literature published during this period.

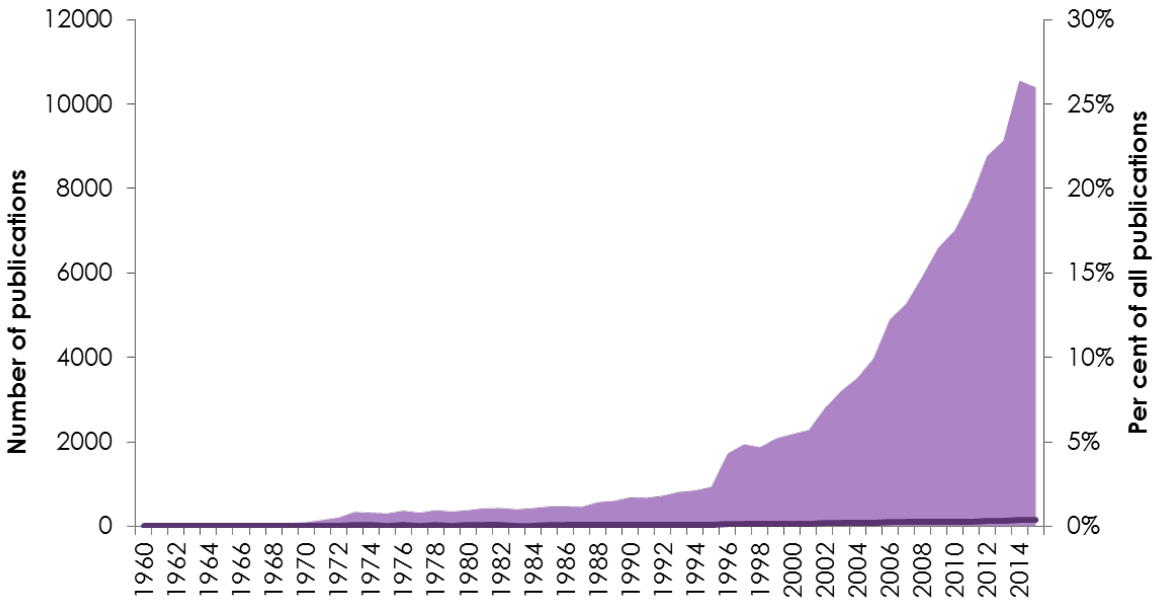

Figure 23: Number and proportion of publications affiliated with Chile

In 2014, 59 per cent of papers authored by Chilean researchers had cross-border co-authors (SCImago, 2016d). As shown in Figure 24, between 2011 and 2015, 20 per cent of all Chilean publications were co-authored with researchers affiliated with the United States, and 13 per cent were co-authored with researchers from Spain.

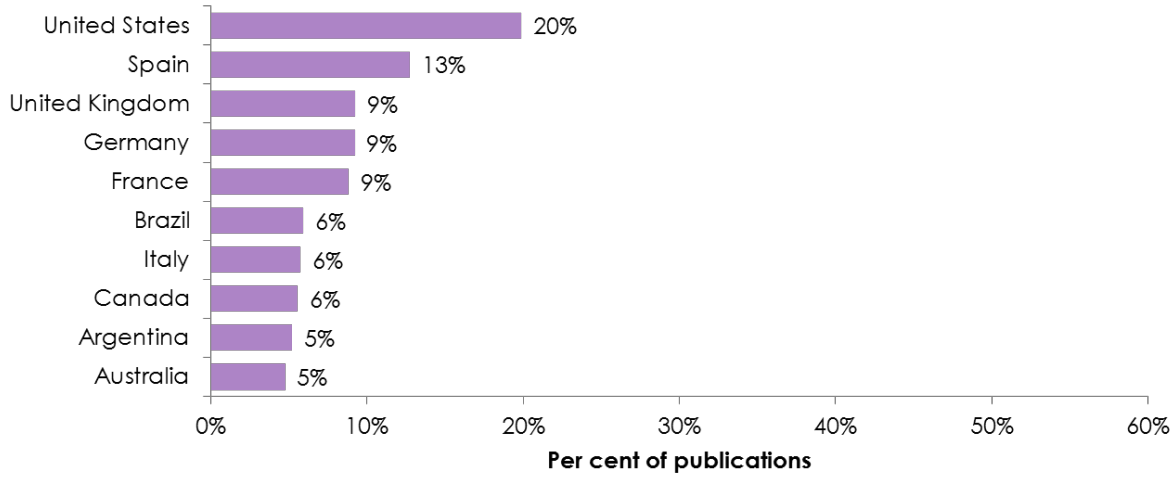

Figure 24: Most common cross-border co-authorship for Chilean publications (2011-2015)

In addition to growth in the total number of peer-reviewed research literature published by researchers from Chile, as shown in Figure 25, the number of publications co-authored with researchers from other APEC economies has also increased substantially in recent decades. Between 2011 and 2015, a total of 13 055 documents were co-authored by researchers from Chile and from other APEC economies. Figure 25 also shows that in addition to the growth in the total number of documents being co-authored by researchers from Chile and from other APEC economies, the proportion of all Chilean publications has

been growing steadily since the mid-1970s. Between 2011 and 2015, 28 per cent of all Chilean publications were co-authored with researchers from at least one other APEC economy.

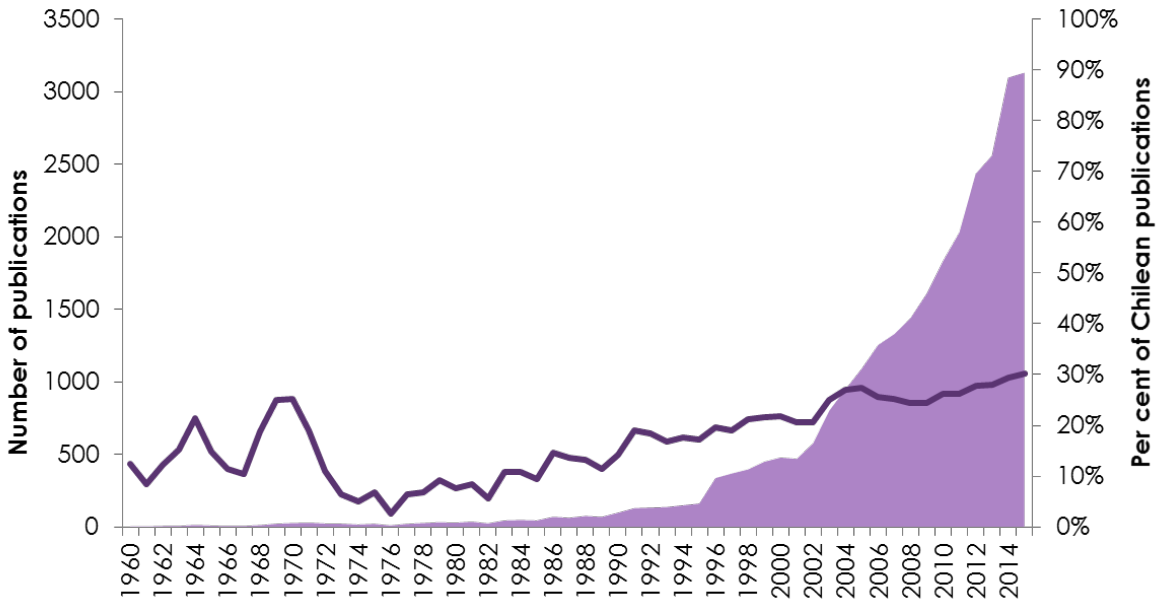

Figure 25: Number and proportion of Chilean publications co-authored with other APEC economies

Table 9 lists the number of publications that Chilean researchers have co-authored with researchers in each of the other APEC economies between 2011 and 2015. It also shows the proportion of all Chilean publication that each number represents. This indicates that the most common cross-border co-authorship for Chilean researchers occurs with the United States.

Table 9: Number and proportion of Chilean publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	2 203	5
Brunei Darussalam	3	0
Canada	2 555	5
China	1 114	2
Hong Kong, China	188	0
Indonesia	36	0
Japan	1 449	3
Korea	541	1
Malaysia	182	0
Mexico	1 463	3
New Zealand	497	1
Papua New Guinea	5	0
Peru	475	1
Philippines	45	0

Other APEC Economies	Publications	
	#	%
Russia	1 015	2
Singapore	104	0
Chinese Taipei	827	2
Thailand	79	0
United States	9 120	20
Viet Nam	39	0

Figure 26 shows the number of peer-reviewed research publications affiliated with Chile has been steadily increasing in recent years. This also shows that the number of publications co-authored with researchers from other APEC economies has also been increasing. Between 2011 and 2015, the number of publications co-authored with researchers from other APEC economies has increased by 50 per cent.

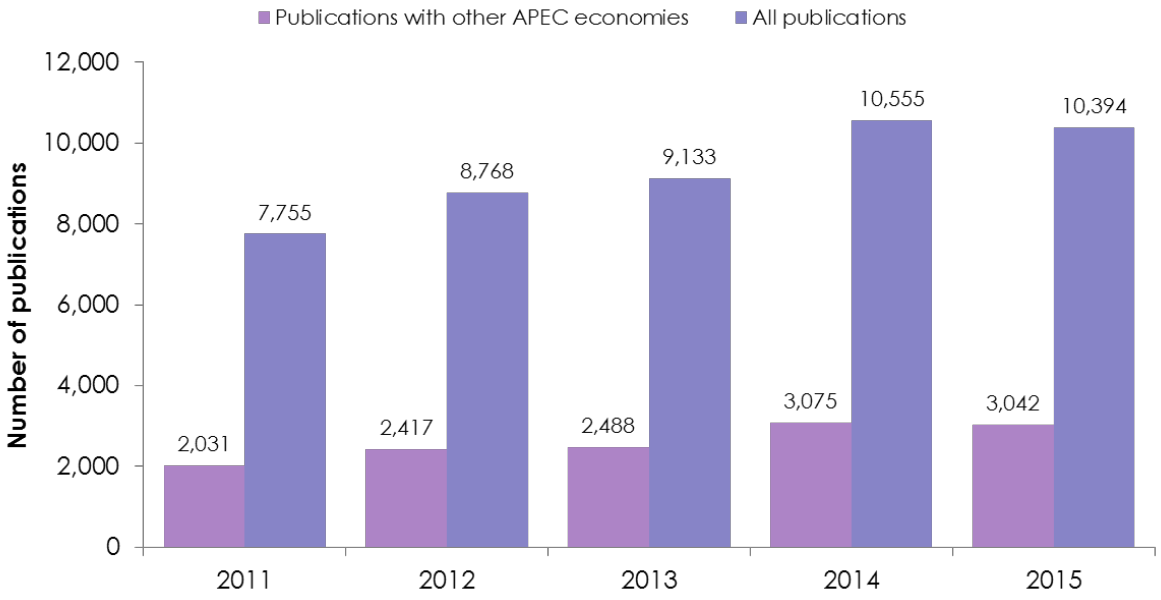

Figure 26: All Chilean publications and Chilean publications co-authored with another APEC economy

As shown in Figure 27, 72 per cent of publications by Chilean researchers did not have any co-authors from APEC economies. Around 20 per cent of all Chilean publications were co-authored with researchers from just one other APEC economy, and around eight per cent with researchers from two or more APEC economies.

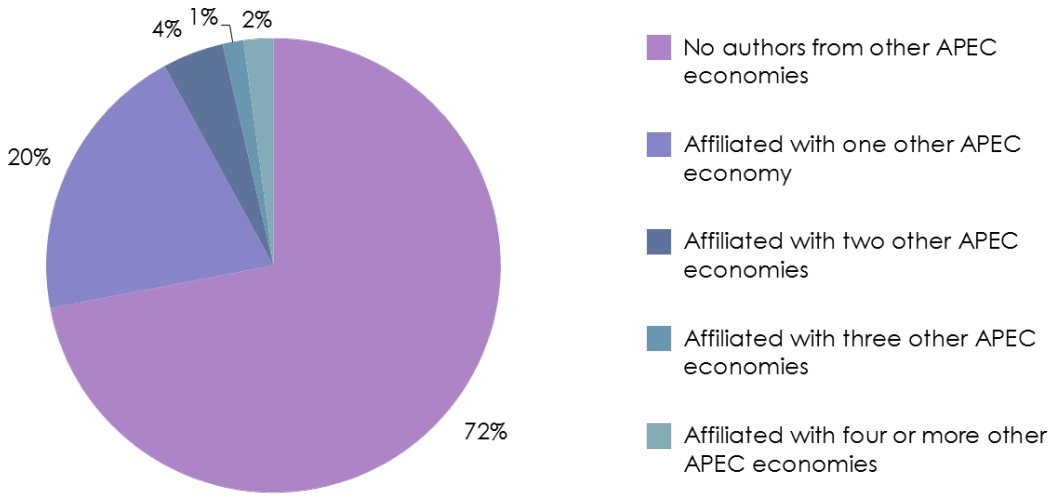

Figure 27: Proportion of all Chilean publications co-authored with one or more other APEC economies (2011-2015)

Cross-border co-authorship varies by subject area. As shown in Figure 28, more than half of all publications by Chilean researchers in the earth and planetary sciences, physics and astronomy, and multidisciplinary fields had a cross-border co-author from another APEC economy. Only four per cent of publications in the arts and humanities field were co-authored with researchers from another APEC economy.

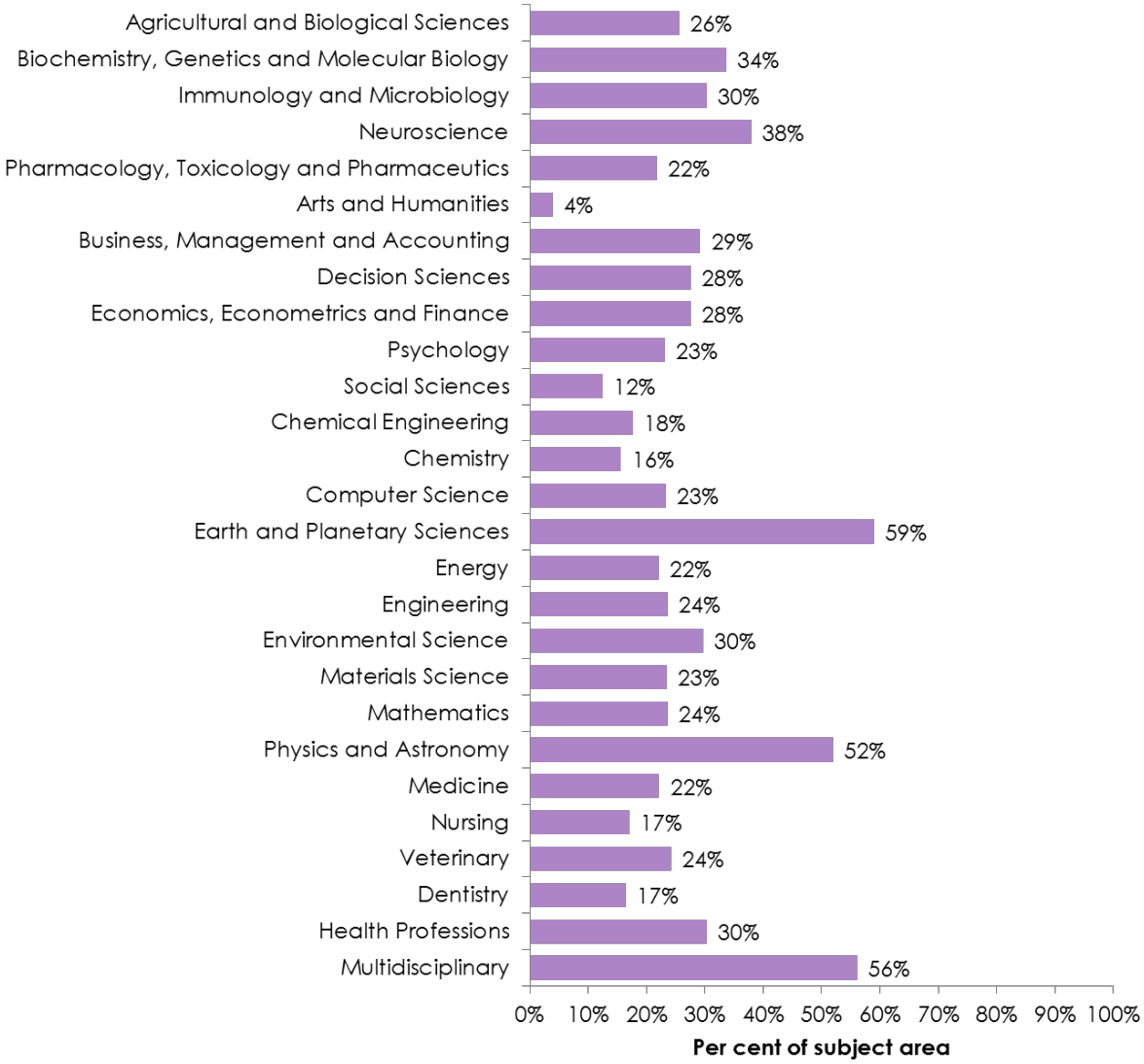

Figure 28: Proportion of Chilean publications co-authored with other APEC economy by subject area (2011-2015)

China

Up until the 1980s, fewer than 1 000 peer-reviewed research publications were published annually by researchers from China. Since then the amount of peer-reviewed research literature published by Chinese researchers has grown immensely, as shown in Figure 29. Even though very little was published before 1980, between 1960 and 2015, close to 4.2 million documents affiliated with researchers from China were published and included in the Scopus index. Figure 29 also shows that the proportion of documents published by researchers affiliated with China has also increased dramatically in recent decades. China is now the second largest producer of research documents after the United States. Between 2011 and 2015, more than 2.1 million documents were affiliated with China. This represents around 16 per cent of all documents published globally.

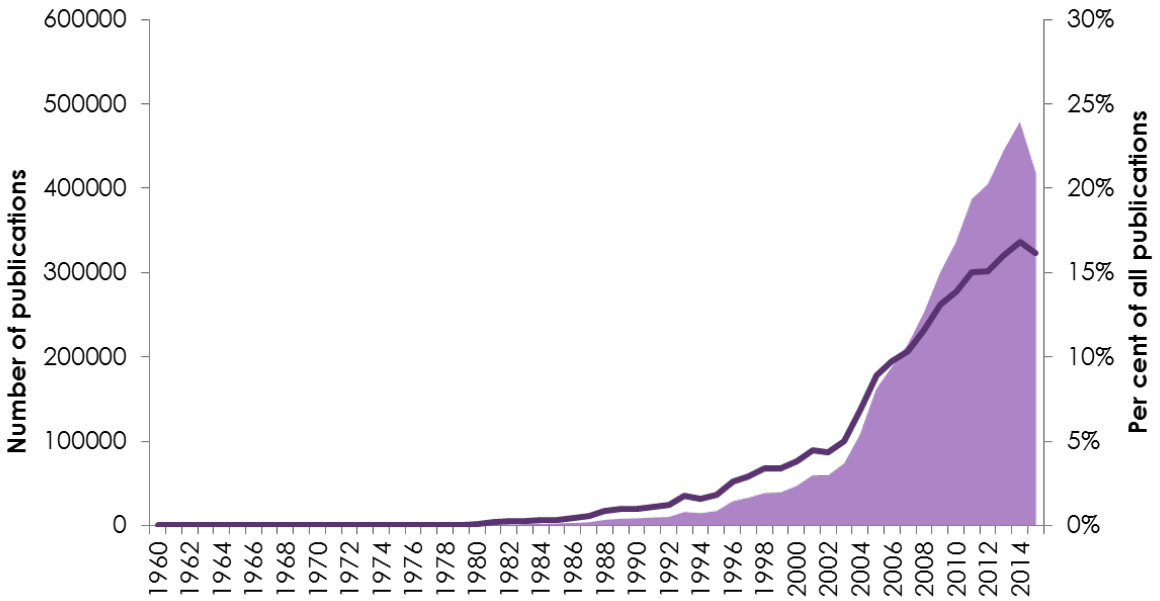

Figure 29: Number and proportion of publications affiliated with China

In 2014, 18 per cent of papers by Chinese researchers had cross-border co-authors (SCImago, 2016e). As shown in Figure 30, between 2011 and 2015, the most frequent cross-border collaboration for Chinese researchers was with researchers from the United States. Seven per cent of all publications affiliated with China were co-authored with American researchers.

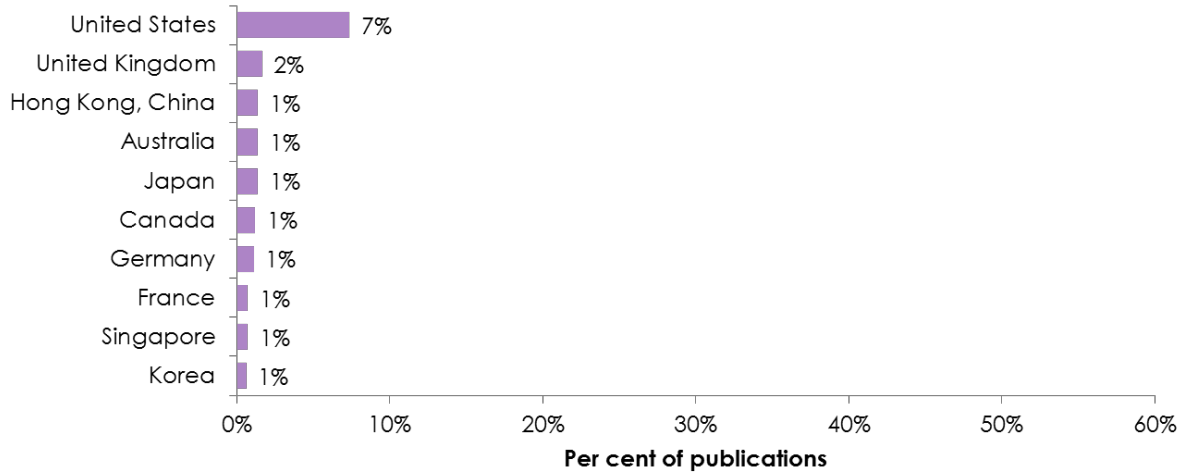

Figure 30: Most common cross-border co-authorship for Chinese publications (2011-2015)

Echoing the tremendous growth in the number of publications by Chinese researchers is the equally huge growth in publications co-authored by researchers from China and other APEC economies (Figure 31). Although there has been huge growth in the number of publications involving collaboration between researchers from China and other APEC economies, there has been little growth in the proportion of all Chinese documents that this represents. Between 2011 and 2015, a total of 2 134 251

documents were co-authored by researchers from China and from other APEC economies representing 13 per cent of all Chinese publications.

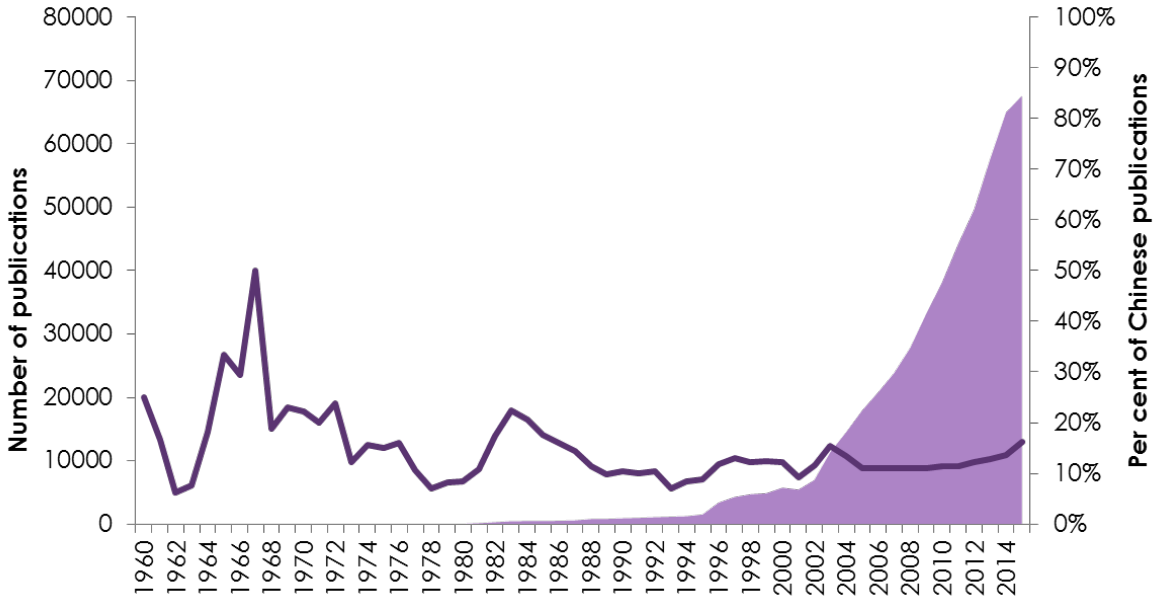

Figure 31: Number and proportion of Chinese publications co-authored with other APEC economies

Table 10 lists the number of publications that researchers from China have co-authored with researchers from each APEC economy between 2011 and 2015. This shows that the most frequent cross-border co-authorship occurs with researchers from the United States.

Table 10: Number and proportion of Chinese publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	29 600	1
Brunei Darussalam	79	0
Canada	25 345	1
Chile	1 114	0
Hong Kong, China	30 787	1
Indonesia	464	0
Japan	29 574	1
Korea	13 271	1
Malaysia	2 086	0
Mexico	1 836	0
New Zealand	2 877	0
Papua New Guinea	21	0
Peru	276	0
Philippines	551	0

Other APEC Economies	Publications	
	#	%
Russia	5 260	0
Singapore	15 256	1
Chinese Taipei	11 245	1
Thailand	2 472	0
United States	156 826	7
Viet Nam	1 125	0

Figure 32 shows that the overall number of documents being published by Chinese authors is increasing annually, although there was a small decrease in 2015. This increase is also seen among the publications co-authored with researchers from other APEC economies. Between 2011 and 2015, the number of publications co-authored with researchers from other APEC economies has increased by 51 per cent.

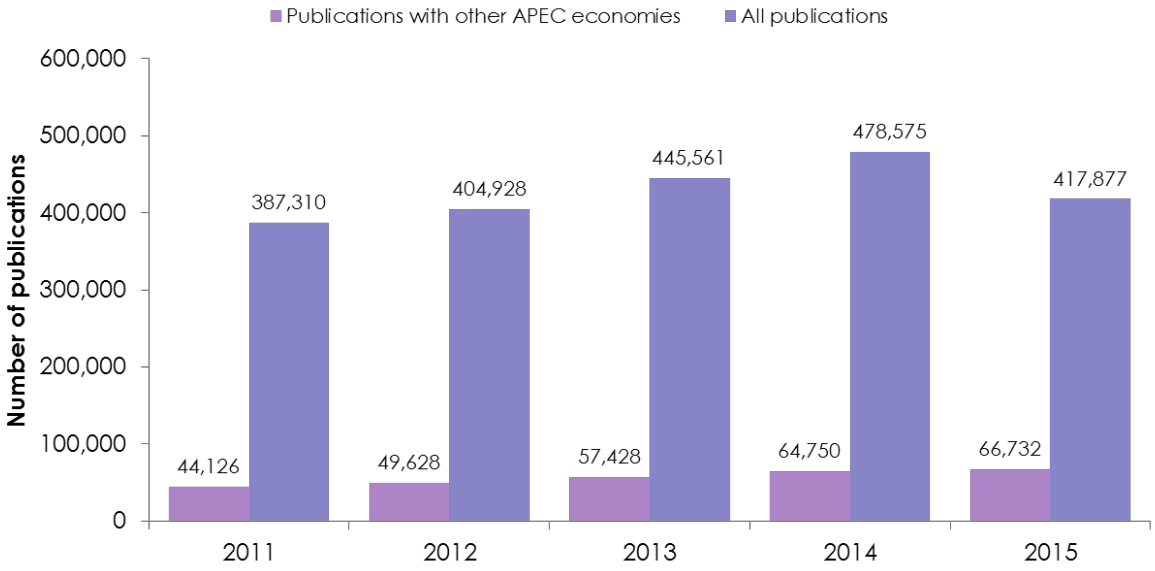

Figure 32: All Chinese publications and Chinese publications co-authored with another APEC economy

As shown in Figure 33, the vast majority of publications by Chinese researchers did not include co-authors from other APEC economies. Around 12 per cent of all publications with a Chinese author included a co-author from one other APEC economy, and around one per cent included co-authors from two or more other APEC economies.

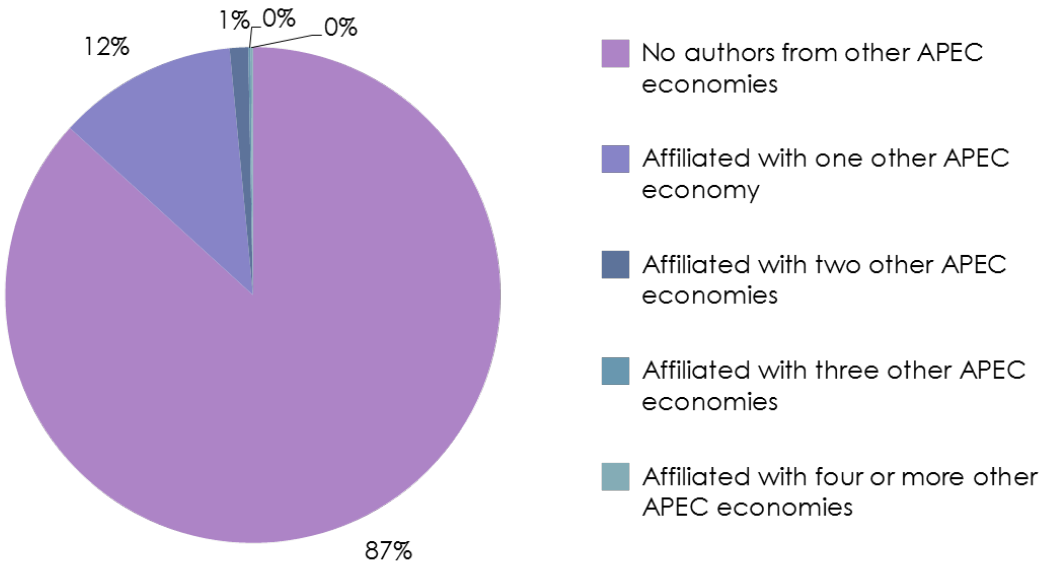

Figure 33: Proportion of all Chinese publications co-authored with one or more other APEC economies (2011-2015)

The level of cross-border co-authorship with researchers from other APEC economies varies greatly by subject area, as shown in Figure 34. The subject area of psychology had the largest proportion of papers co-authored with researchers from other APEC economies. However, psychology is one of the smallest subject areas in terms of total number of documents published by researchers from China. Interestingly, although engineering is the subject area in which the greatest number of documents affiliated with China have been published, and is also the subject area in which the greatest number of documents have been co-authored with researchers from other APEC economies, only eight per cent of all Chinese publications in the field of engineering was co-authored with researchers from other APEC economies.

Figure 34: Proportion of Chinese publications co-authored with another APEC economy by subject area (2011-2015)

Hong Kong, China

As shown in Figure 35, the number of documents being published by researchers from Hong Kong, China has increased substantially in recent decades. Between 1960 and 2015, more than 230 000 documents affiliated with Hong Kong, China were published and indexed by Scopus. The proportion of documents published by Hong Kong, China researchers has also risen in recent decades. Between 2011 and 2015, close to 77 000 documents were affiliated with Hong Kong, China representing around 0.6 per cent of all documents published during this period.

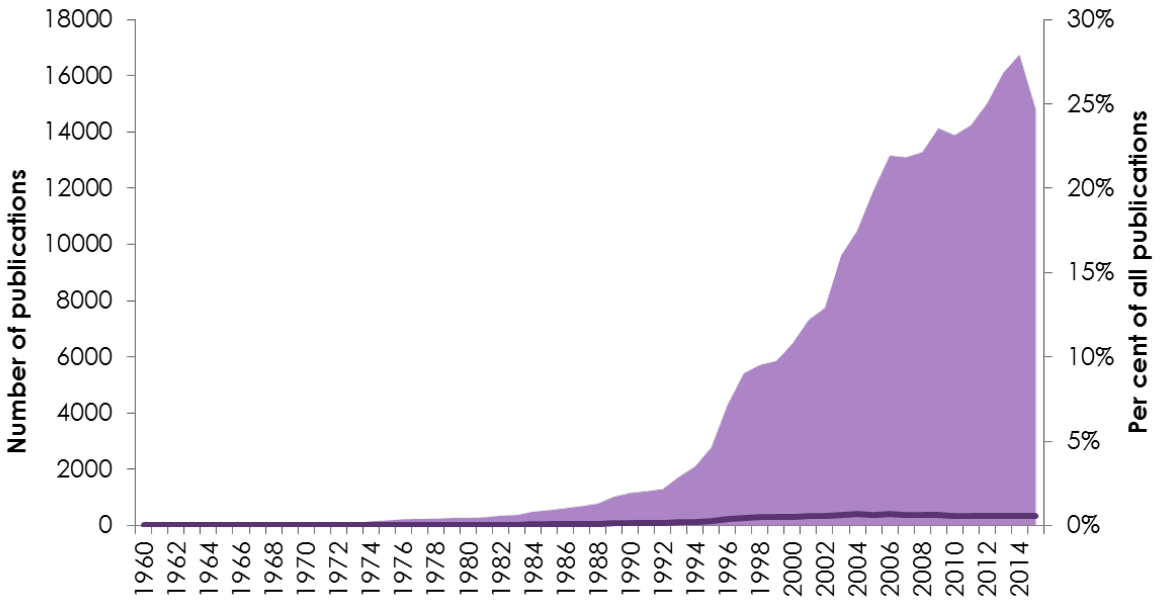

Figure 35: Number and proportion of publications affiliated with Hong Kong, China

According to analyses by SCImago (2016f), in 2014, two thirds of publications written by researchers from Hong Kong, China had cross-border co-authors. As shown in Figure 36, between 2011 and 2015, 39 per cent of all publications by Hong Kong researchers were co-authored with researchers from China and 15 per cent with researchers from the United States.

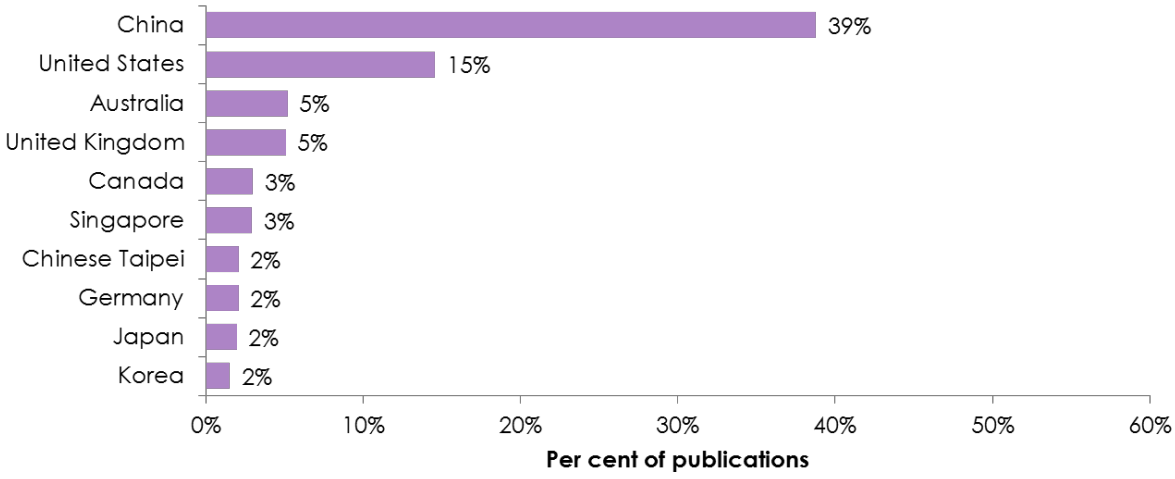

Figure 36: Most common cross-border co-authorship for Hong Kong Chinese publications (2011-2015)

As shown in Figure 37, recent years have also seen a huge level of growth in the number of publications co-authored by researchers from Hong Kong, China and other APEC economies. Between 2011 and 2015, a total of 44 326 papers were co-authored by researchers form Hong Kong, China and researchers from other APEC economies. In addition to the growth in the number of documents co-authored with researchers from other APEC economies, there has been strong growth in the proportion of publications that were co-authored with other APEC economies.

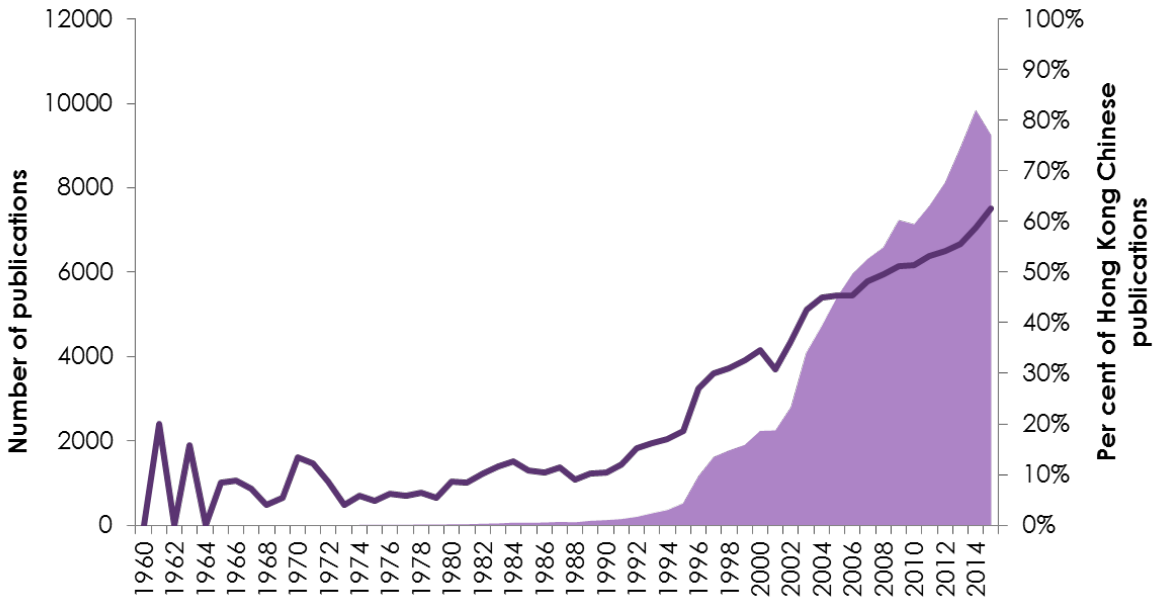

Figure 37: Number and proportion of Hong Kong publications co-authored with other APEC economies

Table 11 lists the number of publications that Hong Kong researchers have co-authored with researchers from each other APEC economy between 2011 and 2015 along with the proportion of all Hong Kong publications that this represents. This shows that the most frequent cross-border co-authorship occurred with researchers from China.

Table 11: Number and proportion of Hong Kong Chinese publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	4 238	6
Brunei Darussalam	19	0
Canada	2 434	3
Chile	188	0
China	30 787	40
Indonesia	135	0
Japan	1 608	2
Korea	1 230	2
Malaysia	587	1
Mexico	151	0
New Zealand	467	1
Papua New Guinea	9	0
Peru	39	0
Philippines	192	0
Russia	365	0
Singapore	2 352	3
Chinese Taipei	1 669	2

Thailand	391	1
United States	11 678	15
Viet Nam	120	0

Figure 38 shows that the number of documents published by researchers from Hong Kong, China has been increasing year-on-year., with the exception of 2015. At the same time, the number of publications co-authored with researchers from other APEC economies has also been increasing. Between 2011 and 2015, the number of publications co-authored by researchers from Hong Kong, China and other APEC economies has increased by around 18 per cent.

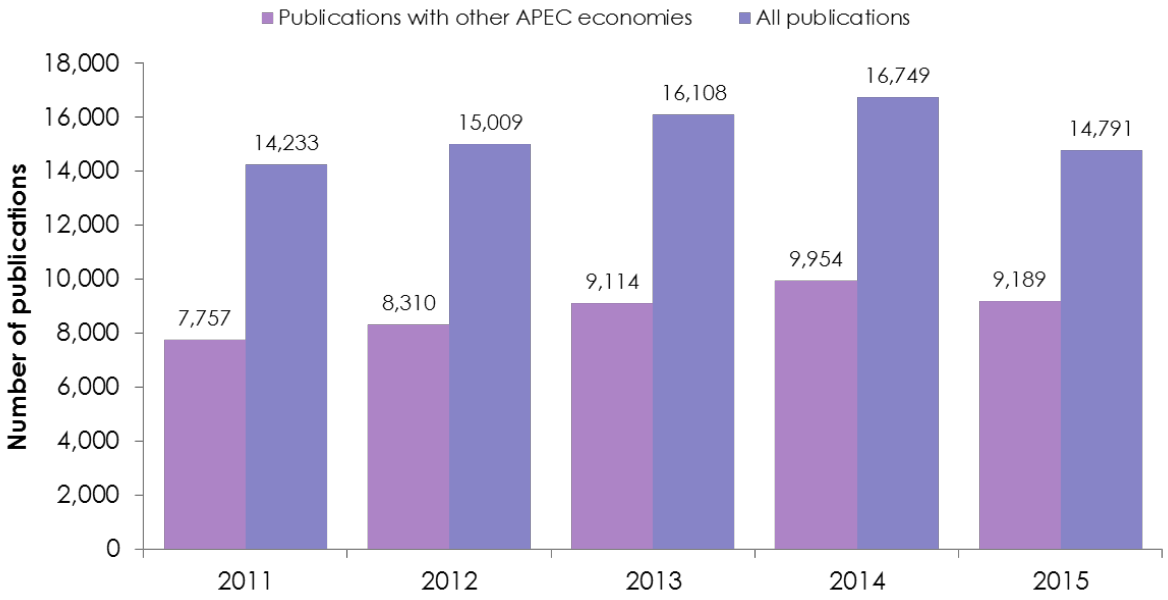

Figure 38: All Hong Kong Chinese publications and Hong Kong Chinese publications co-authored with another APEC economy

Only 42 per cent of research publications affiliated with Hong Kong, China did not include a co-author from another APEC economy. 45 per cent of all Hong Kong, China publications were co-authored with researchers from one other APEC economy, and around 12 per cent were co-authored with researchers from two or more other APEC economies.

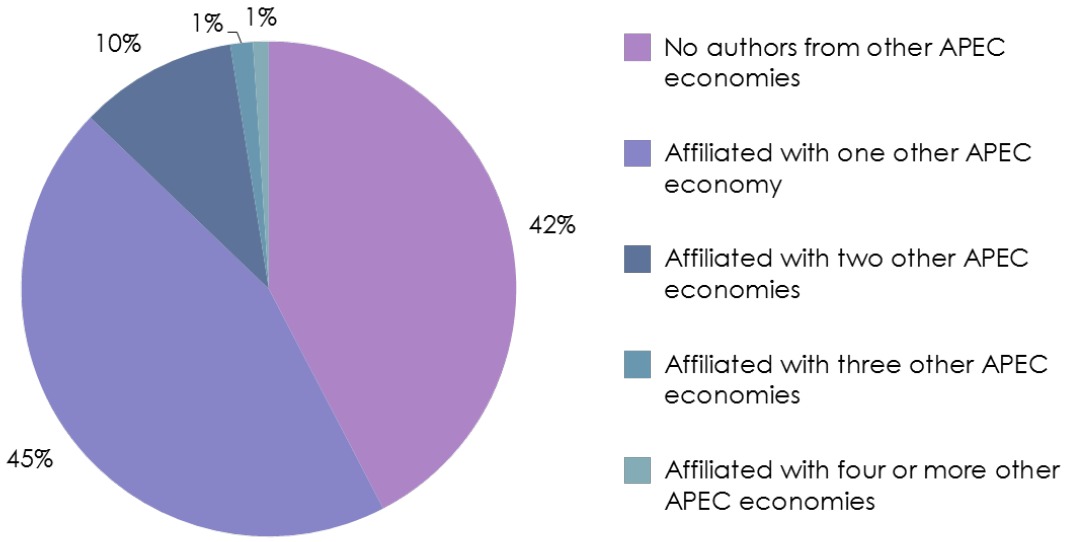

Figure 39: Proportion of all Hong Kong Chinese publications co-authored with one or more other APEC economies (2011-2015)

The level of cross-border co-authorship by researchers from Hong Kong, China is relatively high in most subject areas. Seventy per cent or more of the publications in the fields of mathematics, earth and planetary sciences, decision sciences and multidisciplinary fields were co-authored with researchers from other APEC economies. The lowest level of cross-border co-authorship with researchers from other APEC economies occurred in the subject area of arts and humanities.

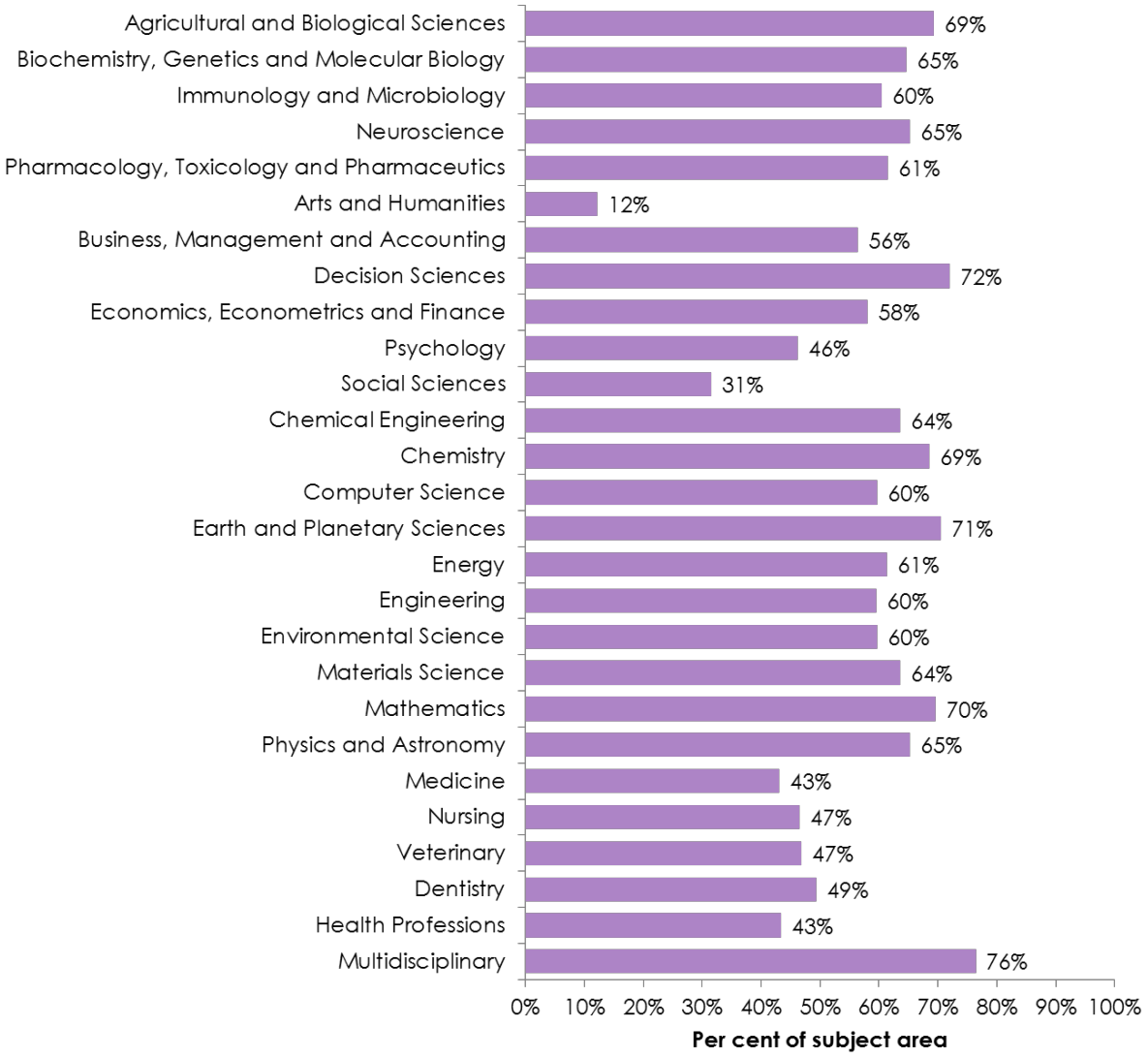

Figure 40: Proportion of Hong Kong Chinese publications co-authored with another APEC economy by subject area (2011-2015)

Indonesia

Between 1960 and 2015, around 40 000 pieces of peer-reviewed research literature affiliated with an Indonesian researcher were published and indexed by Scopus. As shown in Figure 41, the past decade has seen a rapid increase in the number of publications affiliated with researchers from Indonesia with the number of documents published each year quadrupling. Recent years have also seen an increase in the proportion of all documents that have been authored or co-authored by Indonesian researchers. Between 2011 and 2015, almost 25 000 documents were published by researchers from Indonesia, representing around 0.2 per cent of all documents published during this period.

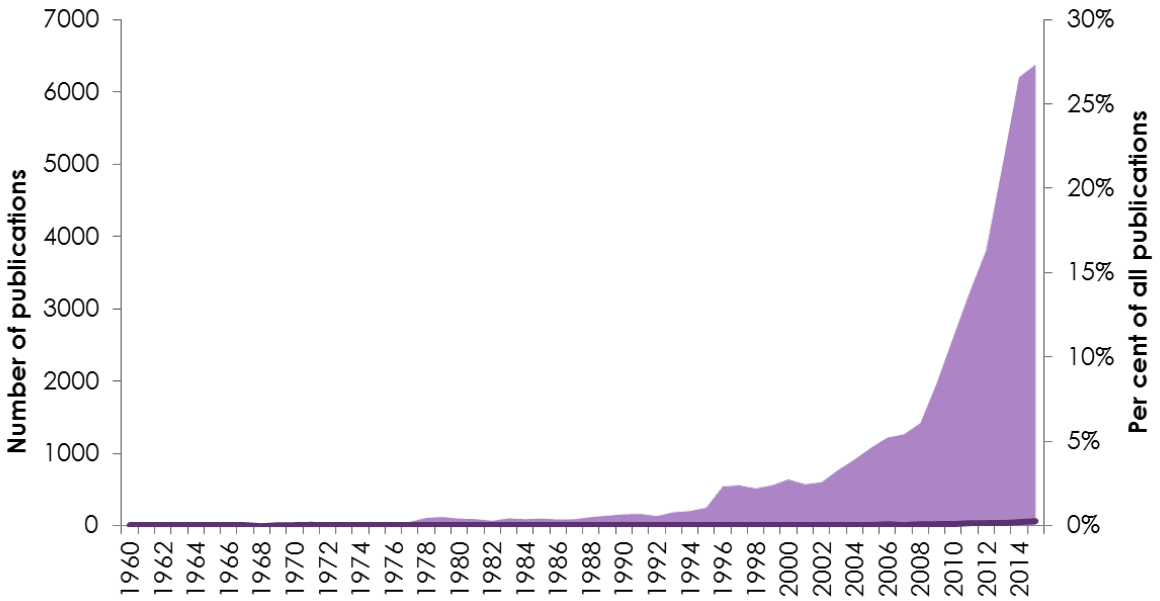

Figure 41: Number and proportion of publications affiliated with Indonesia

In 2014, 44 per cent of all research literature published by Indonesian researchers had cross-border co-authors (SCImago, 2016g). Figure 42 shows that between 2011 and 2015, 11 per cent of all Indonesian publications were co-authored with researchers from Japan and ten per cent were co-authored with researchers from Malaysia.

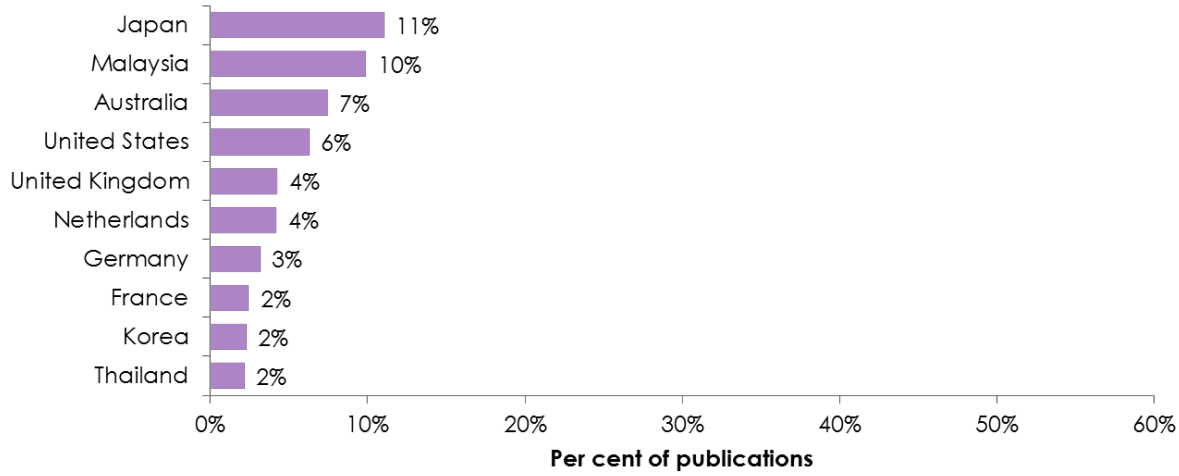

Figure 42: Most common cross-border co-authorship for Indonesian publications (2011-2015)

Mirroring the recent growth in the overall level of publication by Indonesian researchers is the growth in cross-border co-authorship with researchers from other APEC economies, as shown in Figure 43. During this period, 8 910 documents were co-authored by researchers from Indonesia and researchers from other APEC economies. Figure 43 shows that although there has been growth in the overall number of co-authored publications in recent years, the proportion of all Indonesian documents co-authored with researchers from other APEC economies has decreased in the past decade. However, a

significant proportion of publications authored by Indonesian researchers continue to have cross-border co-authors. Between 2011 and 2015, 36 per cent of all documents published by Indonesian researchers had a co-author from another APEC economy.

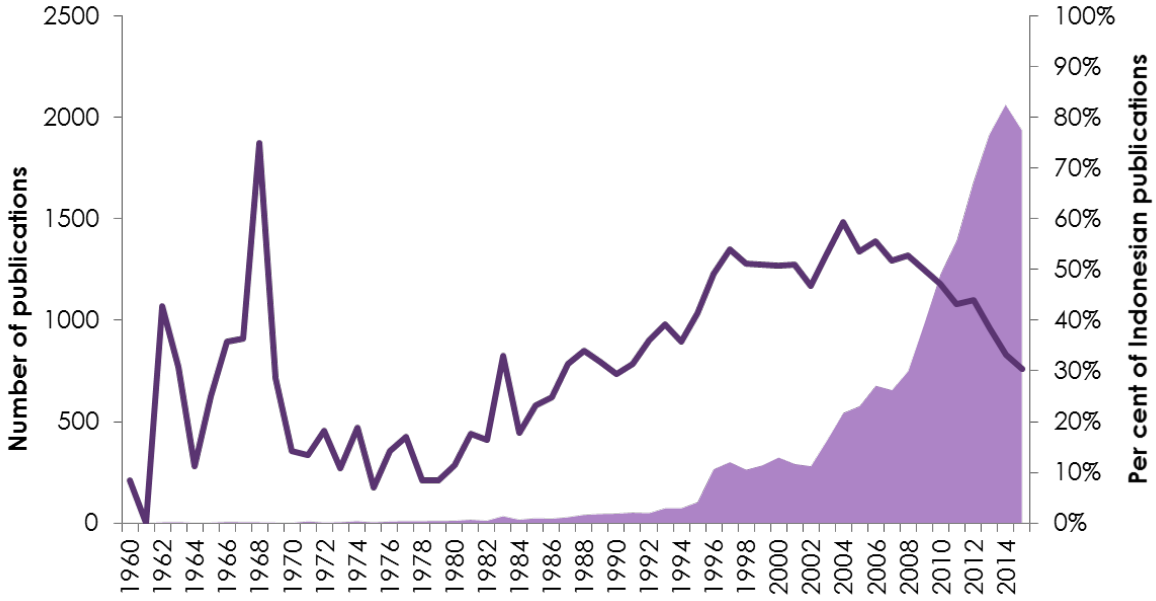

Figure 43: Number and proportion of Indonesian publications co-authored with other APEC economies

Table 12 shows the number of publications that Indonesian researchers have co-authored with researchers affiliated with each of the other APEC economies between 2011 and 2015. This also shows the proportion of all Indonesian documents that each cross-border collaboration represents. The most frequent cross-border co-authorship occurs with Japan and Malaysia.

Table 12: Number and proportion of Indonesian publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	1 824	7
Brunei Darussalam	21	0
Canada	251	1
Chile	36	0
China	464	2
Hong Kong, China	135	1
Japan	2 703	11
Korea	557	2
Malaysia	2 423	10
Mexico	80	0
New Zealand	189	1
Papua New Guinea	33	0
Peru	50	0

Other APEC Economies	Publications	
	#	%
Philippines	302	1
Russia	66	0
Singapore	445	2
Chinese Taipei	504	2
Thailand	524	2
United States	1 560	6
Viet Nam	243	1

As shown in Figure 44, the number of papers written by Indonesian researchers has been increasing rapidly in recent years. The number of papers co-authored with researchers from other APEC economies also appears to be increasing, but not at quite the same rate. Between 2011 and 2015, the number of publications co-authored with researchers from other APEC economies increased by 36 per cent. At the same time, the overall number of papers affiliated with Indonesian researchers almost doubled.

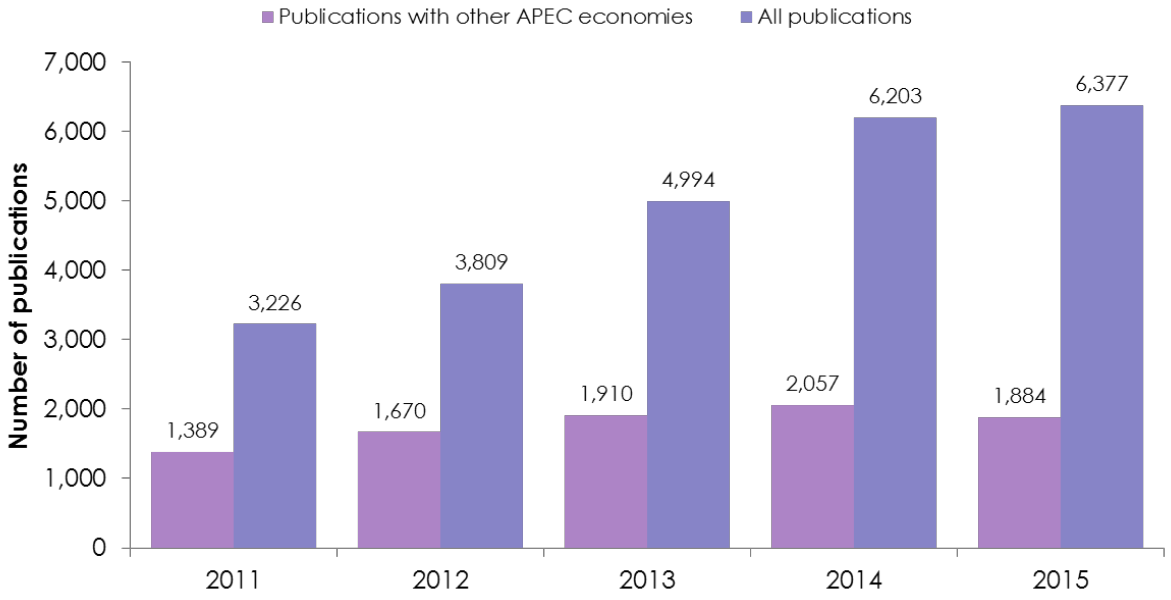

Figure 44: All Indonesian publications and Indonesian publications co-authored with another APEC economy

Figure 45 shows that around 64 per cent of all Indonesian documents published between 2011 and 2015 did not have a co-author from another APEC economy. Around 29 per cent had co-authors from one other APEC economy and around seven per cent had co-authors from two or more other APEC economies.

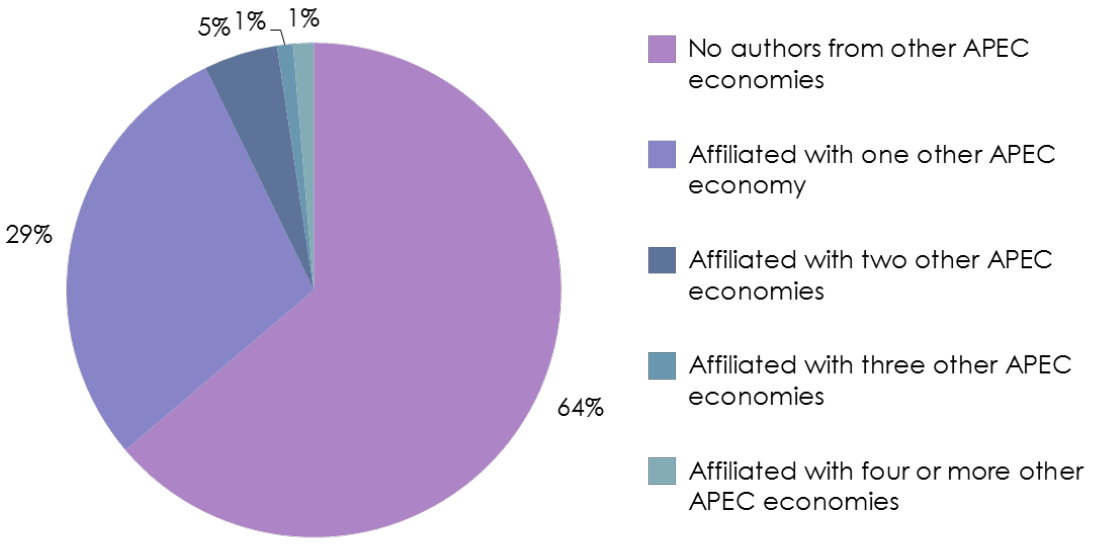

Figure 45: Proportion of all Indonesian publications co-authored with one or more other APEC economies (2011-2015)

As with other economies, the level of cross-border co-authorship with researchers from other APEC economies varies by subject area. More than half of all publications were co-authored with researchers from other APEC economies in a number of different subject areas, including immunology and microbiology; chemical engineering; biochemistry, genetics and molecular biology; earth and planetary sciences; chemistry; and materials science. More than half of all publications in psychology and neuroscience also had a co-author from another APEC economy. However, only a relatively small overall number of papers were published in these fields.

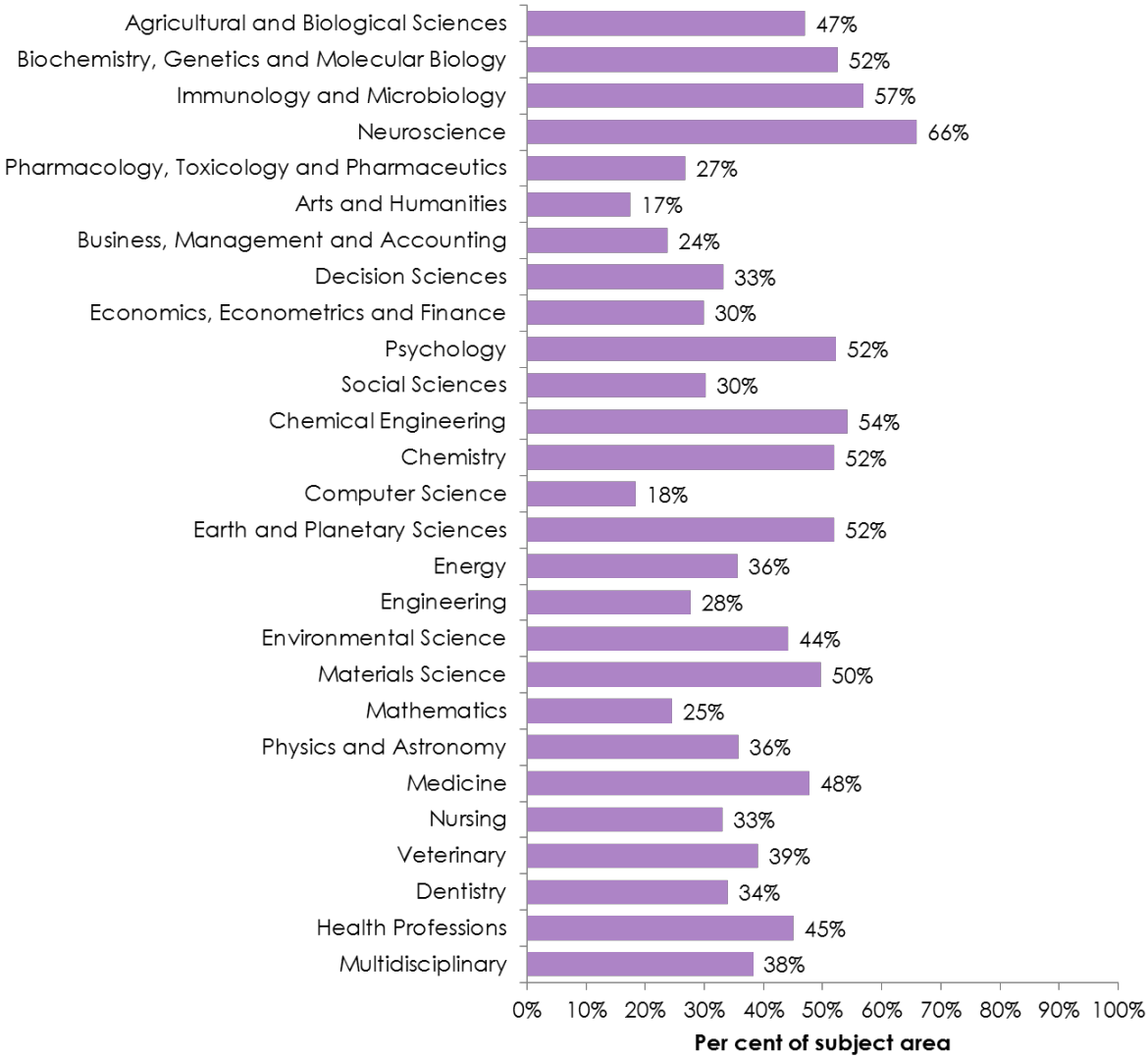

Figure 46: Proportion of Indonesian publications co-authored with another APEC economy by subject area (2011-2015)

Japan

As shown in Figure 47, between 1960 and 2015, the number of peer-reviewed research documents affiliated with researchers from Japan has grown continuously. During this time period, more than three million documents affiliated with Japan were published and indexed by Scopus. The proportion of all publications that Japanese publications represent peaked at around eight per cent at the turn of the century and has since halved. Between 2011 and 2015, over 600 000 documents were affiliated with Japan, representing close to five per cent of all research publications.

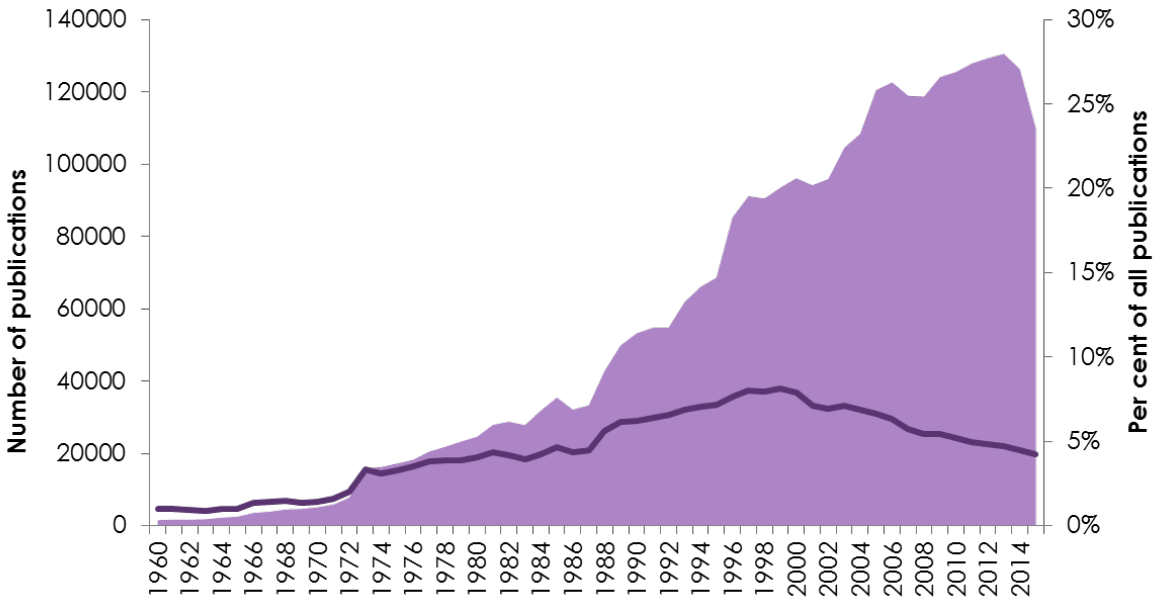

Figure 47: Number and proportion of publications affiliated with Japan

According to analyses conducted by SCImago (2016h), in 2014, around a quarter of all papers published by Japanese researchers had cross-border co-authors. Figure 48 lists the ten most common economies for cross-border co-authorship with Japanese researchers. This shows that eight per cent of all Japanese publications had a co-author from the United States, and five per cent had a co-author from China.

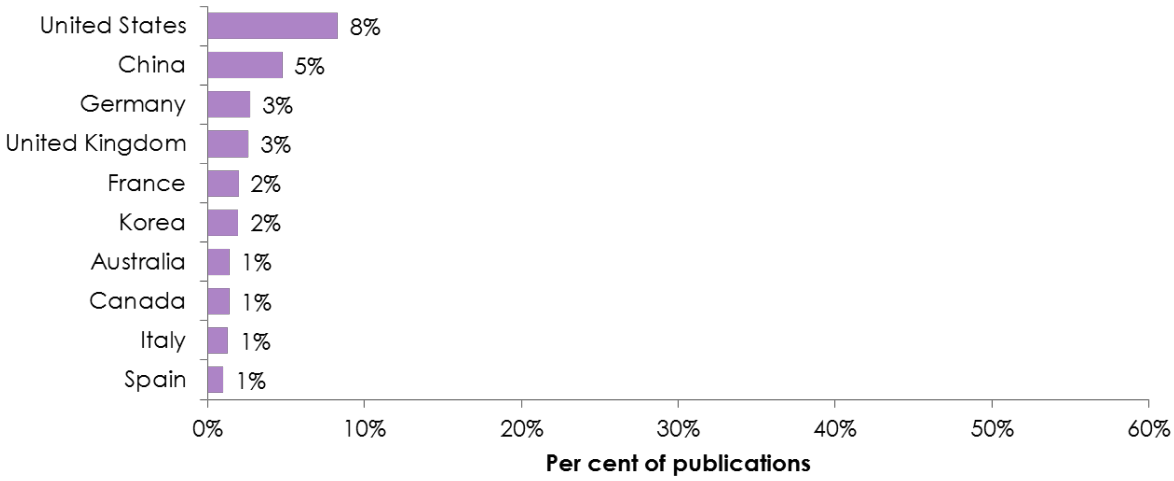

Figure 48: Most common cross-border co-authorship for Japanese publications (2011-2015)

As well as the overall growth in the amount of peer-reviewed research literature being published by Japanese researchers, as seen in Figure 49, recent decades have also seen a rapid increase in the number of documents co-authored by Japanese researchers and researchers from other APEC economies. Figure 49 shows that since the mid-1970s there has also been an increase in the proportion of all Japanese publications that have been co-authored with researchers from other APEC economies. Between 2011

and 2015, a total of 623 636 papers affiliated with Japan were co-authored with researchers from other APEC economies, representing 18 per cent of all Japanese publications.

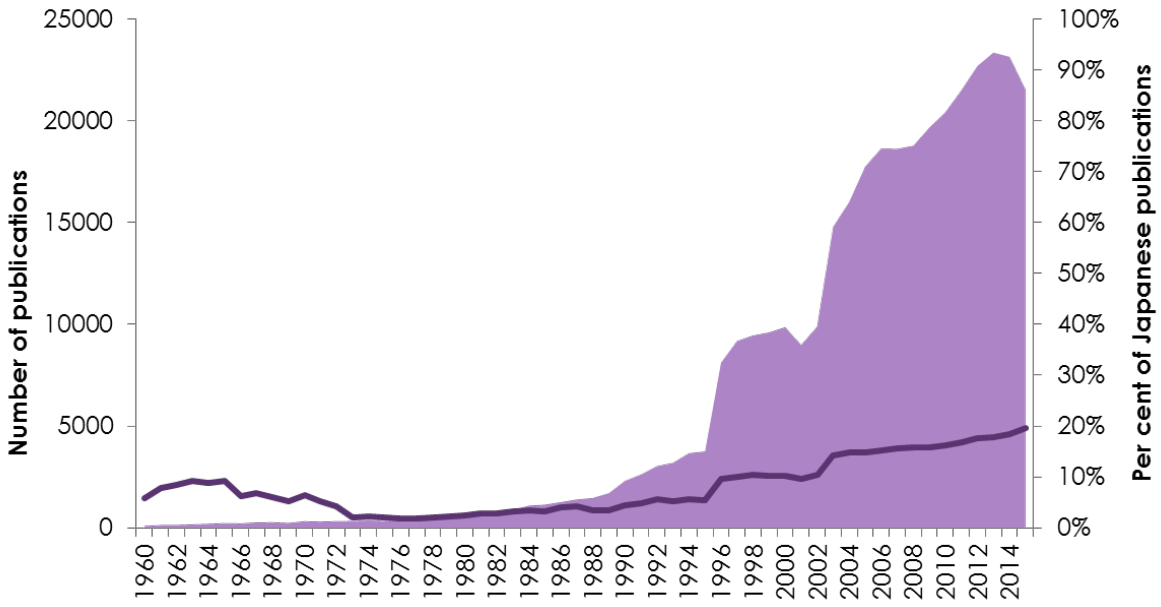

Figure 49: Number and proportion of Japanese publications co-authored with other APEC economies

The level of cross-border co-authorship varies by economy. Table 13 shows the number of publications that Japanese researchers have co-authored with each of the other APEC economies and the proportion of all Japanese publications that this represents. This indicates that between 2011 and 2015 more than 50 000 documents were co-authored with researchers in the United States, and close to 30 000 were co-authored with researchers in China.

Table 13: Number and proportion of Japanese publications with co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	8 669	1
Brunei Darussalam	37	0
Canada	8 677	1
Chile	1 449	0
China	29 574	5
Hong Kong, China	1 608	0
Indonesia	2 703	0
Korea	12 210	2
Malaysia	3 493	1
Mexico	1 367	0
New Zealand	1 407	0
Papua New Guinea	36	0
Peru	308	0

Other APEC Economies	Publications	
	#	%
Philippines	1 072	0
Russia	4 872	1
Singapore	2 842	0
Chinese Taipei	5 993	1
Thailand	4 555	1
United States	51 853	8
Viet Nam	1 899	0

As shown in Figure 50, the number of documents published annually by Japanese researchers appears to have relatively little movement, although there appear to be fewer documents published in 2015 than in previous years. There also appears to be little change in the number of documents being co-authored with researchers from other APEC economies.

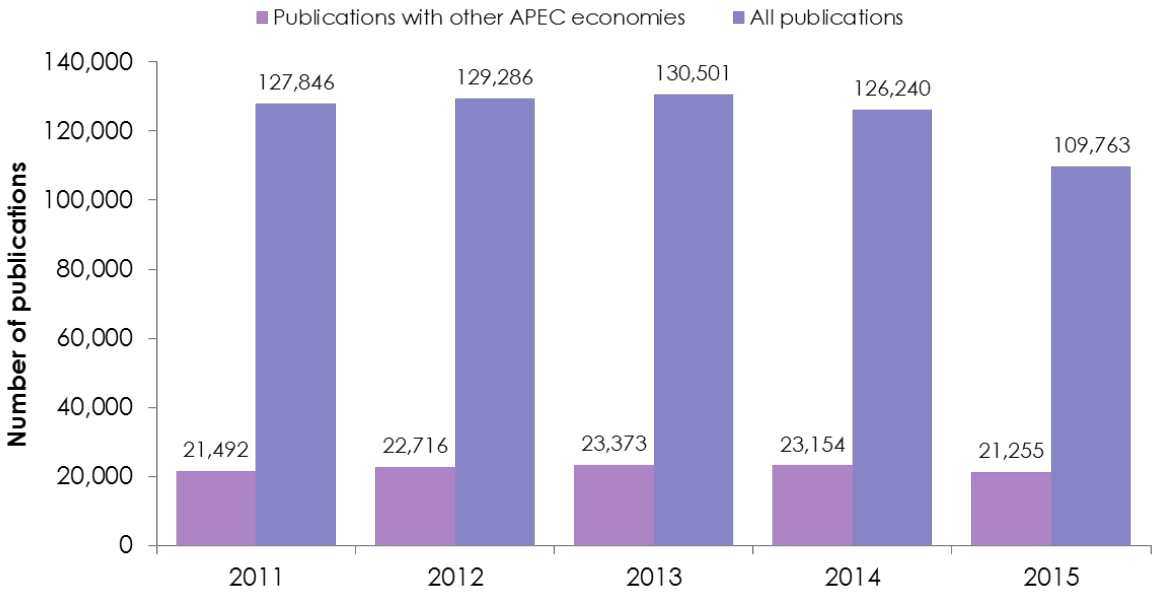

Figure 50: All Japanese publications and Japanese publications co-authored with another APEC economy

As shown in Figure 51, the vast majority of Japanese publications did not include a co-author from another APEC economy. Around 15 per cent had co-authors from one other APEC economy and around two per cent were co-authored with researchers from two or more other APEC economies.

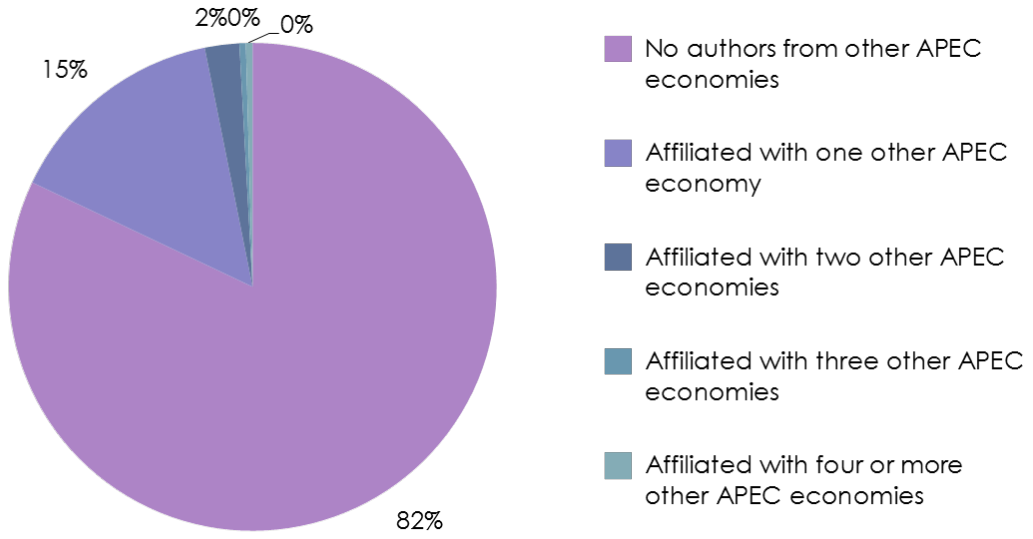

Figure 51: Proportion of all Japanese publications co-authored with one or more other APEC economies (2011-2015)

The level of cross-border co-authorship with researchers from other APEC economies varies by subject area. As shown in Figure 52, arts and humanities had the lowest level of cross-border co-authorship with researchers from other APEC economies. On the other hand, earth and planetary sciences had the highest proportion of papers co-authored with researchers from other APEC economies.

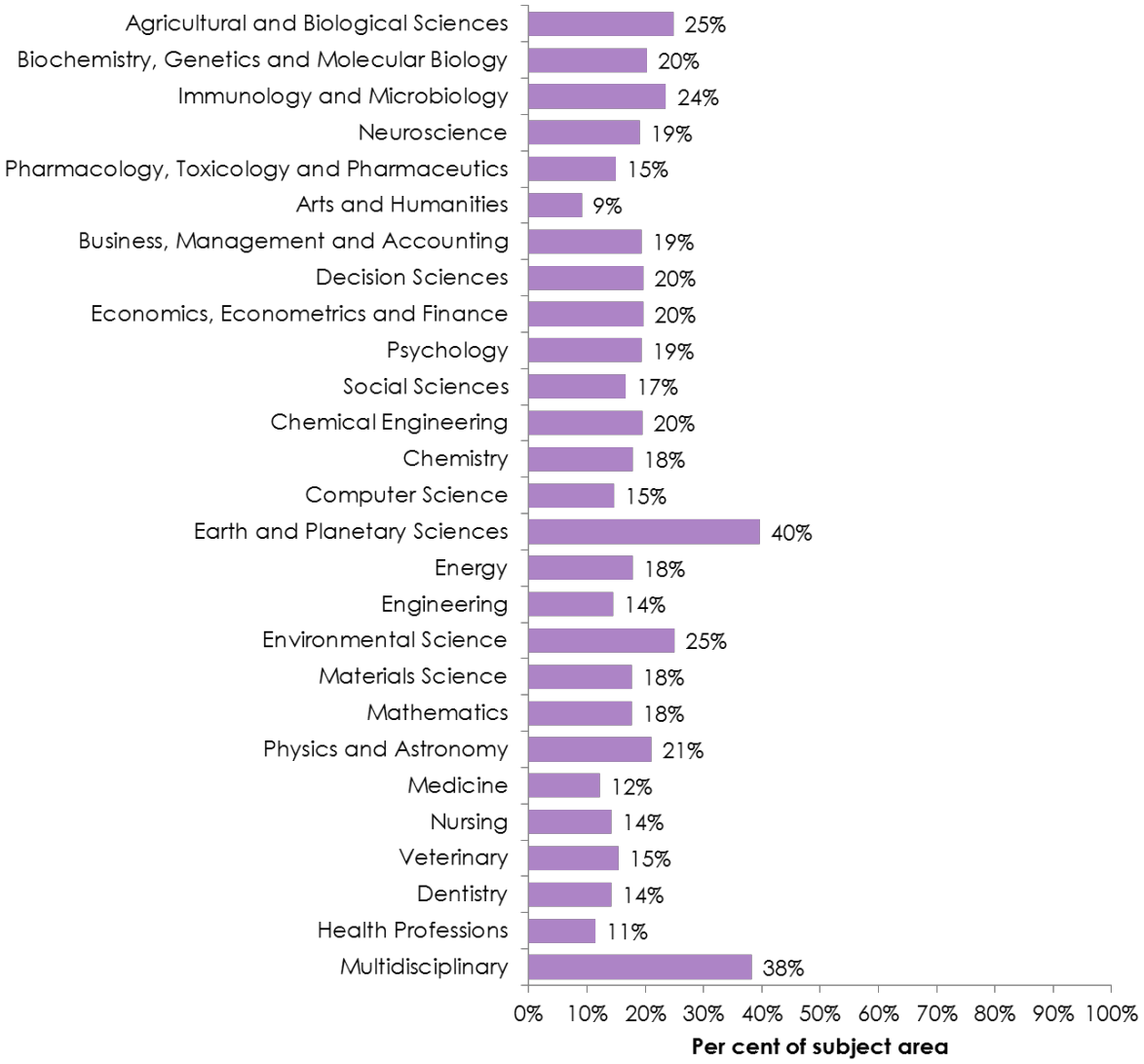

Figure 52: Proportion of Japanese publications co-authored with another APEC economy by subject area (2011-2015)

Korea

Between 1960 and 2015, more than 850 000 documents affiliated with Korea were published and indexed by Scopus. As shown in, Figure 53, the number of documents published by researchers from Korea has rapidly increased since the late 1980s. In the past two decades, the amount of peer-reviewed research literature published by Korean researchers has increased more than 10 times over. Figure 53 also shows that the proportion of all documents that include at least one author affiliated with Korea has also increased substantially in recent years. Between 2011 and 2015, more than 360 000 documents were published by researchers from Korea. This represents close to three per cent of all documents published during this period.

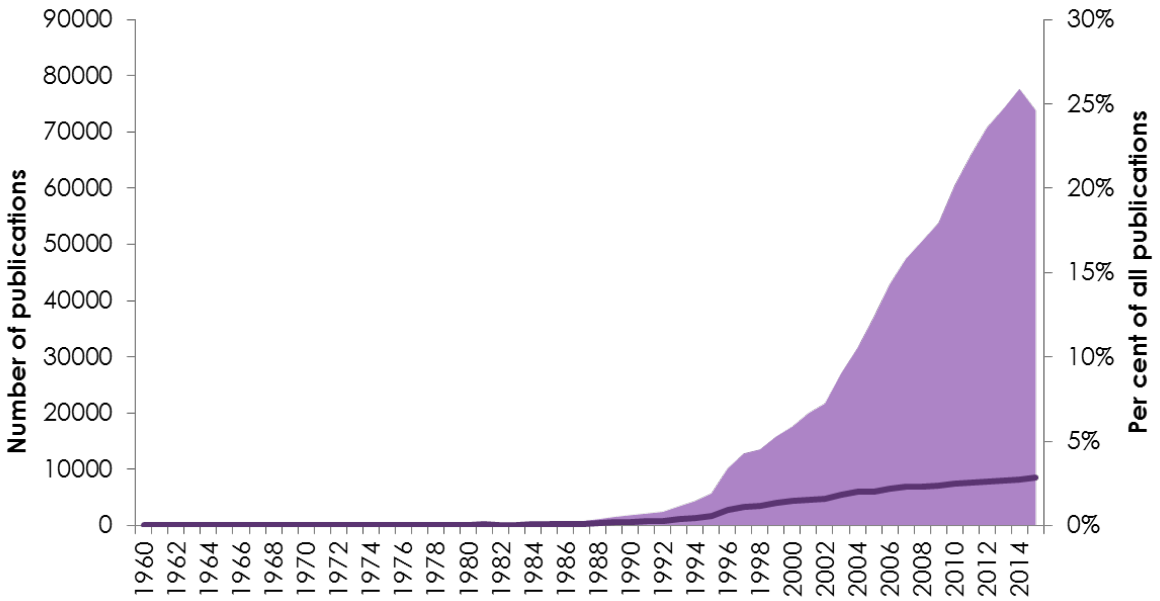

Figure 53: Number and proportion of publications affiliated with Korea

In 2014, 27 per cent of peer-reviewed research literature published by researchers from Korea had cross-border co-authors (SCImago, 2016q). Figure 54 shows economies of the most frequent cross-border co-authors for South Korean publications. This indicates that 13 per cent of all South Korea publications were co-authored with researchers from the United States.

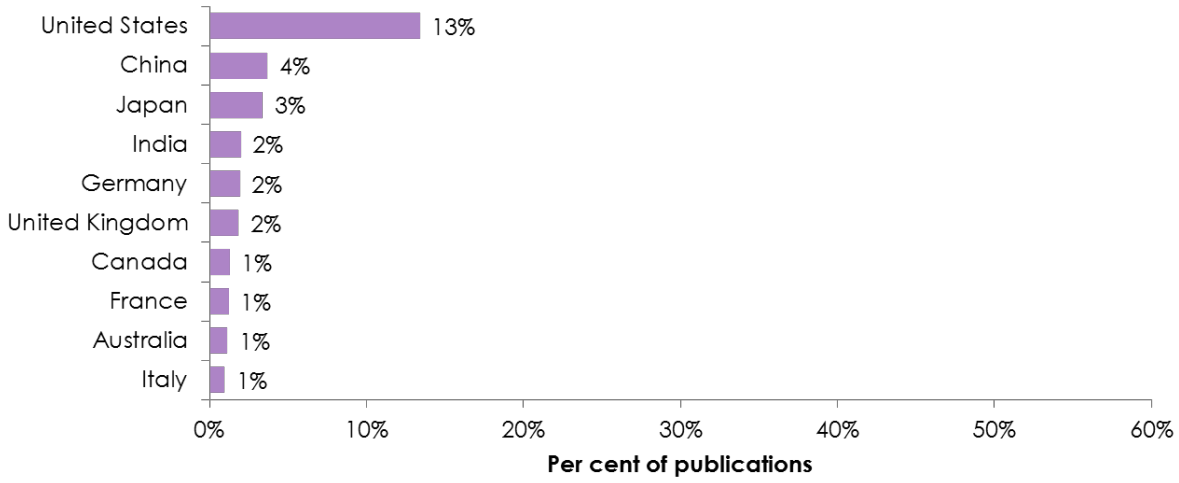

Figure 54: Most common cross-border co-authorship for Korean publications (2011-2015)

Echoing the tremendous growth in production of research literature by researchers from Korea is the growth in the number of documents co-authored with researchers from other APEC economies (Figure 55). Although recent years have seen a huge level of growth in the number of documents being co-authored with researchers from other APEC economies, the proportion of all Korean publication that this represents appears to be relatively stable. Between 2011 and 2015, a total of 76 422 documents

were co-authored by researchers from Korea and other APEC economies, representing around 21 per cent of all publications affiliated with Korea.

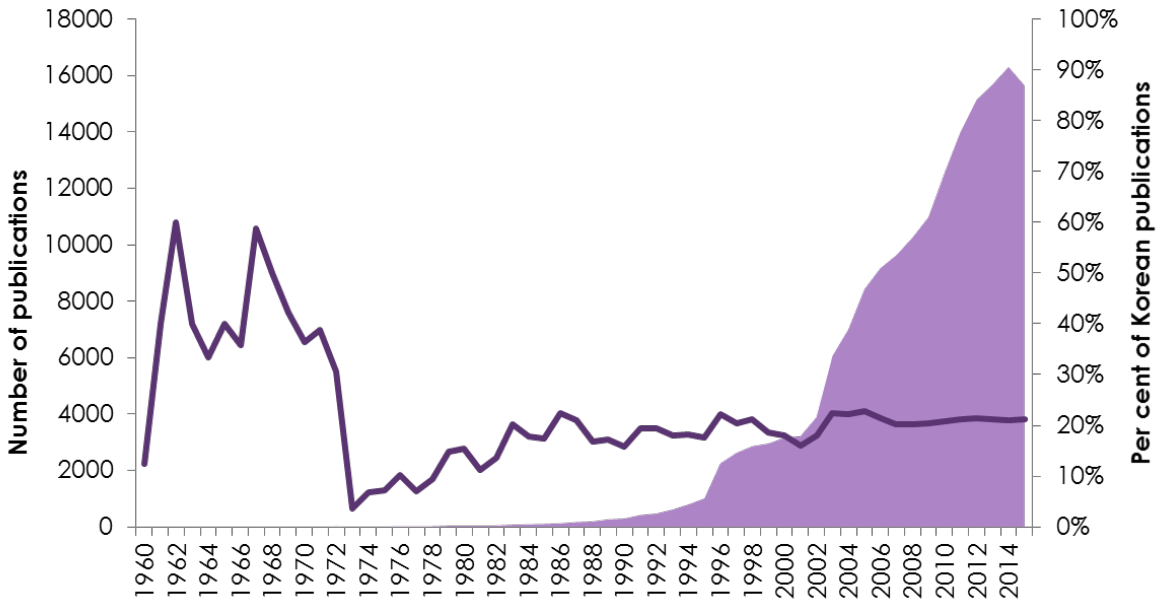

Figure 55: Number and proportion of Korean publications co-authored with other APEC economies

Table 14 lists the number of publications that researchers from Korea have co-authored with each of the other APEC economies. It also shows the proportion of all Korean publications that this represents. This indicates that the most common cross-border co-authorship occurs with researchers from the United States; China; and Japan.

Table 14: Number and proportion of Korean publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	4 046	1
Brunei Darussalam	41	0
Canada	4 641	1
Chile	541	0
China	13 271	4
Hong Kong, China	1 230	0
Indonesia	557	0
Japan	12 210	3
Malaysia	1 235	0
Mexico	1 247	0
New Zealand	1 024	0
Papua New Guinea	9	0
Peru	182	0
Philippines	516	0

Other APEC Economies	Publications	
	#	%
Russia	2 732	1
Singapore	2 156	1
Chinese Taipei	2 998	1
Thailand	1 253	0
United States	48 468	13
Viet Nam	1 665	0

Figure 56 shows that the number of documents being published by Korean researchers has been increasing annually, with a small decrease seen in 2015. At the same time, the number of publications co-authored with researchers from other APEC economies also appears to be slowly increasing. Between 2011 and 2015, the number of publications co-authored with other APEC economies has increased by 10 per cent.

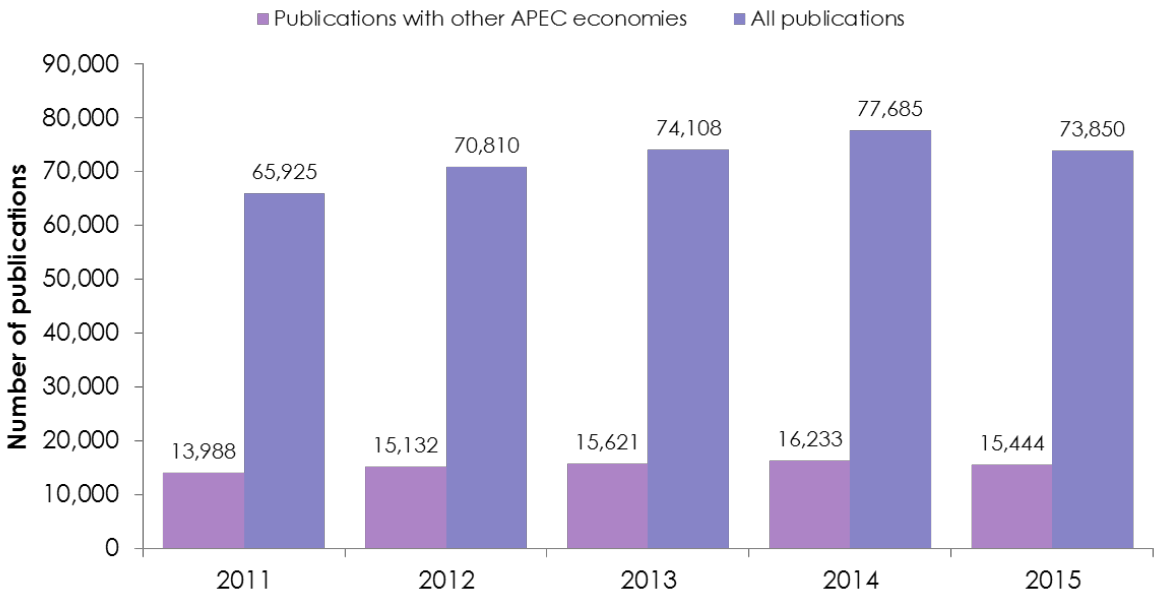

Figure 56: All Korean publications and Korean publications co-authored with another APEC economy

As shown in Figure 57, around 79 per cent of all publications by researchers from Korea did not include any co-authors from other APEC economies. Around 18 per cent had co-authors from just one other APEC economy and around three per cent had co-authors from two or more other APEC economies.

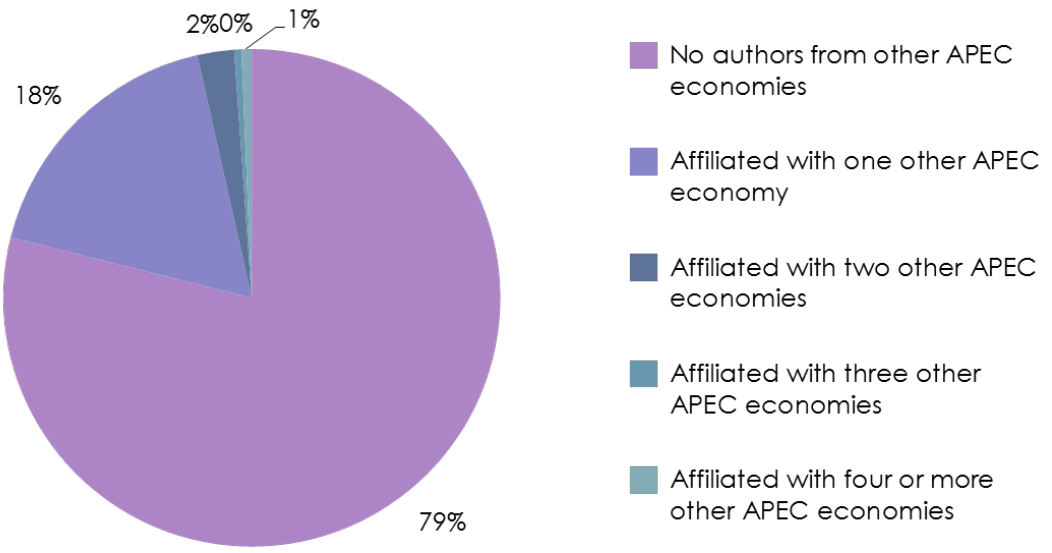

Figure 57: Proportion of all Korean publications co-authored with one or more other APEC economies (2011-2015)

The level of cross-border co-authorship with researchers from other APEC economies varies by subject area. As shown in Figure 58, the proportion of papers co-authored with researchers from other APEC economies ranges from around nine per cent in the subject area of arts and humanities to more than 40 per cent in the fields of business, management and accounting; psychology; and earth and planetary sciences.

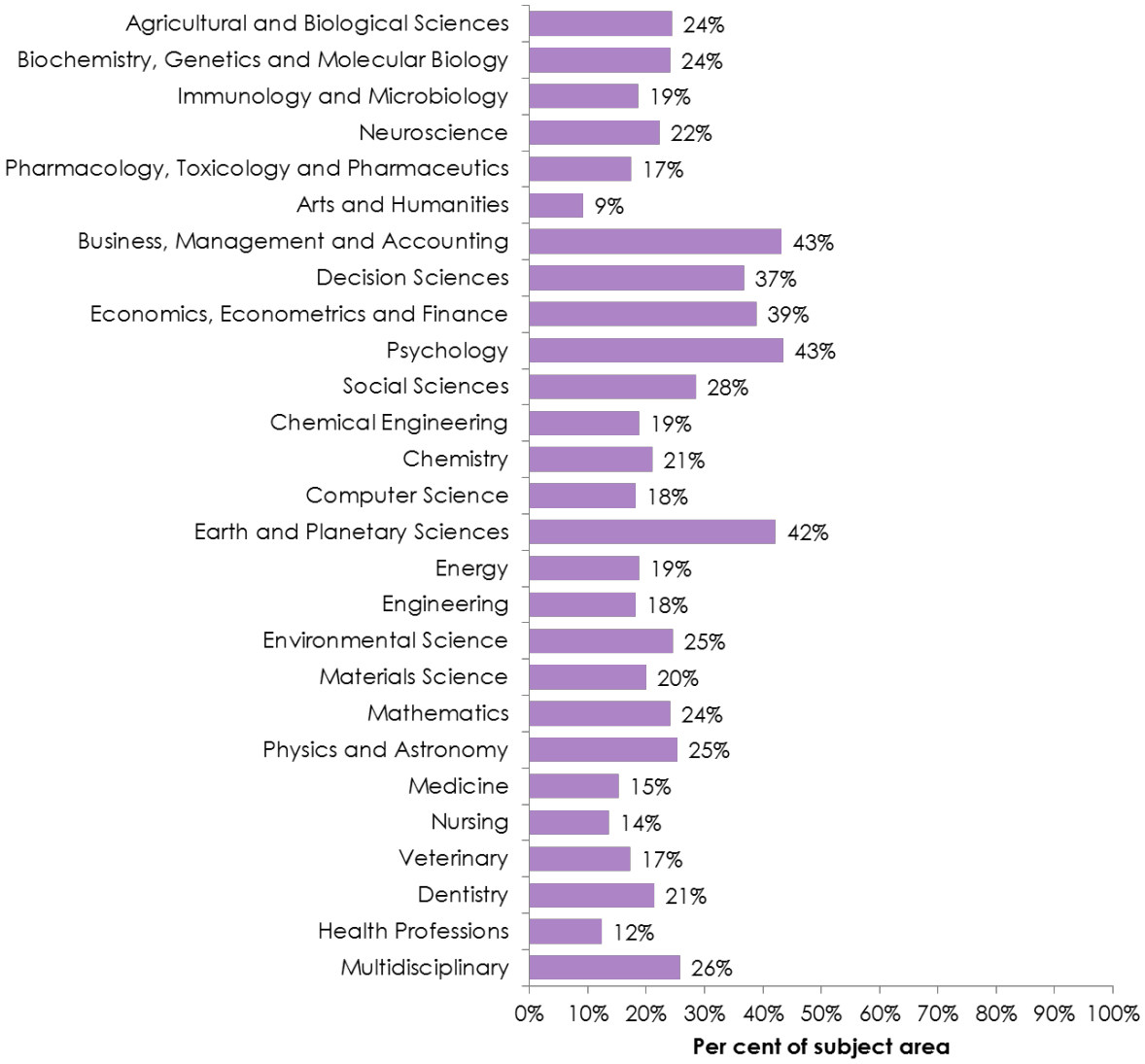

Figure 58: Proportion of Korean publications co-authored with another APEC economy by subject area (2011-2015)

Malaysia

Between 2011 and 2015, close to 190 000 pieces of peer-reviewed research literature affiliated with Malaysia were published and included in Scopus's index. Figure 59 highlights the huge level of growth in publication by Malaysian researchers in the past decade and also shows that the proportion of all documents published that have a Malaysian affiliation has also increased over the past decade. Between 2011 and 2015, more than 119 000 publications were affiliated with Malaysia, representing around 0.9 per cent of all documents published in this period.

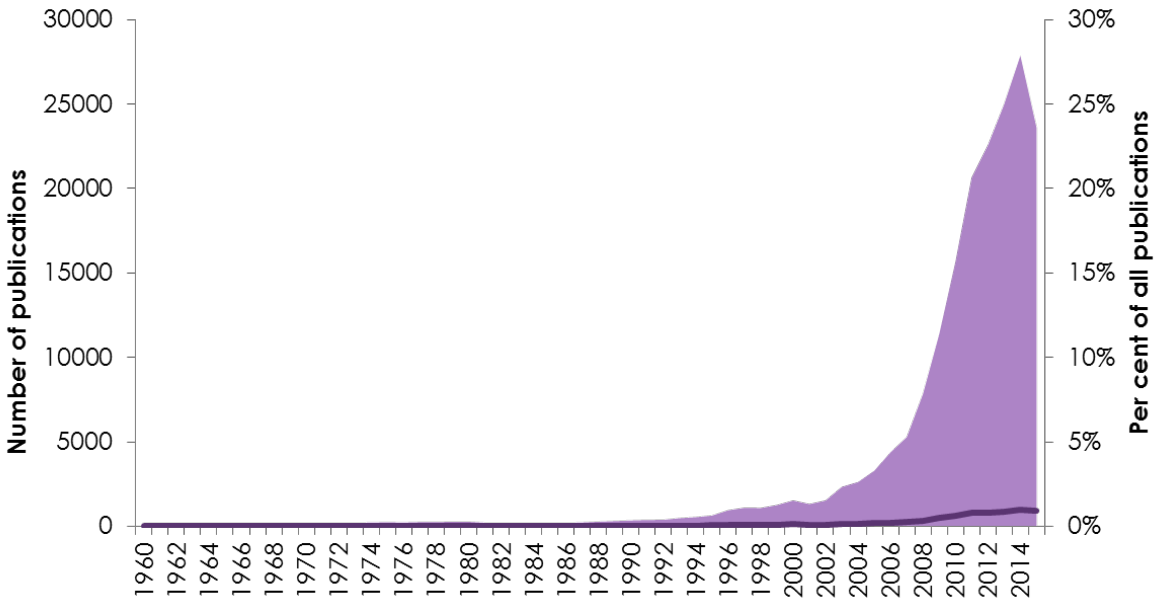

Figure 59: Number and proportion of publications affiliated with Malaysia

In 2014, 36 per cent of publications written by Malaysian researchers had cross-border co-authors (SCImago, 2016i). Figure 60 lists the ten economies that Malaysian researchers most frequently co-authored publications with between 2011 and 2015. This shows that five per cent of all papers had a co-author from the United Kingdom, four per cent had a co-author from Australia and four per cent had an Iranian co-author.

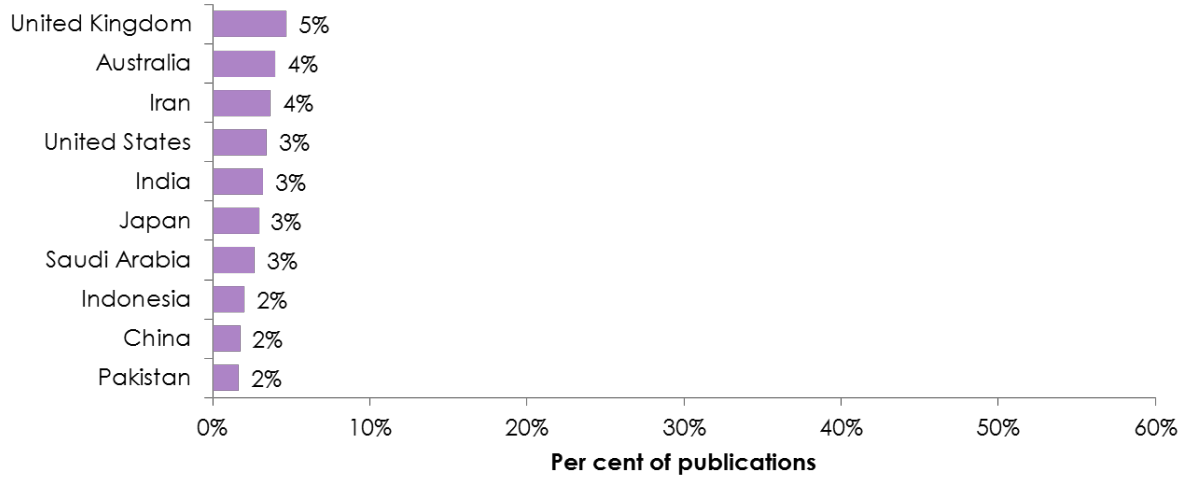

Figure 60: Most common cross-border co-authorship for Malaysian publications (2011-2015)

As shown in Figure 61 the past decade has also seen a rapid increase in the number of publications by Malaysian researchers that have been co-authored with researchers from other APEC economies. The proportion of all Malaysian publications that include co-authors from other APEC economies also appears to have increased in recent years. Between 2011 and 2015, a total of 18 618 papers were co-

authored by researchers from Malaysia and other APEC economies representing around 16 per cent of all documents published by Malaysian researchers.

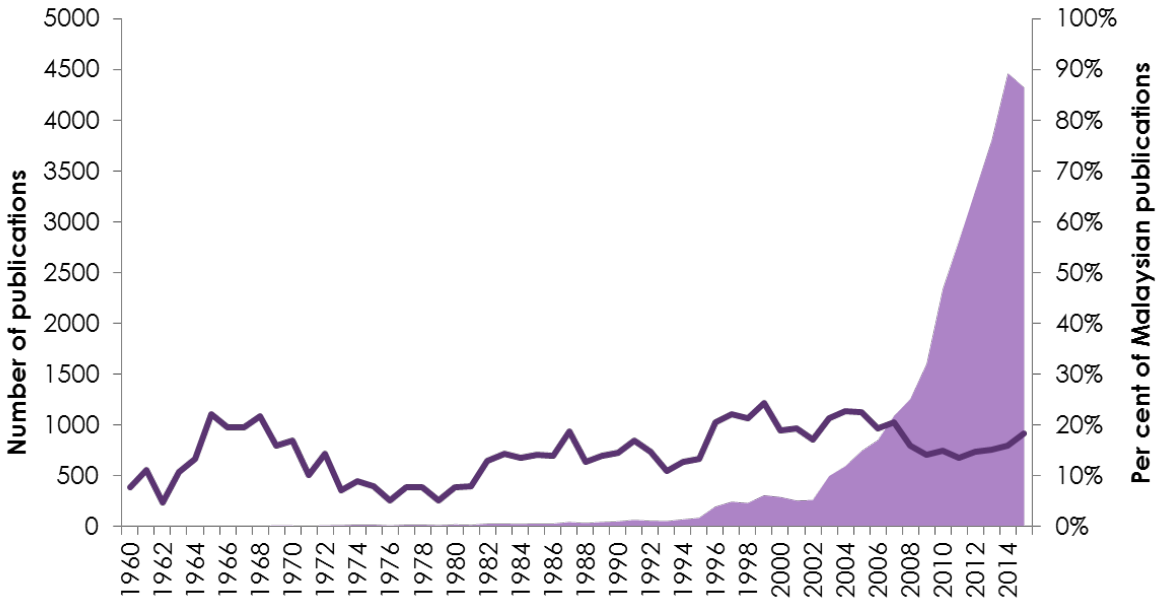

Figure 61: Number and proportion of Malaysian publications co-authored with other APEC economies

Table 15 lists the number of publications Malaysian researchers have co-authored with researchers from other APEC economies between 2011 and 2015. It also shows the proportion of all Malaysian documents that these publications represent. This shows that the most common cross-border co-authorship occurs with Australia; the United States; and Japan.

Table 15: Number and proportion of Malaysian publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	4 754	4
Brunei Darussalam	196	0
Canada	1 322	1
Chile	182	0
China	2 086	2
Hong Kong, China	587	0
Indonesia	2 423	2
Japan	3 493	3
Korea	1 235	1
Mexico	312	0
New Zealand	897	1
Papua New Guinea	27	0
Peru	51	0
Philippines	411	0

Russia	404	0
Singapore	1 495	1
Chinese Taipei	1 025	1
Thailand	1 269	1
United States	4 116	3
Viet Nam	305	0

As shown in Figure 62, recent years, excluding 2015, have seen an increase in the number of documents being published annually by researchers affiliated with Malaysia. The number of papers being co-authored with researchers from other APEC economies also appears to be rising. Between 2011 and 2015, the number of publications co-authored with researchers from other APEC economies has increased by 51 per cent.

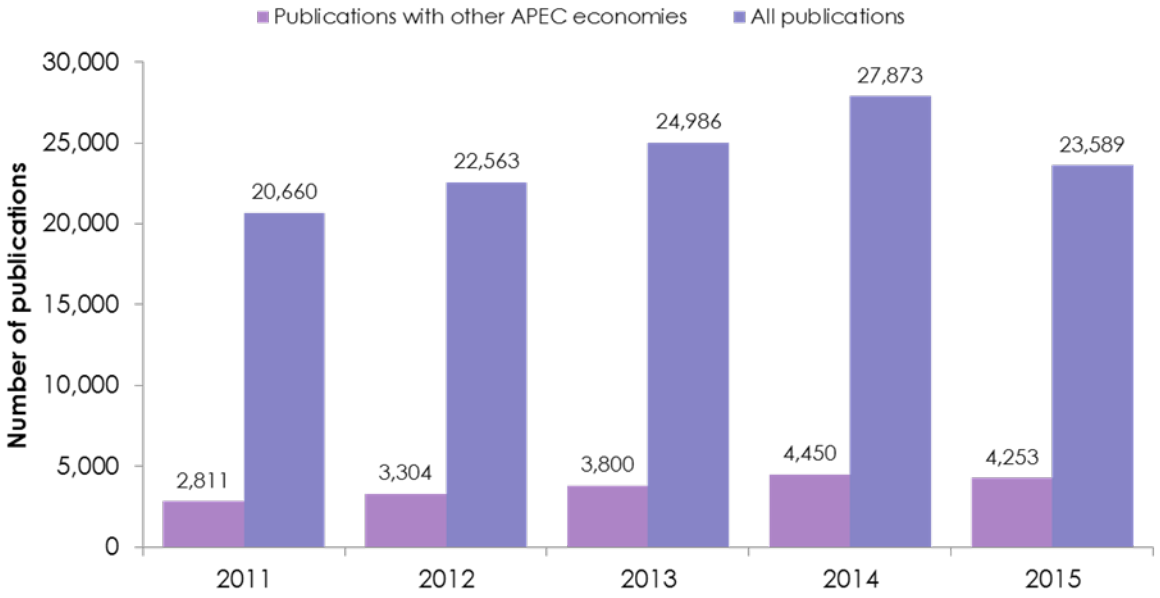

Figure 62: All Malaysian publications and Malaysian publications co-authored with another APEC economy

As shown in Figure 63, 84 per cent of all Malaysian publications did not have a cross-border co-author from another APEC economy. Around 13 per cent were co-authored with researchers from just one other APEC economy, and three per cent were co-authored with researchers from two or more other APEC economies.

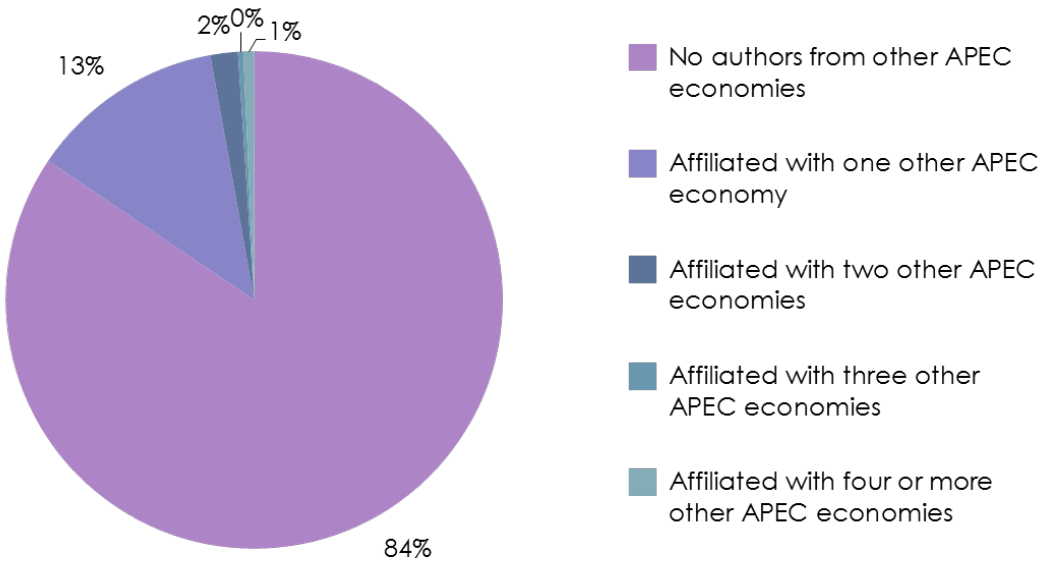

Figure 63: Proportion of all Malaysian publications co-authored with one or more other APEC economies (2011-2015)

Figure 64 shows the proportion of all documents published by Malaysian researchers between 2011 and 2015 that were co-authored with researchers from other APEC economies by subject area. This shows that the lowest level of cross-border co-authorship occurred in the field of arts and humanities. The highest rate of co-authorship with other APEC economies occurred in the field of neuroscience. However, because relatively few papers were written by Malaysian researchers in this field, this only represents 225 publications. The largest number of papers co-authored with researchers from other APEC economies were in the fields of engineering (4 701 papers) and medicine (3 314).

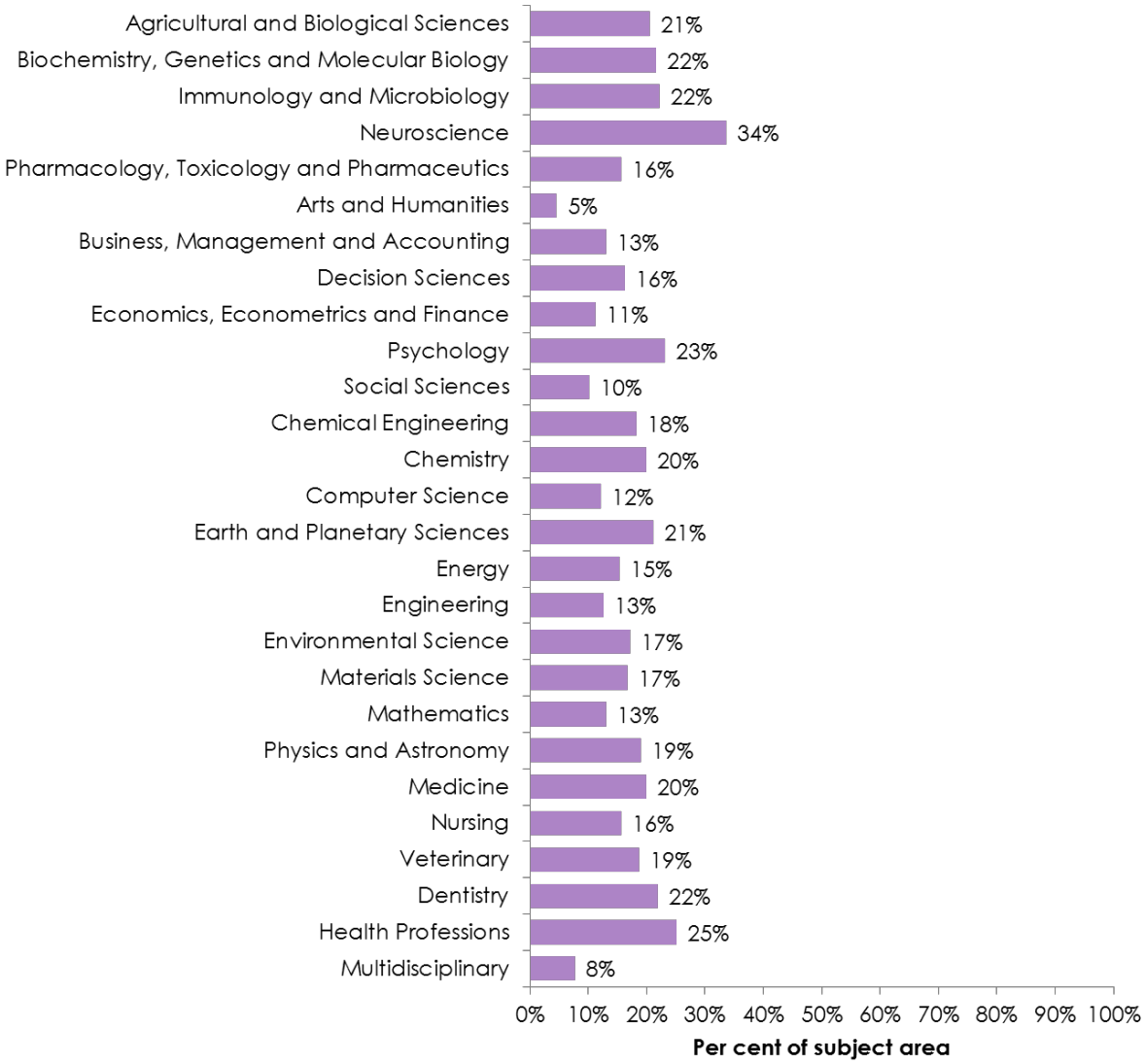

Figure 64: Proportion of Malaysian publications co-authored with another APEC economy by subject area (2011-2015)

Mexico

Between 1960 and 2015, more than 260 000 documents affiliated with Mexican researchers were published and indexed by Scopus. As with many other economies, recent decades have seen an increase in the number of publications being produced by researchers affiliated with Mexico (Figure 65). Recent years have also seen an increase in the proportion of all documents affiliated with Mexico. Between 2011 and 2015, more than 920 000 documents had a Mexican affiliation, representing 0.7 per cent of all documents published during this period.

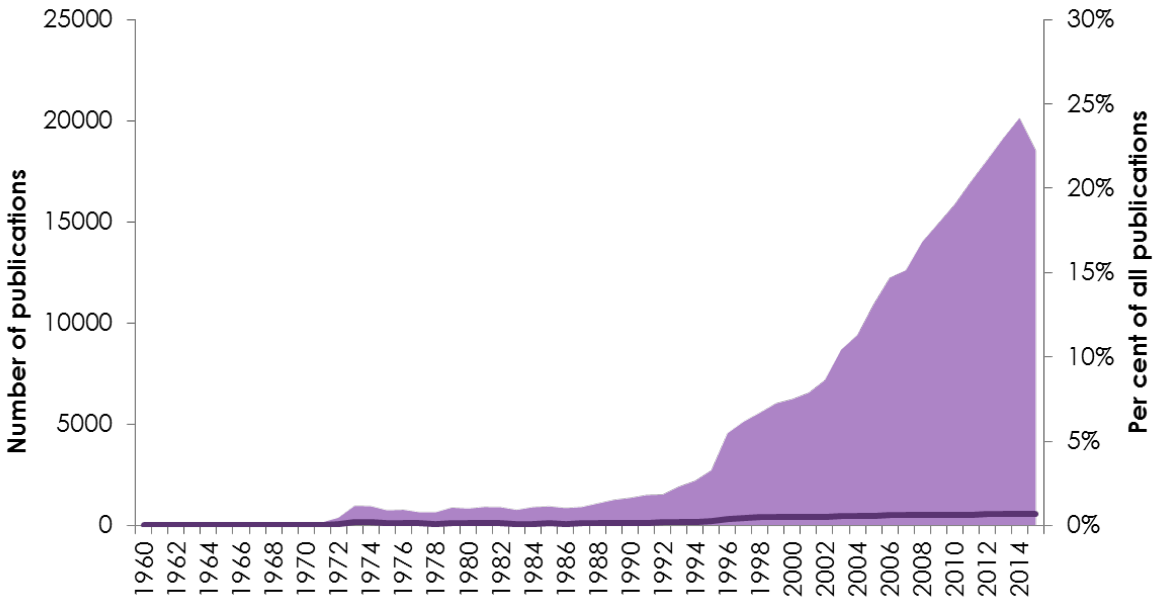

Figure 65: Number and proportion of publications affiliated with Mexico

According to SCImago (2016j), in 2014, 41 per cent of all documents published by Mexican researchers had cross-border co-authors. Figure 66 lists the ten most common economies with which researchers from Mexico collaborated between 2011 and 2015. This indicates that of all publications affiliated with Mexico, 16 per cent were co-authored with researchers from the United States, and nine per cent were co-authored with Spanish researchers.

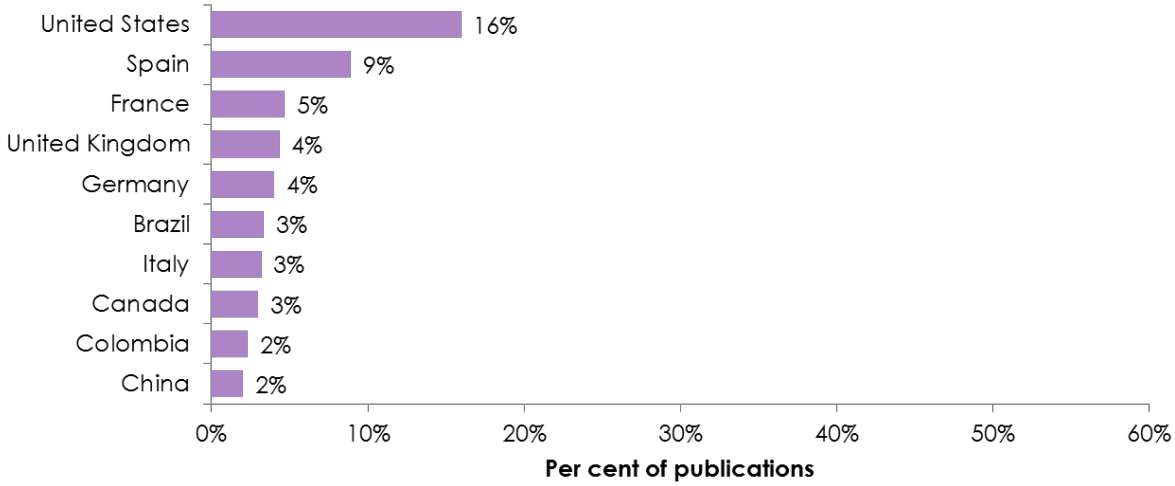

Figure 66: Most common cross-border co-authorship for Mexican publications (2011-2015)

Figure 67 shows the level of growth in the number of documents co-authored by researchers from Mexico and other APEC economies between 1960 and 2015. As shown in Figure 67, the proportion of all publications affiliated with Mexico that had co-authors from other APEC economies has also increased since the mid-1970s, although this appears to have remained relatively steady during the past

decade. Between 2011 and 2015, a total of 19 617 papers were co-authored by Mexican researchers and researchers from other APEC economies, representing 21 per cent of all Mexican publications.

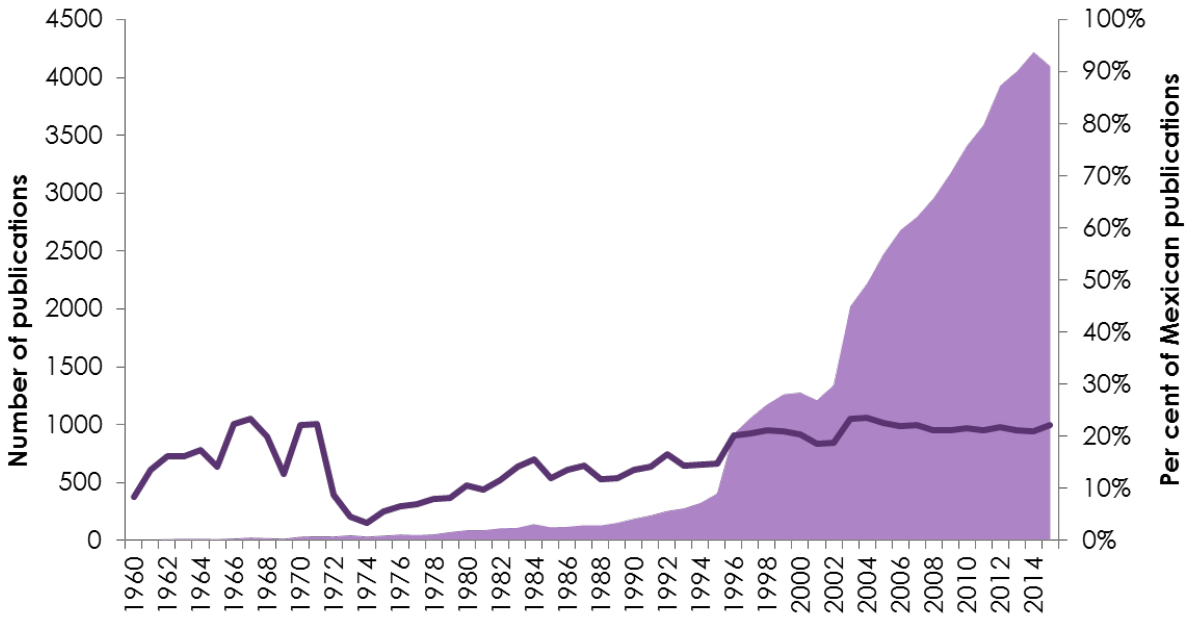

Figure 67: Number and proportion of Mexican publications co-authored with other APEC economies

Table 16 lists the number of publications that Mexican researchers have co-authored with researchers from other APEC economies. It also indicates the proportion of all publications written by Mexican researchers that this level of publication represents. This shows that the most frequent cross-border co-authorship occurs with researchers from the United States.

Table 16: Number and proportion of Mexican publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	1 585	2
Brunei Darussalam	6	0
Canada	2 740	3
Chile	1 463	2
China	1 836	2
Hong Kong, China	151	0
Indonesia	80	0
Japan	1 367	1
Korea	1 247	1
Malaysia	312	0
New Zealand	707	1
Papua New Guinea	12	0
Peru	536	1
Philippines	129	0

Other APEC Economies	Publications	
	#	%
Russia	1 703	2
Singapore	231	0
Chinese Taipei	864	1
Thailand	471	1
United States	14 662	16
Viet Nam	92	0

As shown in Figure 68, the number of documents published by Mexican researchers has been steadily increasing between 2011 and 2015, with a small dip seen in 2015. There also appears to be a steady increase in the number of documents co-authored with researchers from other APEC economies. During this time period, the number of publications co-authored with researchers from other APEC economies has increased by 12 per cent.

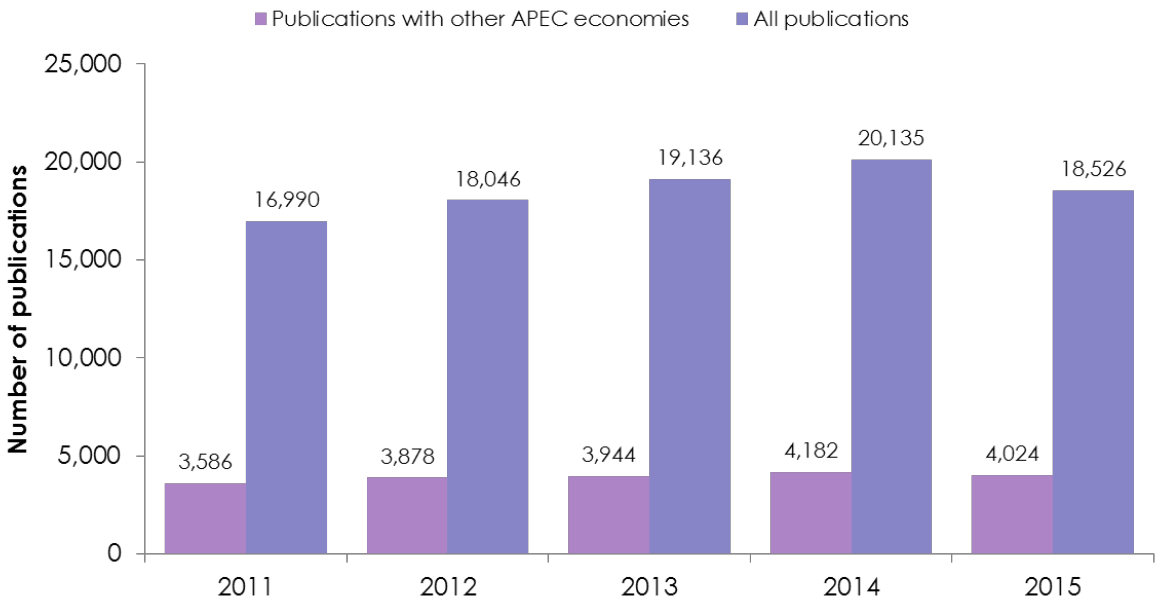

Figure 68: All Mexican publications and Mexican publications co-authored with another APEC economy

As shown in Figure 69, 79 per cent of all Mexican publications did not include a co-author from another APEC economy. Around 17 per cent were co-authored with researchers from just one other APEC economy, and around four per cent included co-authors from two or more other APEC economies.

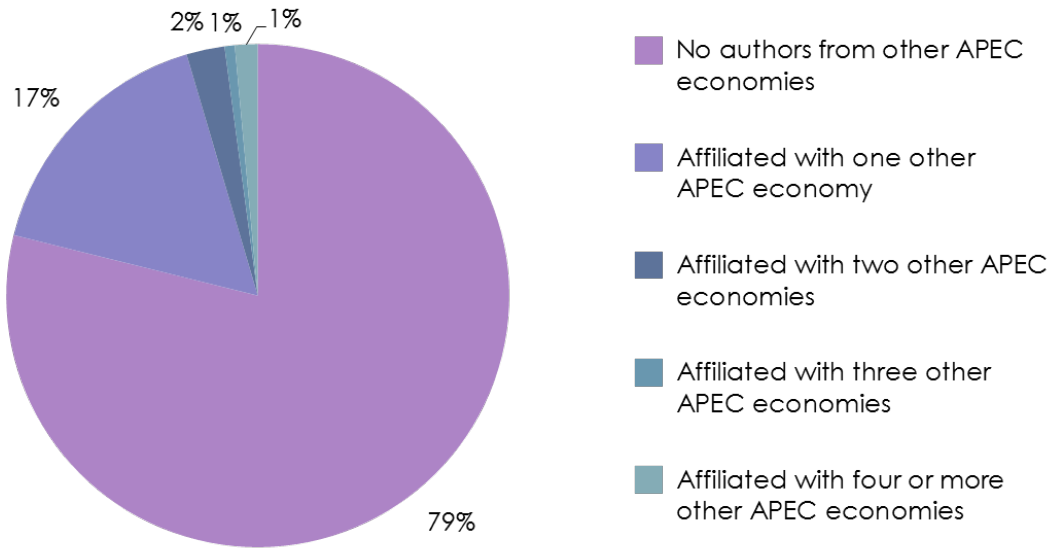

Figure 69: Proportion of all Mexican publications co-authored with one or more APEC economies (2011-2015)

The level of cross-border co-authorship with researchers from other APEC economies varies by subject area. As shown in Figure 70, only eight per cent of papers in the field of arts and humanities included co-authors from another APEC economy. Around 48 per cent of all publications in the multidisciplinary field had co-authors from another APEC economy. However, only 303 papers in this field were co-authored with another APEC economy, as only a relatively small number of publications in the multidisciplinary subject area were published by Mexican researchers. In terms of the sheer numbers of publications, the largest number of publications co-authored with researchers from other APEC economies occurred in the subject areas of medicine (4 758), agriculture (3 859) and physics and astronomy (3 766).

Figure 70: Proportion of Mexican publications co-authored with another APEC economy by subject area (2011-2015)

New Zealand

In the period from 1960 to 2015, more than 230 000 documents affiliated with researchers from New Zealand were published and indexed by Scopus. Figure 71 shows the huge growth in the level of publication by New Zealand researchers which mirrors the overall growth in research publication over recent decades. The proportion of documents published by New Zealand researchers has also increased in recent decades. Between 2011 and 2015, more than 68 000 documents had a New Zealand affiliation. This represented around 0.5 per cent of all documents published.

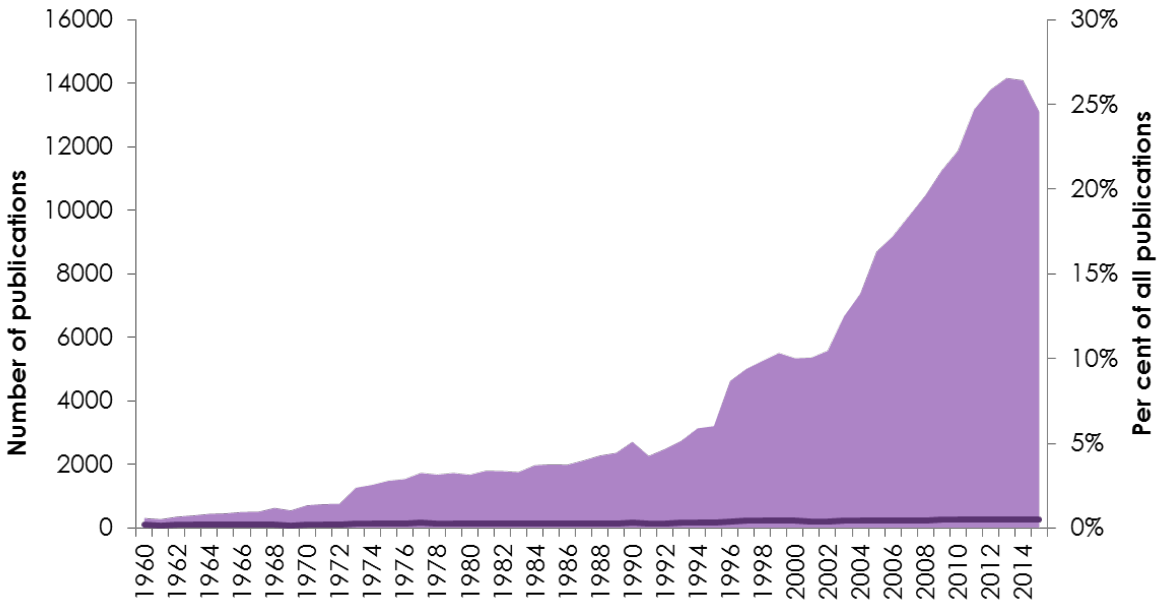

Figure 71: Number and proportion of publications affiliated with New Zealand

According to analyses conducted by SCImago (2016k), in 2014, 55 per cent of papers published by New Zealand researchers had cross-border co-authors. Figure 72 lists the ten economies which New Zealand researchers most frequently collaborated during 2011 to 2015. This shows that of all publications affiliated with New Zealand, 16 per cent had co-authors from the United States, 15 per cent had co-authors from Australia and 12 per cent had co-authors from the United Kingdom.

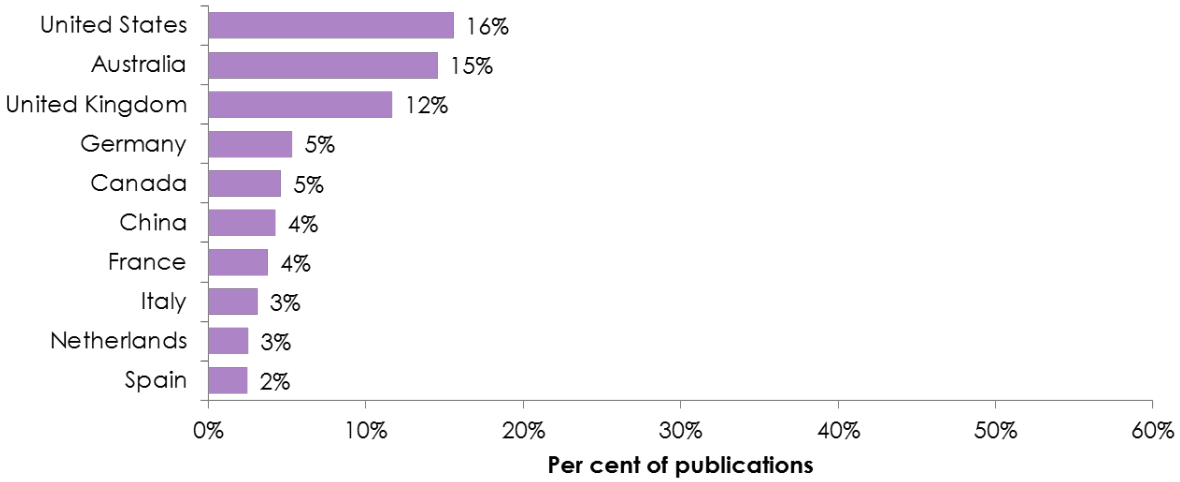

Figure 72: Most common cross-border co-authorship for New Zealand publications (2011-2015)

As shown in Figure 73, recent years have seen strong growth in the number of documents co-authored by researchers from New Zealand and researchers from other APEC economies. As well as growth in the number of documents co-authored with researchers from other APEC economies, the proportion of all New Zealand publications that include co-authors from other APEC economies has also been steadily increasing. In the period between 2011 and 2015, 24 427 papers were co-authored by

researchers from New Zealand and other APEC economies, representing 36 per cent of all documents published by New Zealand researchers.

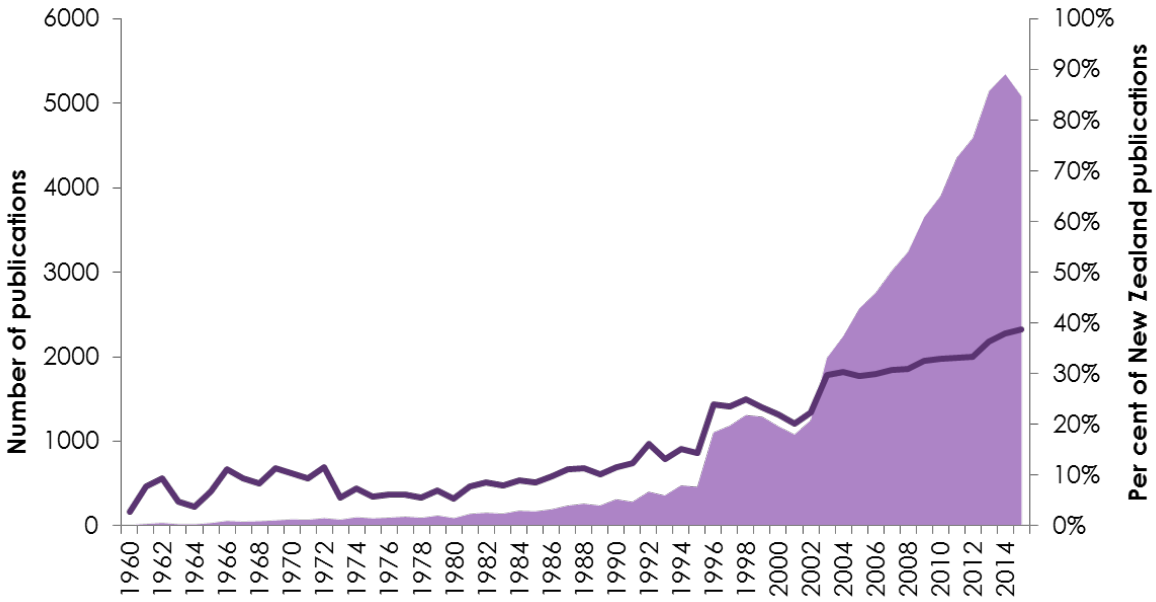

Figure 73: Number and proportion of New Zealand publications co-authored with other APEC economies

Table 17 lists the number of publications that New Zealand researchers have co-authored with researchers affiliated with each of the other APEC economies. It also shows the proportion of all New Zealand publications that this number represents. This shows that the most frequent cross-border co-authorship occurs with the United States and Australia.

Table 17: Number and proportion of New Zealand publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	9 930	15
Brunei Darussalam	18	0
Canada	3 155	5
Chile	497	1
China	2 877	4
Hong Kong, China	467	1
Indonesia	189	0
Japan	1 407	2
Korea	1 024	1
Malaysia	897	1
Mexico	707	1
Papua New Guinea	32	0
Peru	67	0
Philippines	137	0

Other APEC Economies	Publications	
	#	%
Russia	717	1
Singapore	824	1
Chinese Taipei	808	1
Thailand	591	1
United States	10 634	16
Viet Nam	132	0

Figure 74 shows that the number of documents being published by New Zealand researchers appears to be gradually increasing, although a small decrease is shown in 2015. This increase is also seen in the number of documents co-authored with researchers from other APEC economies. Between 2011 and 2015, the number of publications co-authored with researchers from other APEC economies has increased by 16 per cent.

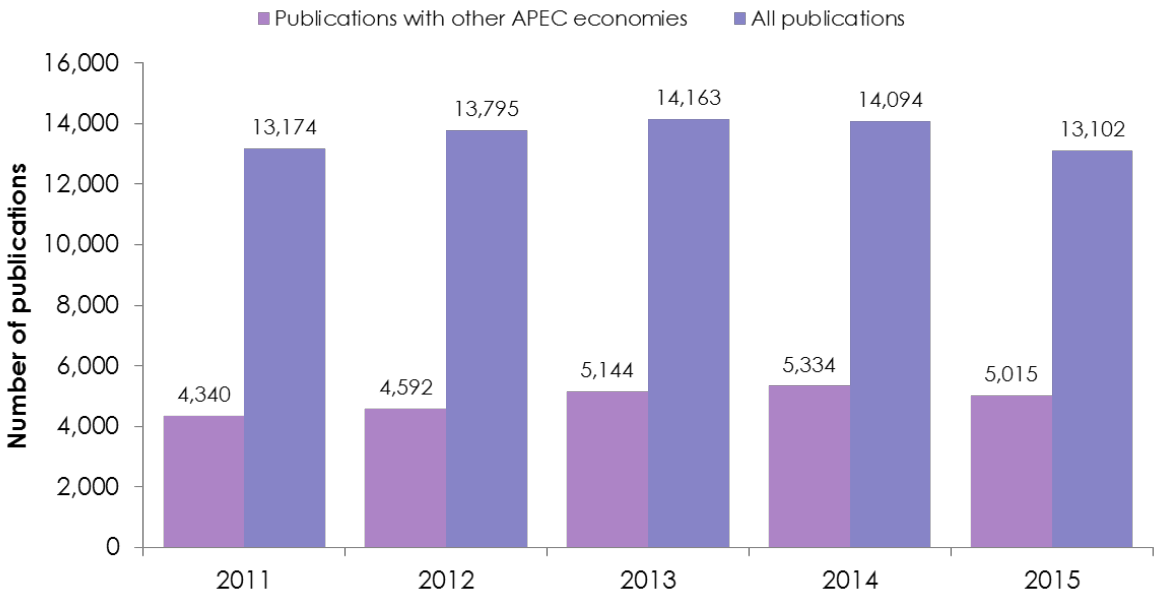

Figure 74: All New Zealand publications and New Zealand publications co-authored with another APEC economy

Figure 75 shows that 64 per cent of all New Zealand publications did not include co-authors from other APEC economies. Around 28 per cent include co-authors from just one other APEC economy, and around eight per cent include co-authors from two or more other APEC economies.

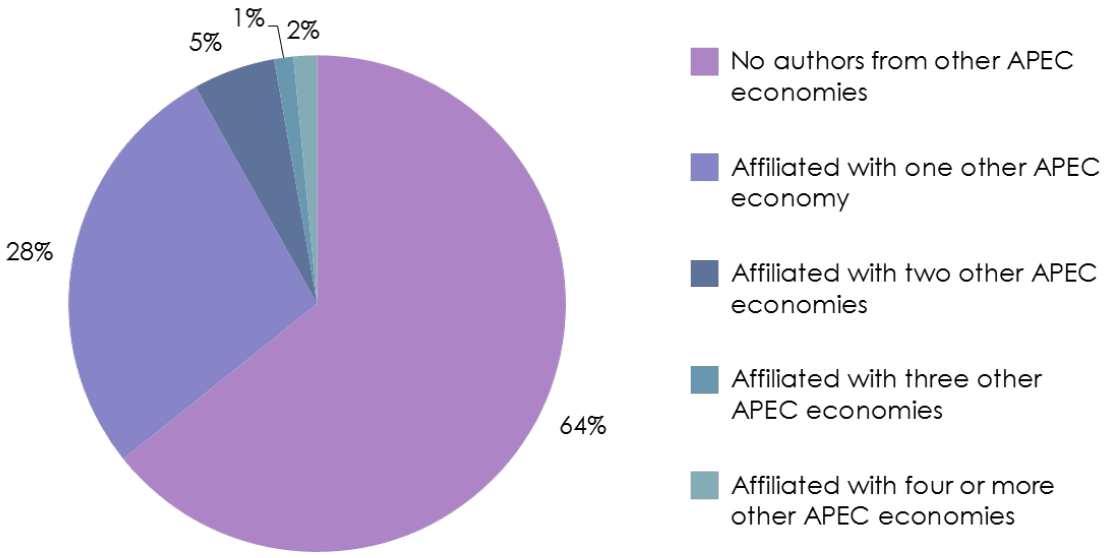

Figure 75: Proportion of all New Zealand publications co-authored with one or more other APEC economies (2011-2015)

The level of co-authorship with researchers from other APEC economies varies by subject area. As shown in Figure 76, the level of co-authorship ranges from 11 per cent in the subject area of arts and humanities to over 50 per cent in multidisciplinary, and earth and planetary sciences subject areas. In terms of the number of publications co-authored with researchers at other APEC economies, medicine (7 185) and agricultural and biological sciences (4 724) had the greatest level of cross-border co-authorship.

Figure 76: Proportion of New Zealand publications co-authored with another APEC economy by subject area (2011-2015)

Papua New Guinea

Between 1960 and 2015, just over 3 500 papers affiliated with researchers from Papua New Guinea were published and indexed by Scopus. Although the overall number of publications by Papua New Guinean researchers is relatively small, Figure 77 shows that the number of documents being published has been gradually increasing in recent decades.

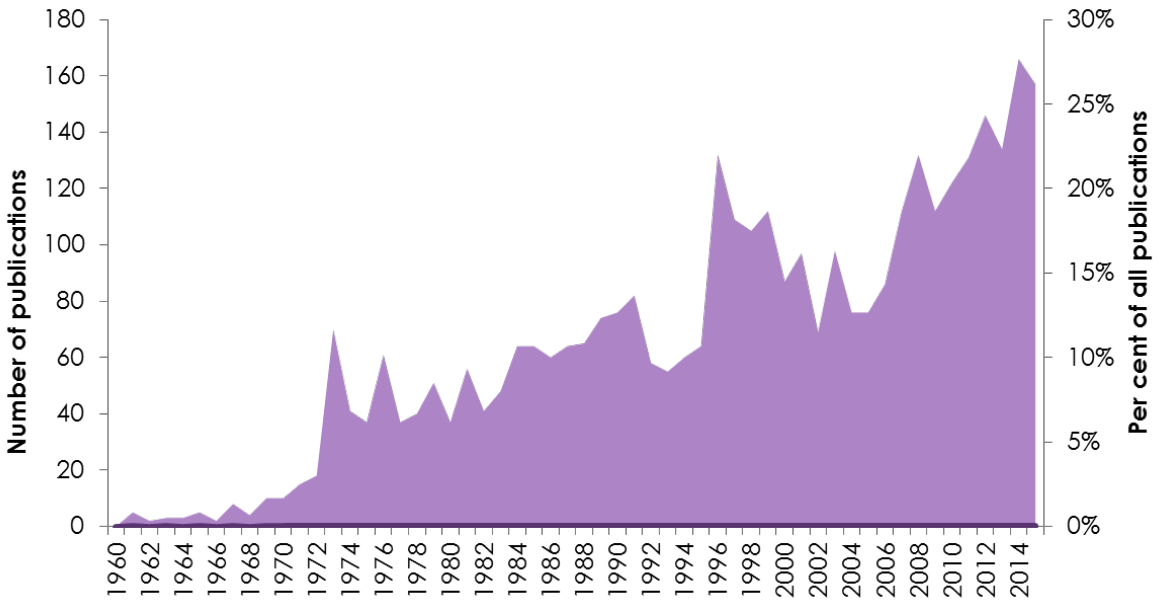

Figure 77: Number and proportion of publications affiliated with Papua New Guinea

In 2014, 88 per cent of all papers written by researchers from Papua New Guinea included cross-border co-authors (SCImago, 2016l). Figure 78 lists the ten economies with which researchers from Papua New Guinea most frequently collaborate. This shows that 58 per cent of all publications were co-authored with researchers from Australia and 26 per cent were co-authored with researchers from the United States.

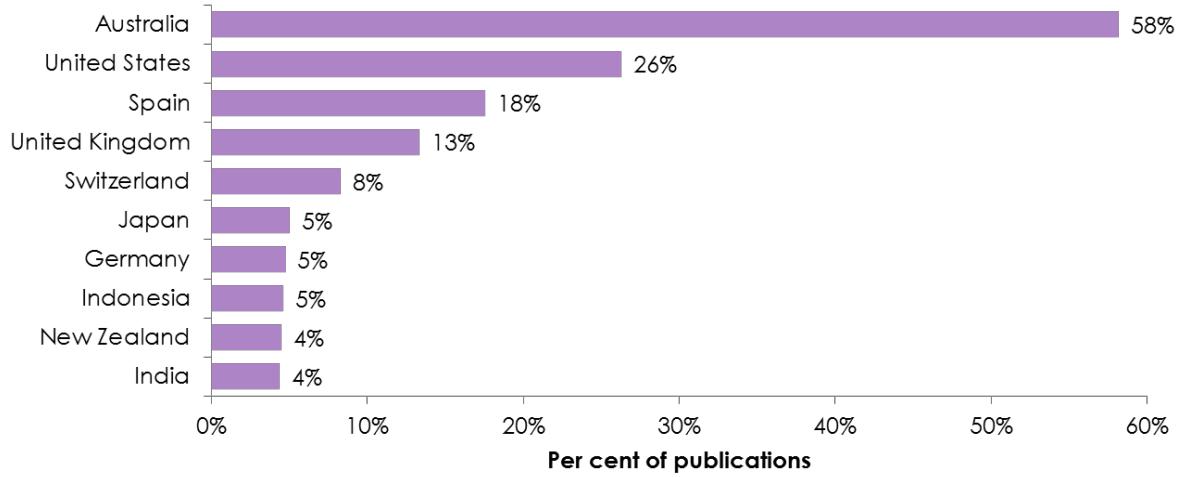

Figure 78: Most common cross-border co-authorship for Papua New Guinean publications (2011-2015)

Figure 79 shows that recent years have also seen an increase in the number and proportion of publications being co-authored by researchers from Papua New Guinea and researchers from other APEC economies. Between 2011 and 2015, a total of 572 papers were co-authored by Papua New Guinean researchers and researchers from other APEC economies, representing 78 per cent of all documents published by researchers from Papua New Guinea

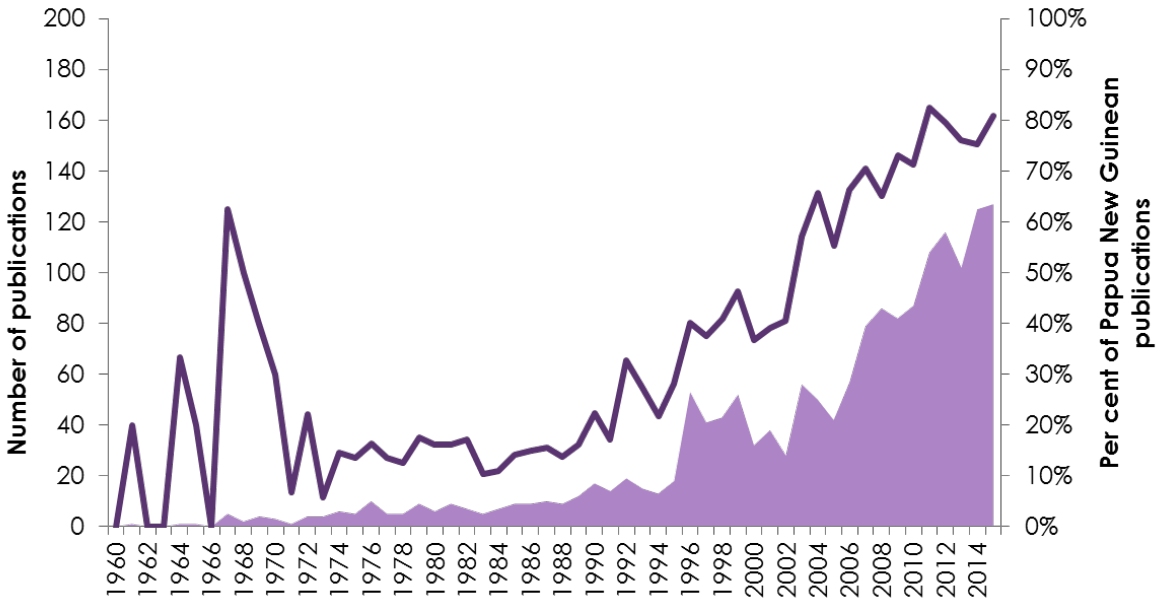

Figure 79: Number of publications affiliated with Papua New Guinea and another APEC economy

Table 18 shows the number of publications that Papua New Guinean researchers have co-authored with researchers from each APEC economy and the proportion of all Papua New Guinea publications that these numbers represent. This indicates that more than half of all publications are co-authored with researchers from Australia, and more than a quarter of all publications are co-authored with researchers from the United States.

Table 18: Number and proportion of Papua New Guinean publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	421	57
Brunei Darussalam	3	0
Canada	25	3
Chile	5	1
China	21	3
Hong Kong, China	9	1
Indonesia	33	4
Japan	36	5
Korea	9	1
Malaysia	27	4
Mexico	12	2
New Zealand	32	4
Peru	6	1
Philippines	23	3
Russia	8	1
Singapore	25	3

Other APEC Economies	Publications	
	#	%
Chinese Taipei	16	2
Thailand	23	3
United States	194	26
Viet Nam	16	2

Figure 80 shows that the number of documents being published by Papua New Guinea researchers appears to be gradually increasing. The annual number of publications co-authored with researchers from other APEC economies also appears to be increasing. Between 2011 and 2015, the number of papers co-authored with researchers from other APEC economies has increased by 15 per cent.

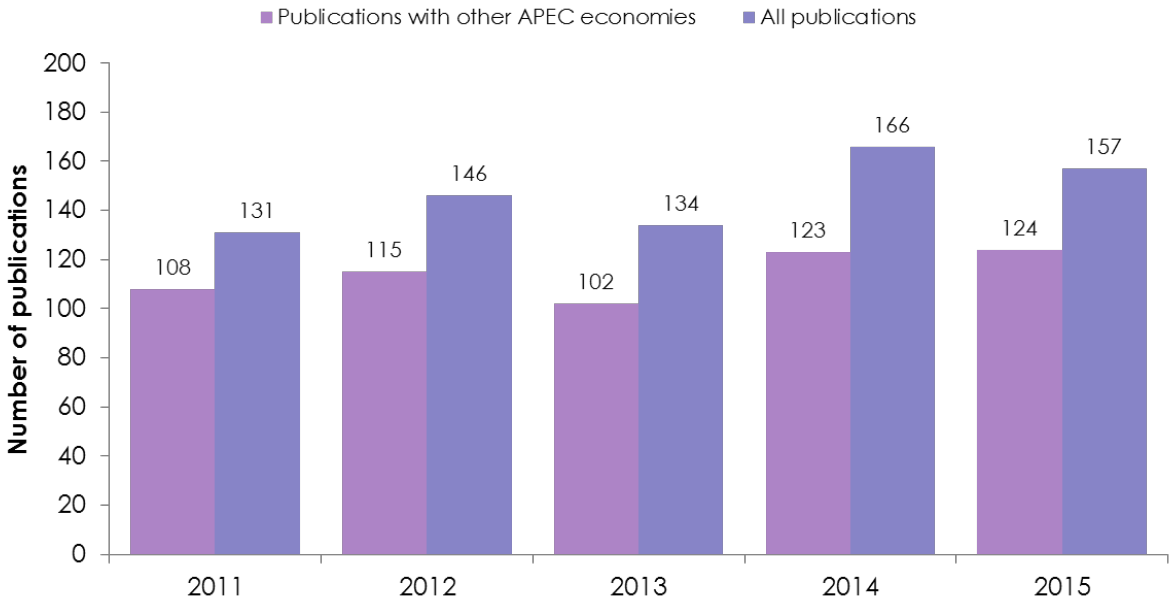

Figure 80: All Papua New Guinean publications and Papua New Guinean publications co-authored with another APEC economy

Figure 81 shows that only 22 per cent of all Papua New Guinean research publications did not include co-authors from other APEC economies. Around 55 per cent of all publications have co-authors from just one other APEC economy, 16 per cent have co-authors from two other APEC economies, and around six per cent have co-authors from three or more other APEC economies.

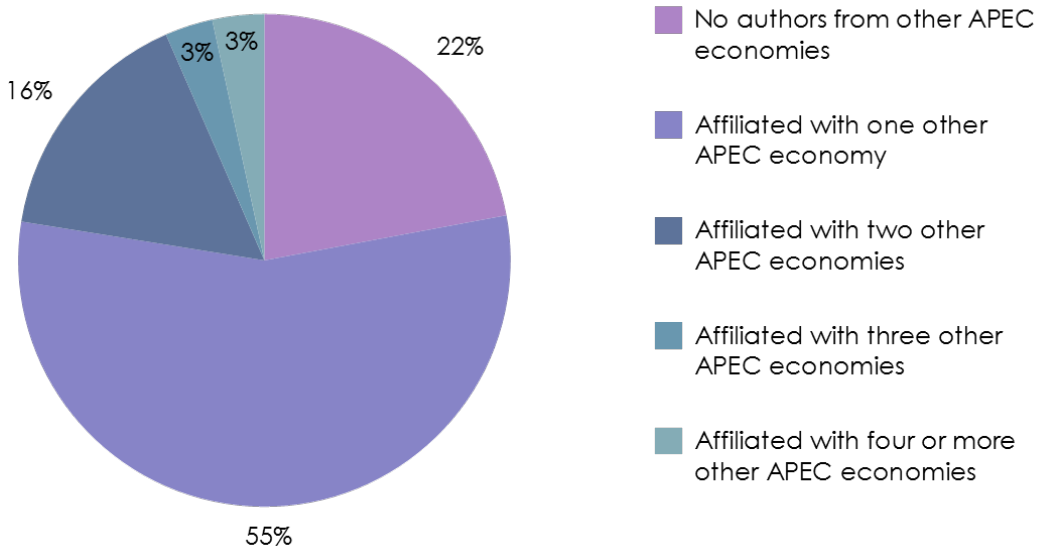

Figure 81: Proportion of all Papua New Guinean publications co-authored with one or more other APEC economies (2011-2015)

As shown in Figure 82, the level of cross-border co-authorship varies by subject area. Because of the relatively small number of publications by Papua New Guinean researchers, these figures should be interpreted with caution. The greatest number of co-authored publications occur in medicine (306) and agricultural and biological sciences (157).

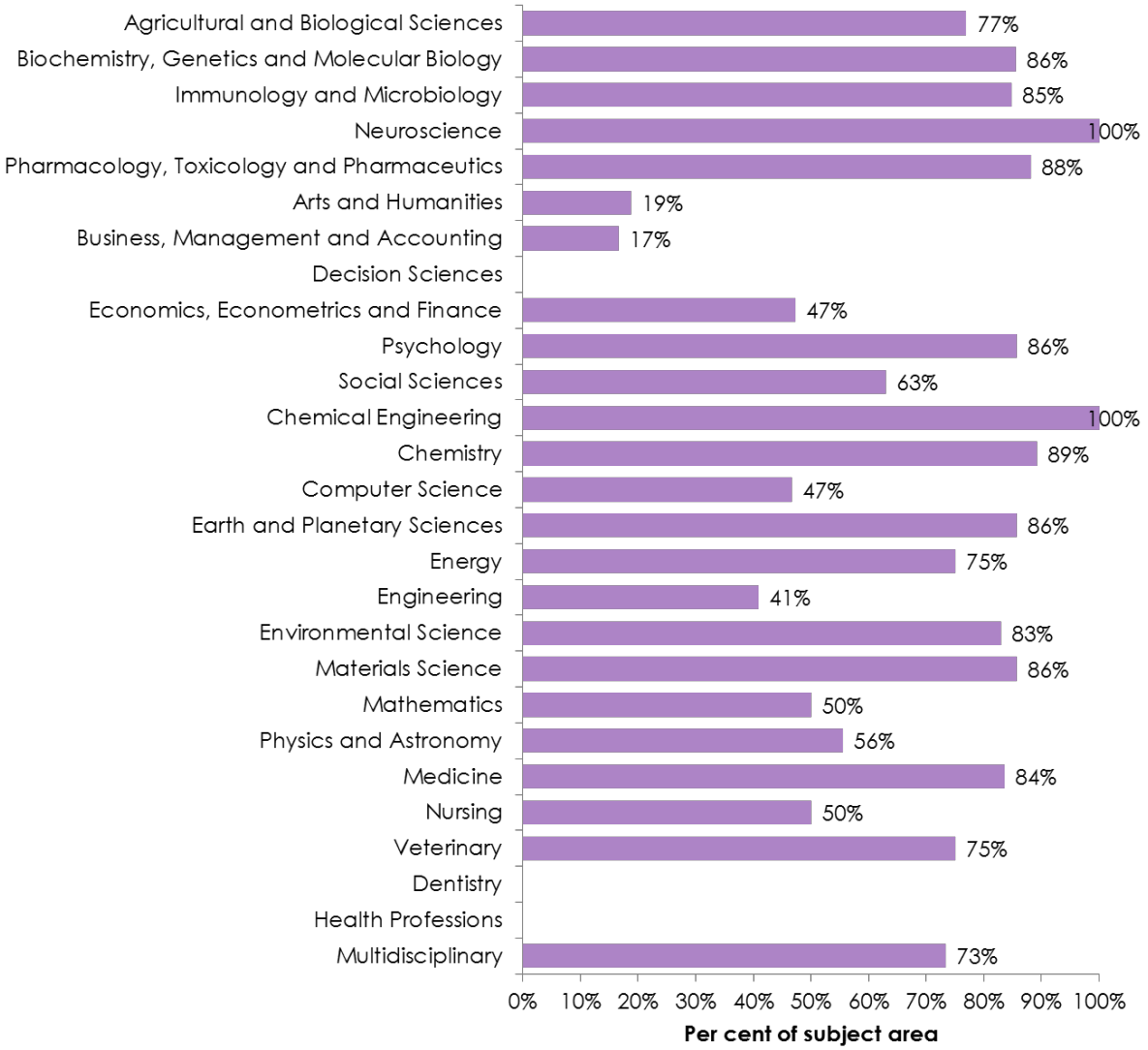

Figure 82: Proportion of Papua New Guinean publications co-authored with another APEC economy by subject area (2011-2015)

Peru

Between 1960 and 2015, more than 16 000 documents affiliated with researchers from Peru were published and included in Scopus's index. Figure 83 Figure 83 highlights the strong level of growth in publication by Peruvian researchers since the early 2000s. Although, as shown in Figure 83, the proportion of all documents that have been written by Peruvian researchers is quite small, it appears to be increasing slightly. Between 2011 and 2015, around 7 500 documents had a Peruvian affiliation. This represents less than 0.1 per cent of all publications worldwide.

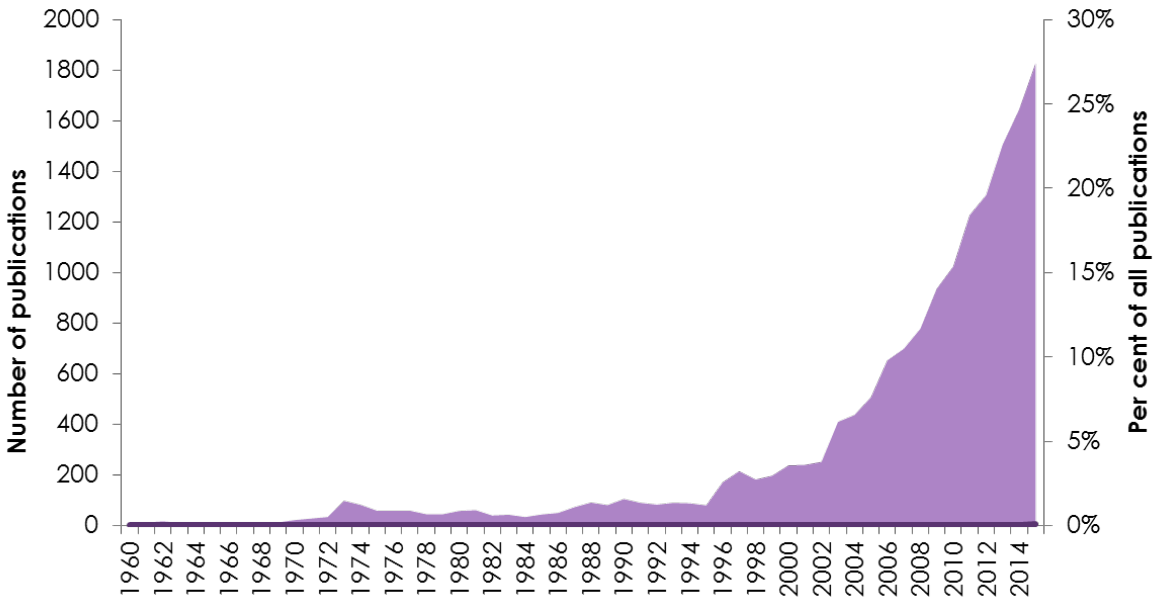

Figure 83: Number and proportion of publications affiliated with Peru

According to analyses conducted by SCImago (2016m), in 2014, 72 per cent of all papers affiliated with Peru had cross-border co-authors. Figure 84 lists the ten economies with which Peruvian researchers most frequently co-authored research publications. This shows that between 2011 and 2015, 35 per cent of all Peruvian publications included co-authors from United States.

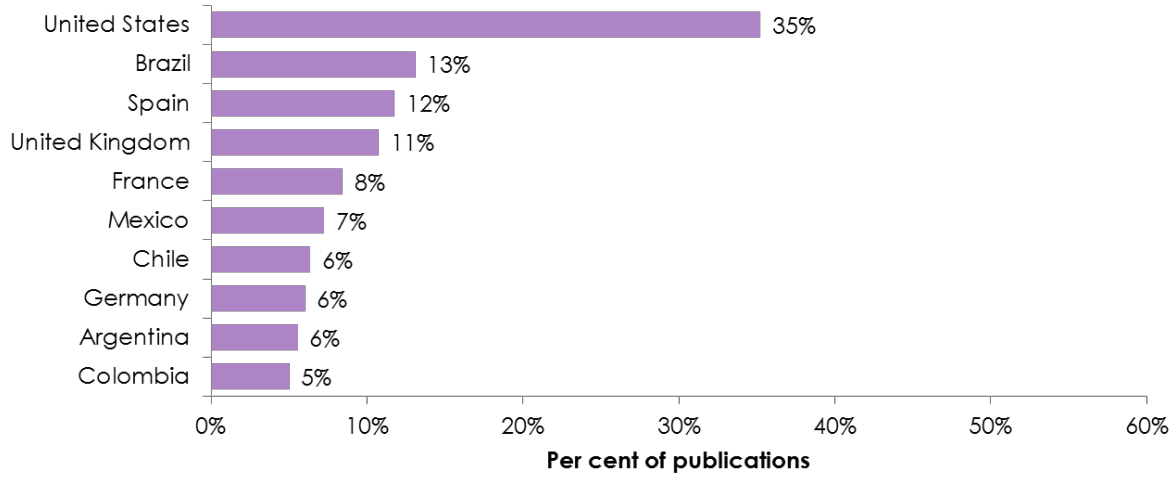

Figure 84: Most common cross-border co-authorship for Peruvian publications (2011-2015)

Mirroring the large level of growth in publication by Peruvian researchers is the growth in cross-border co-authorship between Peruvian researchers and researchers from other APEC economies (Figure 85). Between 2011 and 2015, 3 391 publications were co-authored by researchers from Peru and from other APEC economies, representing 45 per cent of all publications by Peruvian researchers.

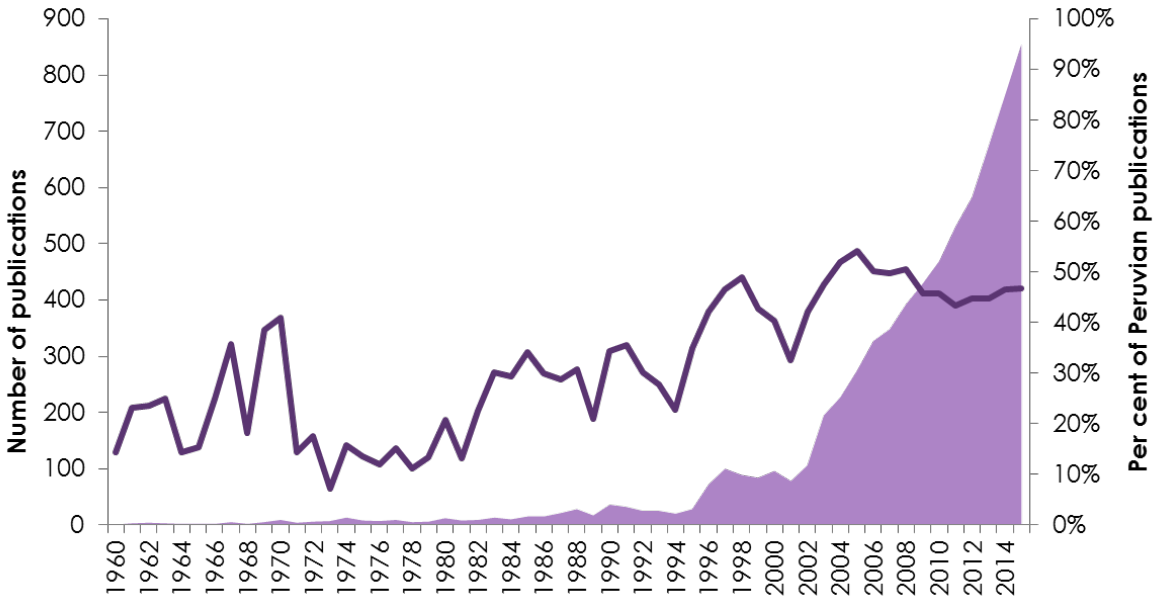

Figure 85: Number and proportion of Peruvian publications co-authored with other APEC economies

Table 19 lists the number of publications that researchers affiliated with Peru have co-authored with researchers from other APEC economies along with the proportion of all Peruvian publications that these numbers represent. This shows that the most frequent cross-border co-authorship takes place with researchers from the United States; Mexico; and Chile.

Table 19: Number and proportion of Peruvian publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	249	3
Brunei Darussalam	2	0
Canada	322	4
Chile	475	6
China	276	4
Hong Kong, China	39	1
Indonesia	50	1
Japan	308	4
Korea	182	2
Malaysia	51	1
Mexico	536	7
New Zealand	67	1
Papua New Guinea	6	0
Philippines	57	1
Russia	181	2
Singapore	46	1
Chinese Taipei	47	1

Other APEC Economies	Publications	
	#	%
Thailand	143	2
United States	2 640	35
Viet Nam	41	1

Figure 86 shows the number of documents being published by Peruvian researchers is increasing year-on-year. This increase is also seen in the number of documents being co-authored with researchers from other APEC economies. Between 2011 and 2015, the number of publications co-authored with researchers from other APEC economies has increased by 60 per cent.

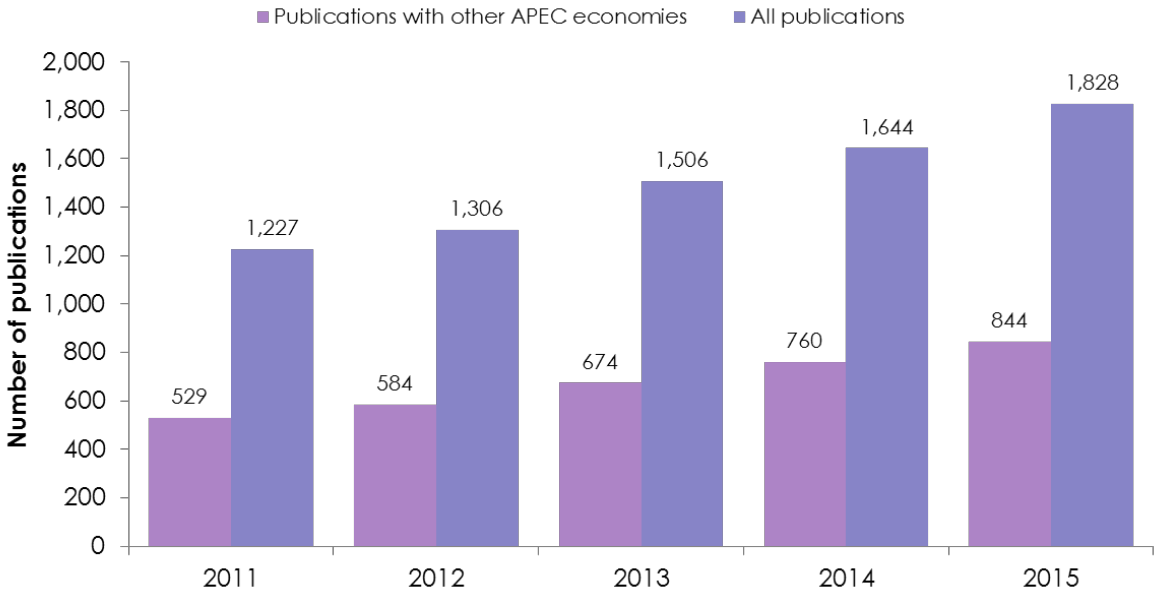

Figure 86: All Peruvian publications and Peruvian publications co-authored with another APEC economy

As shown in, Figure 87, around 55 per cent of all publications affiliated with Peru did not have a co-author from another APEC economy. Around a third were co-authored with researchers from just one other APEC economy, and around nine per cent included co-authors from two or more other APEC economies.

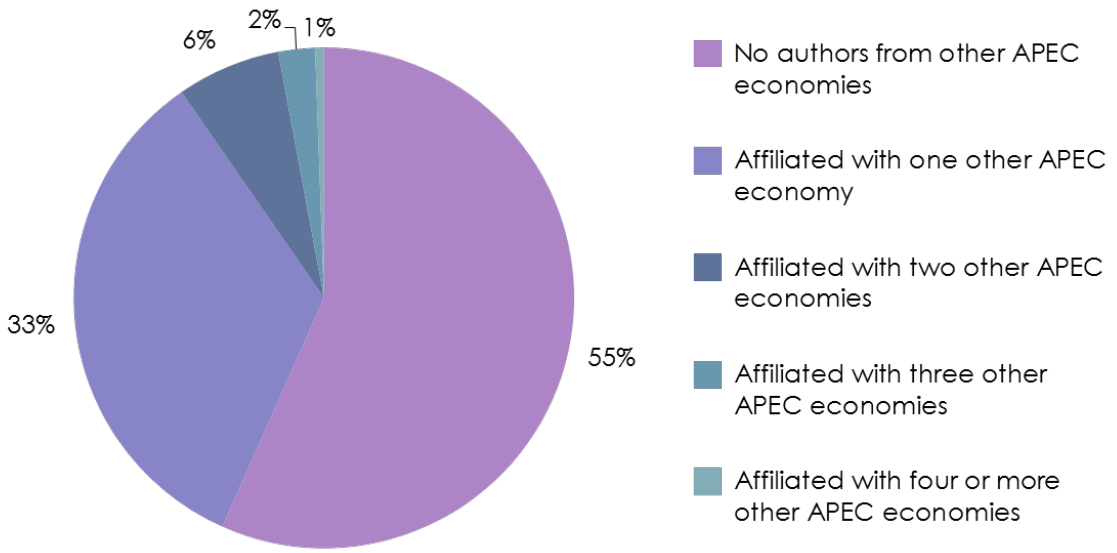

Figure 87: Proportion of all Peruvian publications co-authored with one or more other APEC economies (2011-2015)

As with other economies, the level of cross-border co-authorship varied by subject area. As shown in Figure 88, 60 per cent or more of all publications in the multidisciplinary; immunology and microbiology; nursing; and biochemistry, genetics and molecular biology subject areas included co-authors from other APEC economies. The greatest number of publications co-authored with researchers from other APEC economies was in the subject area of medicine (1 720 papers).

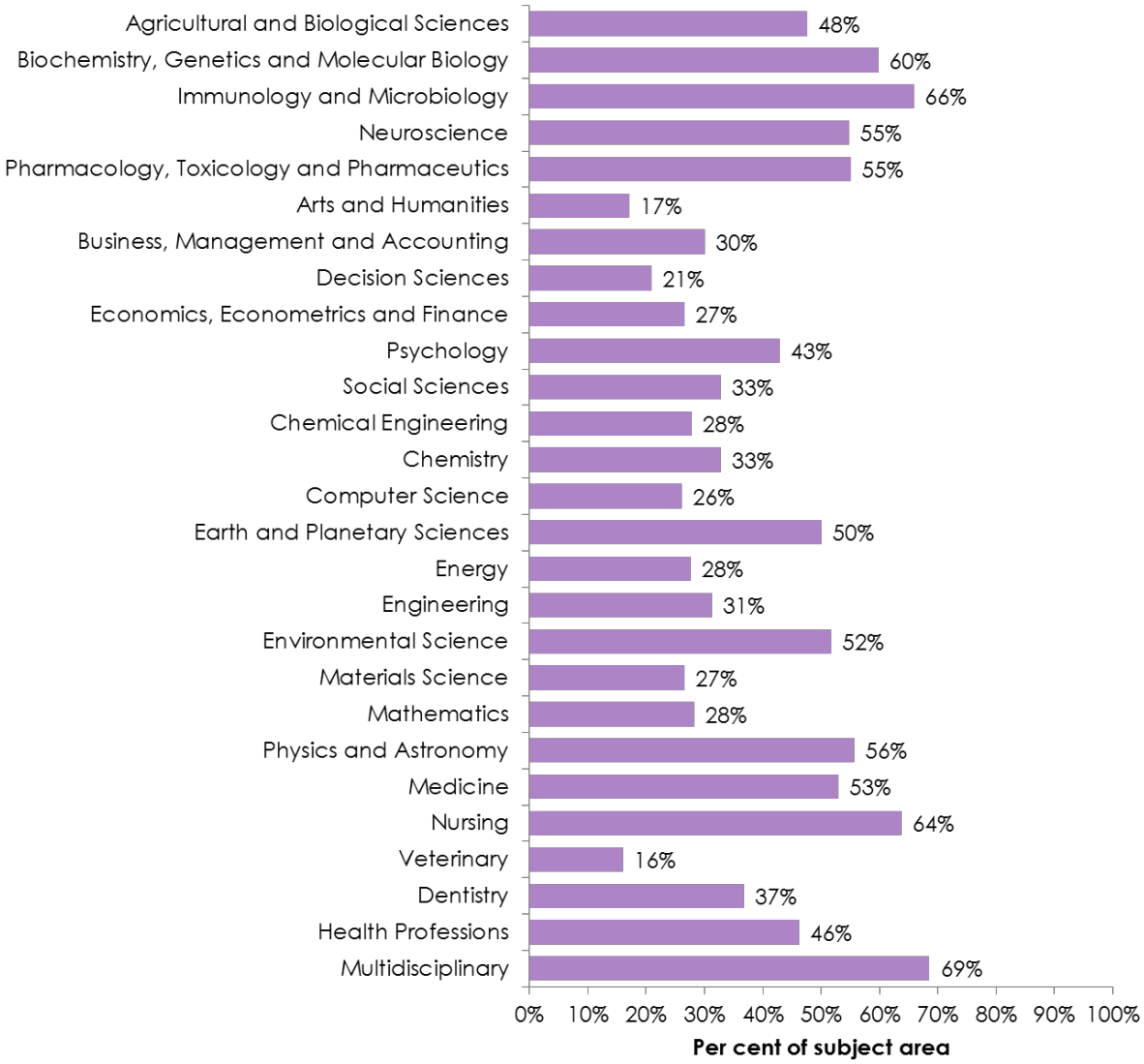

Figure 88: Proportion of Peruvian publications co-authored with another APEC economy by subject area (2011-2015)

The Philippines

Between 1960 and 2015, close to 24 000 documents affiliated with the Philippines were published and indexed by Scopus. Figure 89 shows the number of documents published during this period by researchers affiliated with the Philippines and highlights the strong level of growth in publication over the past decade. Figure 89 also shows the proportion of all documents published that are affiliated with the Philippines. Although only a very small proportion of all documents are authored by Filipino researchers, this proportion appears to be increasing slightly in recent years. Between 2011 and 2015, around 9 000 research publications were affiliated with the Philippines, representing around 0.1 per cent of all publications.

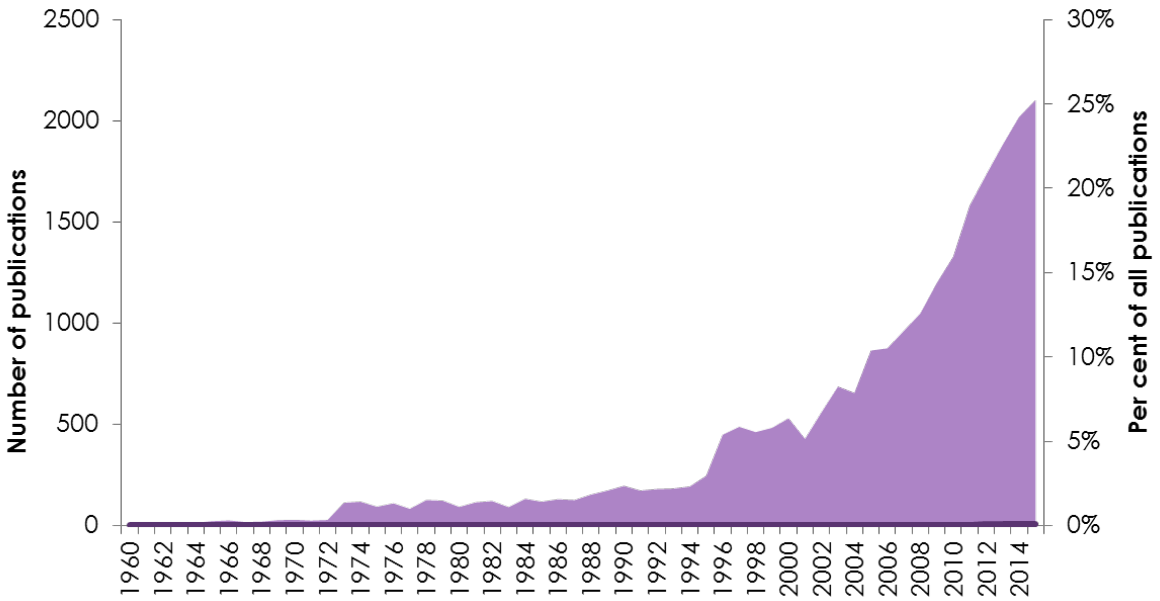

Figure 89: Number and proportion of publications affiliated with the Philippines

In 2014, 60 per cent of papers published by researchers from the Philippines had cross-border co-authors (SCImago, 2016n). As shown in Figure 90, between 2011 and 2015, cross-border co-authors were most commonly from the United States and Japan.

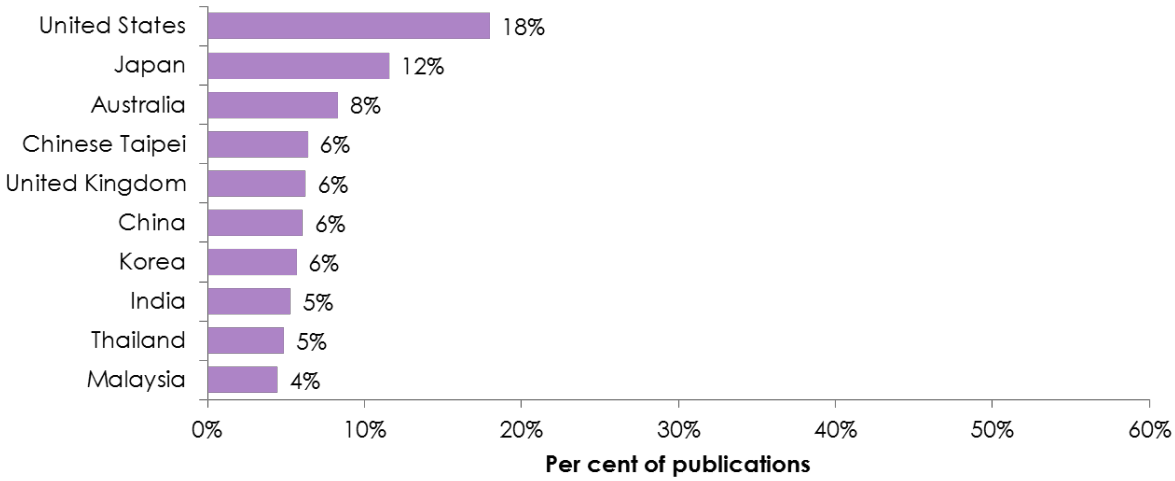

Figure 90: Most common cross-border co-authorship for Philippine publications (2011-2015)

Echoing the overall growth in research publication by researchers from the Philippines is the growth in cross-border co-authorship between Filipino researchers and researchers from other APEC economies, as shown in Figure 91. This also shows that since the mid-1970s the proportion of all Philippine documents co-authored with researchers from other APEC economies has been trending upwards. Between 2011 and 2015, a total of 4 366 papers were co-authored by researchers from the Philippines and from other APEC economies, representing 47 per cent of all Philippine publications.

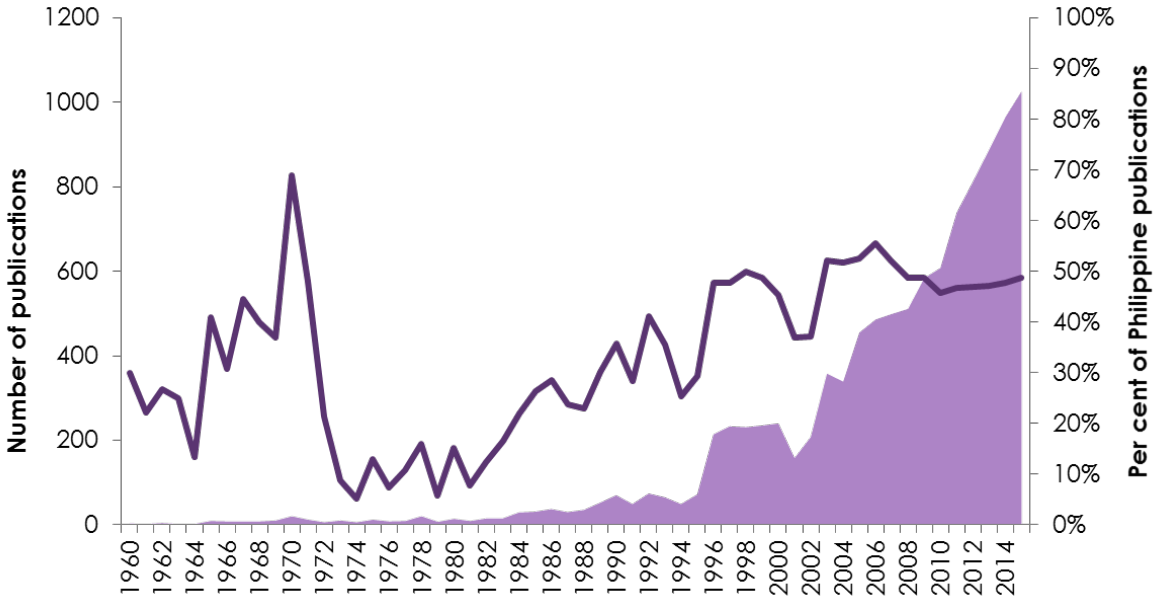

Figure 91: Number and proportion of Philippine publications co-authored with other APEC economies

Table 20 lists the number of publications that researchers from the Philippines have co-authored with researchers affiliated with each of the other APEC economies between 2011 and 2015. It also shows the proportion of all Philippine publications that these numbers represent. This indicates that the most frequent cross-border co-authorship occurs with researchers from the United States and Japan.

Table 20: Number and proportion of Philippine publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	759	8
Brunei Darussalam	15	0
Canada	232	2
Chile	45	0
China	551	6
Hong Kong, China	192	2
Indonesia	302	3
Japan	1 072	12
Korea	516	6
Malaysia	411	4
Mexico	129	1
New Zealand	137	1
Papua New Guinea	23	0
Peru	57	1
Russia	84	1

Other APEC Economies	Publications	
	#	%
Singapore	350	4
Chinese Taipei	590	6
Thailand	444	5
United States	1 648	18
Viet Nam	209	2

The number of publications affiliated with the Philippines has been steadily increasing year-on-year, as shown in Figure 92. At the same time, the number of papers co-authored with researchers from other APEC economies has also steadily risen. Between 2011 and 2015, the number of publications that Filipino researchers have co-authored with researchers from other APEC economies has increased by 38 per cent.

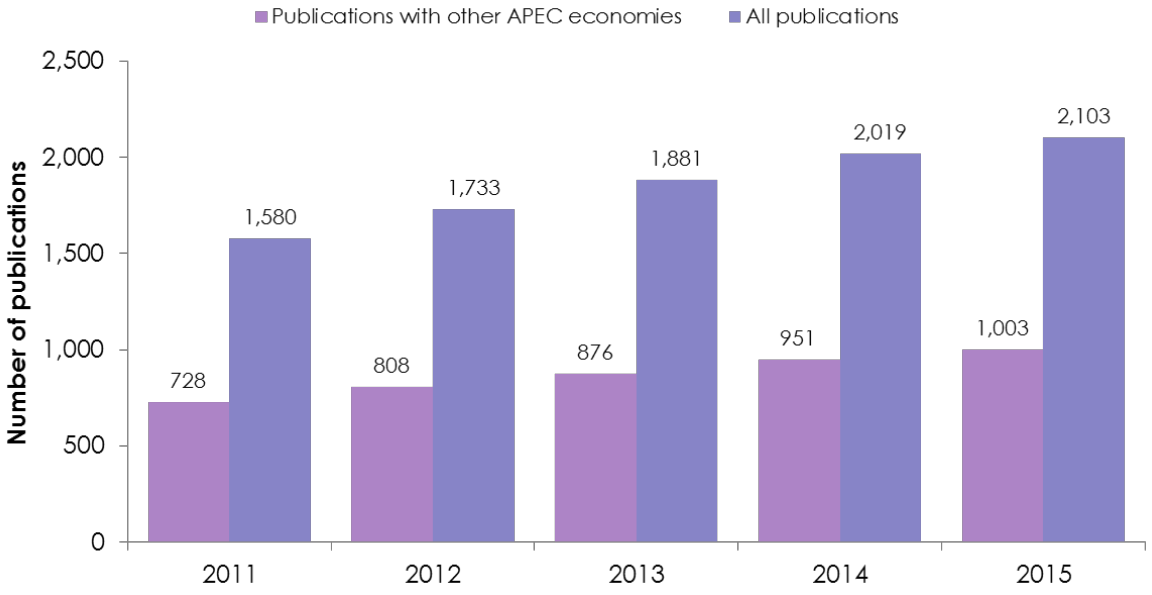

Figure 92: All Philippine publications and Philippine publications co-authored with another APEC economy

As shown in Figure 93, just over half of all documents affiliated with the Philippines did not have a co-author from another APEC economy. Around a third included co-authors from just one other APEC economy, and around 14 per cent had co-authors from two or more other APEC economies.

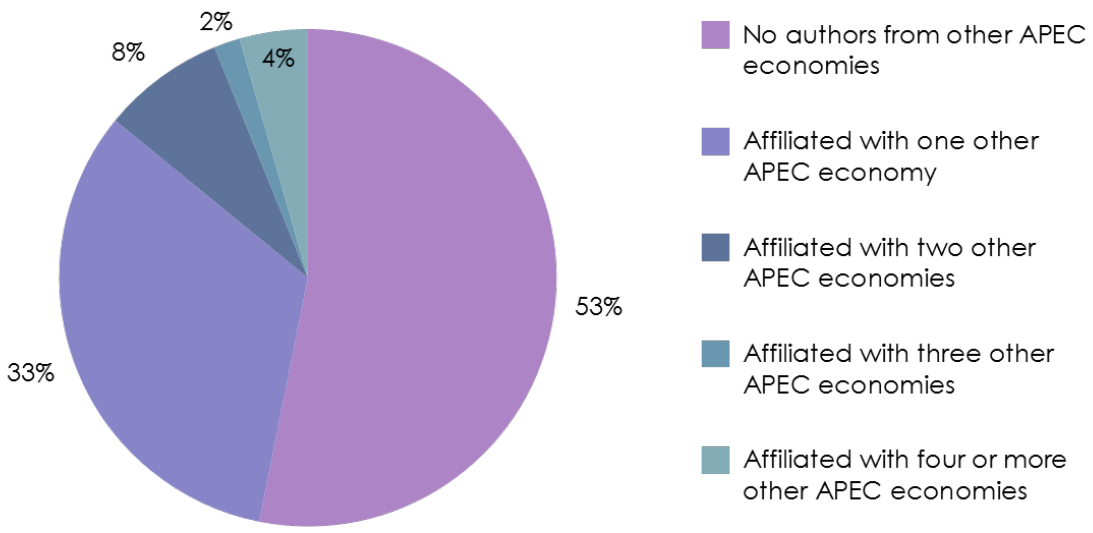

Figure 93: Proportion of all Philippine publications co-authored with one or more other APEC economies (2011-2015)

As for other economies, the level of cross-border co-authorship varies by subject area. Figure 94 lists the proportion of all Philippine publications within a particular subject area that were co-authored with researchers from other APEC economies. The level of collaboration ranges from around seven per cent for the arts and humanities subject area, to 70 per cent or more for the subject areas of immunology and microbiology, and pharmacology, toxiology and pharmaceutics.

Figure 94: Proportion of Philippine publications co-authored with another APEC economy by subject area (2011-2015)

Russia

Between 1960 and 2015, more than 1.1 million documents affiliated with Russia were published and indexed by Scopus. Figure 95 shows the strong growth in publication since the early 1990s around the time the Soviet Union was dissolved. This also shows the proportion of all documents that were published by Russian researchers between 1960 and 2015. This suggests that the level of publication has ebbed and flowed over the past decades, and peaked in the mid-1970s. Between 2011 and 2015, close to 250 000 documents were published by researchers from Russia, representing close to two per cent of all research output.

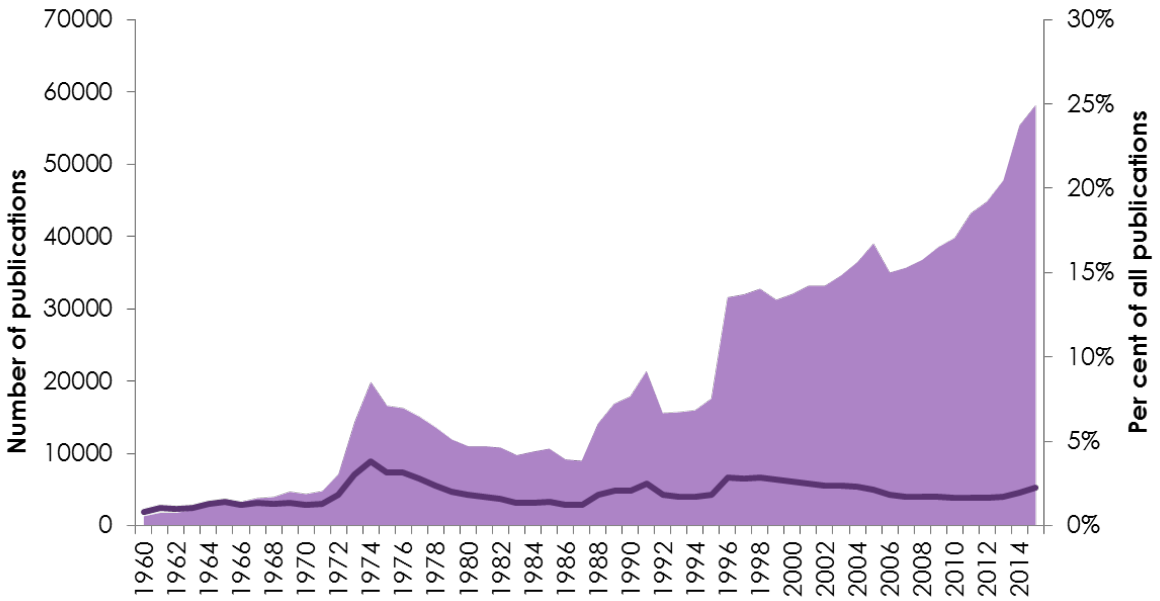

Figure 95: Number and proportion of publications affiliated with Russia

According to analyses by SCImago (2016o), in 2014 27 per cent of all documents published by Russian researchers had cross-border co-authors. Figure 96 lists the economies with which Russian researchers have co-authored the greatest number of publications between 2011 and 2015. Seven per cent of all publications affiliated with Russia were co-authored with researchers from the United States, and seven per cent were co-authored with researchers from Germany.

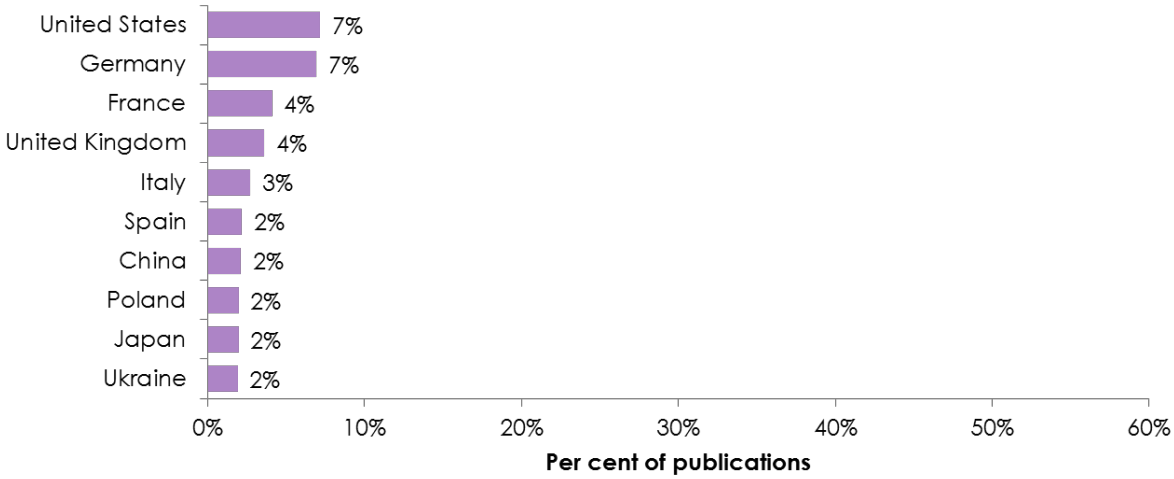

Figure 96: Most common cross-border co-authorship for Russian publications (2011-2015)

The number of documents co-authored by researchers from Russia and from other APEC economies has increased rapidly since the early 1990s, as shown in Figure 97. In addition to the growth in the overall number of documents with a cross-border co-author from another APEC economy, Figure 97 also highlights the growth in the proportion of Russian publications that include co-authors from other APEC economies .Between 2011 and 2015, a total of 28 123 documents were co-authored by

researchers from Russia and from other APEC economies, representing 11 per cent of all Russian publications.

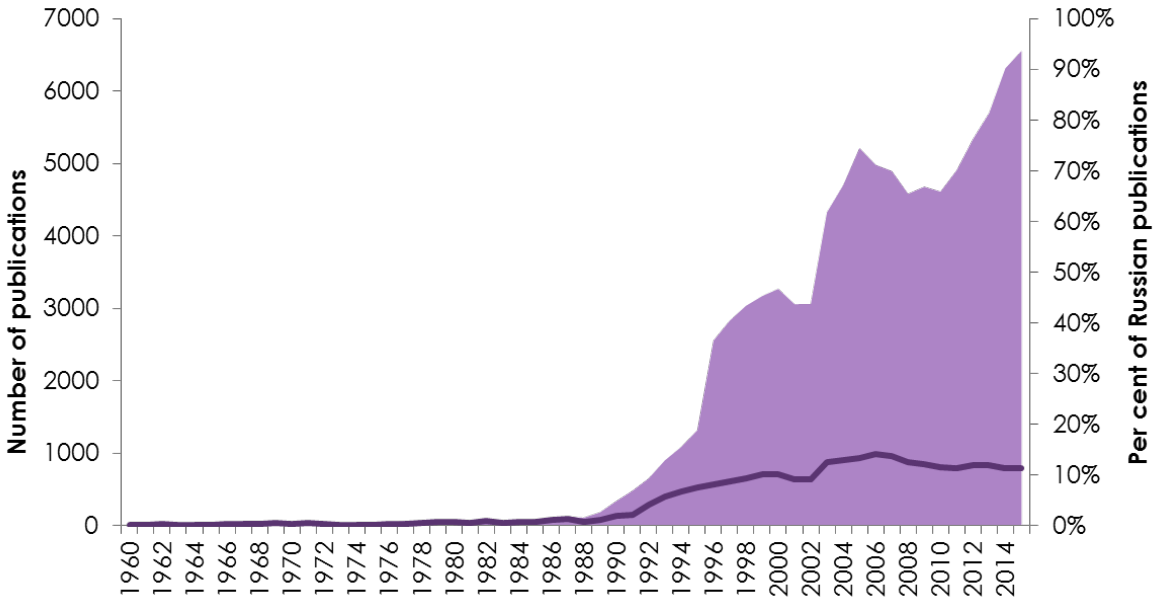

Figure 97: Number and proportion of Russian publications co-authored with other APEC economies

Table 21 lists the number of publications that Russian researchers have co-authored with researchers from each of the other APEC economies between 2011 and 2015. It also lists the proportion of all Russian publications that are co-authored with each of the other APEC economies. This indicates that the most frequent cross-border co-authorship occurs with researchers from the United States, China and Japan.

Table 21: Number and proportion of Russian publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	2 876	1
Brunei Darussalam	11	0
Canada	3 433	1
Chile	1 015	0
China	5 260	2
Hong Kong, China	365	0
Indonesia	66	0
Japan	4 872	2
Korea	2 732	1
Malaysia	404	0
Mexico	1 703	1
New Zealand	717	0
Papua New Guinea	8	0

Other APEC Economies	Publications	
	#	%
Peru	181	0
Philippines	84	0
Singapore	460	0
Chinese Taipei	2 099	1
Thailand	490	0
United States	17 227	7
Viet Nam	658	0

Figure 98 shows that the number of documents being published by researchers from Russia appears to be increasing year-on-year. This also shows that the number of documents being co-authored with researchers from other APEC economies is also increasing. Between 2011 and 2015, the number of documents co-authored with researchers from other APEC economies has increased by 32 per cent.

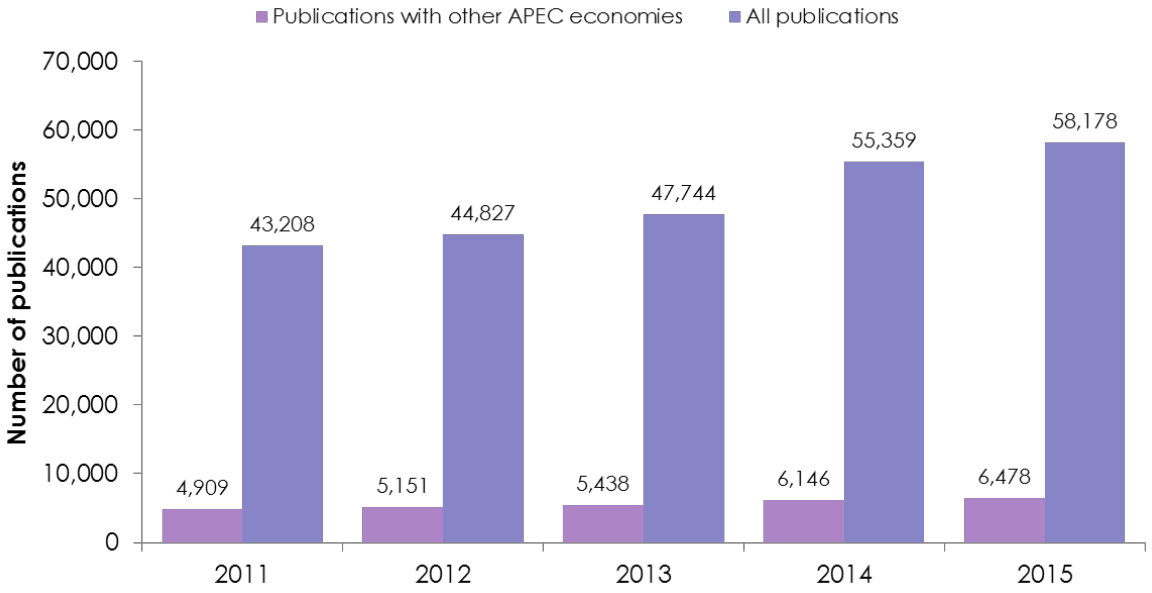

Figure 98: All Russian publications and Russian publications co-authored with another APEC economy

As shown in Figure 99, the vast majority of publications affiliated with Russia did not include a co-author from another APEC economy. Around nine per cent were co-authored with researchers from just one other APEC economy and around two per cent were co-authored with researchers from two or more other APEC economies.

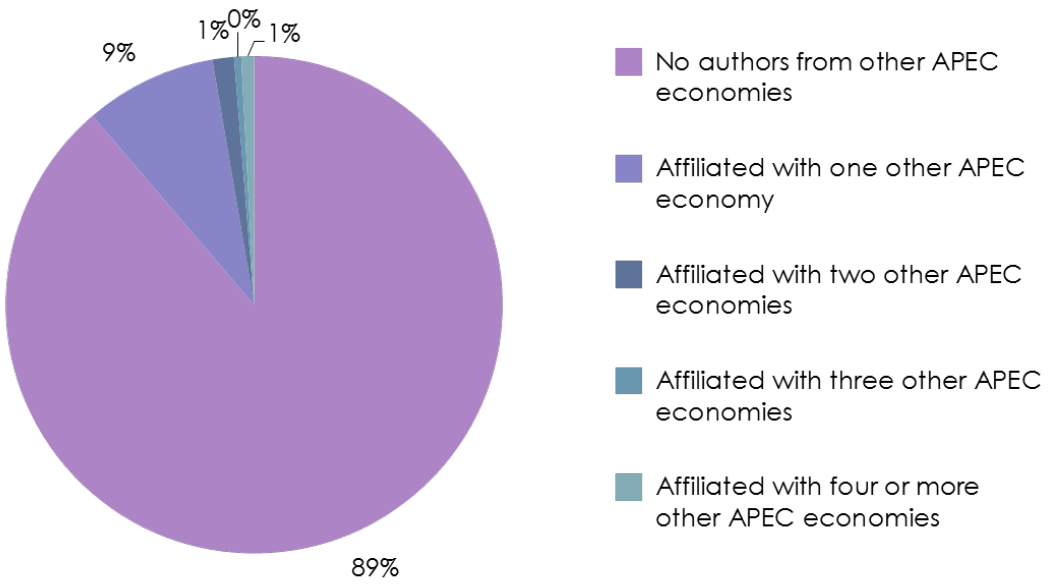

Figure 99: Proportion of all Russian publications co-authored with one or more other APEC economies (2011-2015)

The level of cross-border co-authorship with researchers from other APEC economies varies by subject level. As shown in Figure 100, dentistry had the highest proportion of cross-border co-authorship with researchers from other APEC economies. However, as only 32 articles were published in this subject area by Russian researchers, this does not represent a very large number of papers. Although only around 15 per cent of all documents published in the field of physics and astronomy were co-authored with researchers from other APEC economies, this represented 12 268 papers, which was by far the largest subject area in terms of the number of papers co-authored with researchers from other APEC economies.

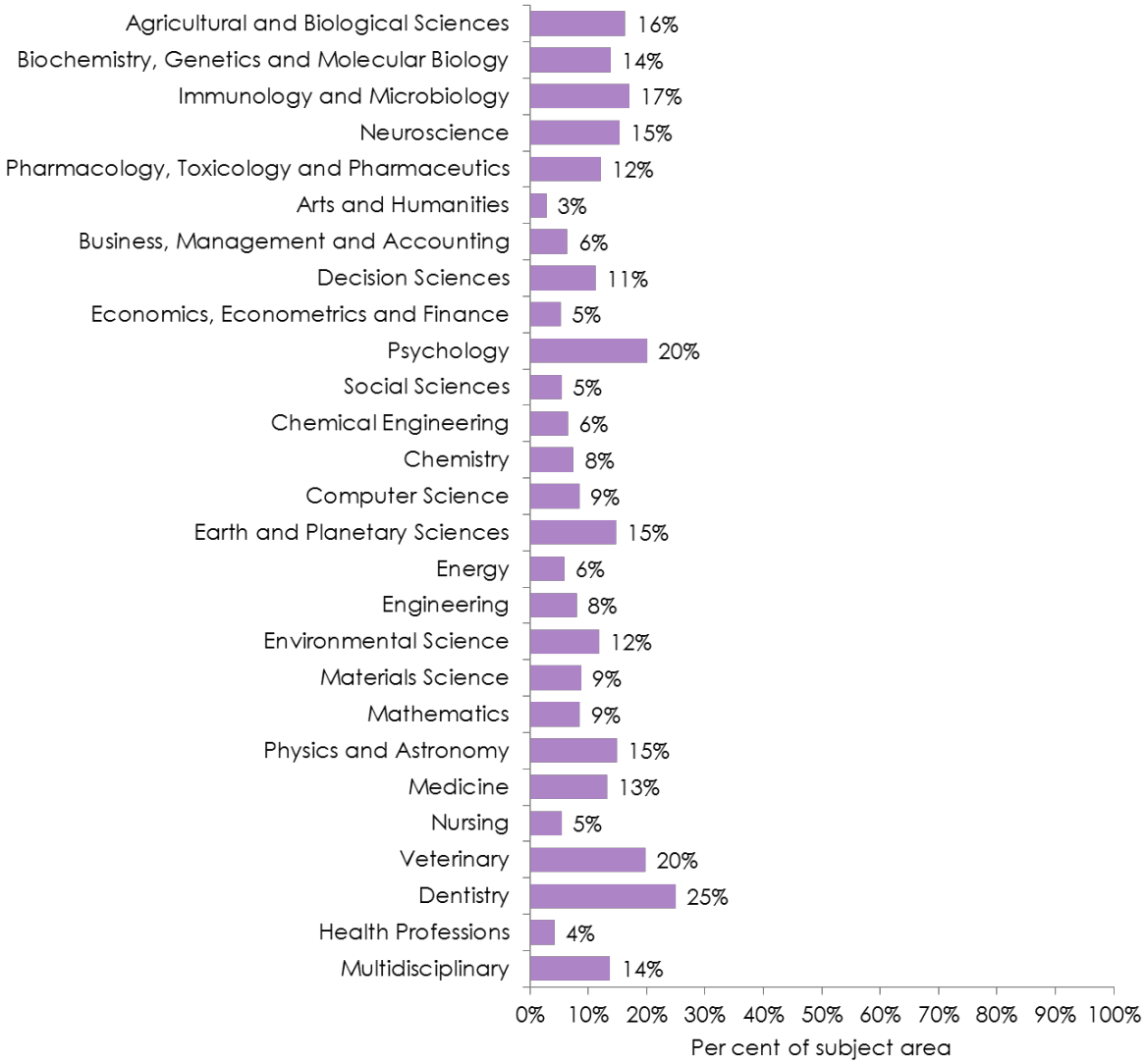

Figure 100: Proportion of Russian publications co-authored with another APEC economy by subject area (2011-2015)

Singapore

Between 1960 and 2015, more than 230 000 documents affiliated with Singapore were published and indexed by Scopus. Figure 101 highlights the strong level of growth in the number of documents published by researchers from Singapore over the past few decades. As well as an increase in the number of publications affiliated with Singapore, recent decades have also seen an increase in the proportion of all documents that are affiliated with Singapore. Between 2011 and 2015, almost 90 000 documents were affiliated with Singapore, representing 0.7 per cent of all documents indexed by Scopus.

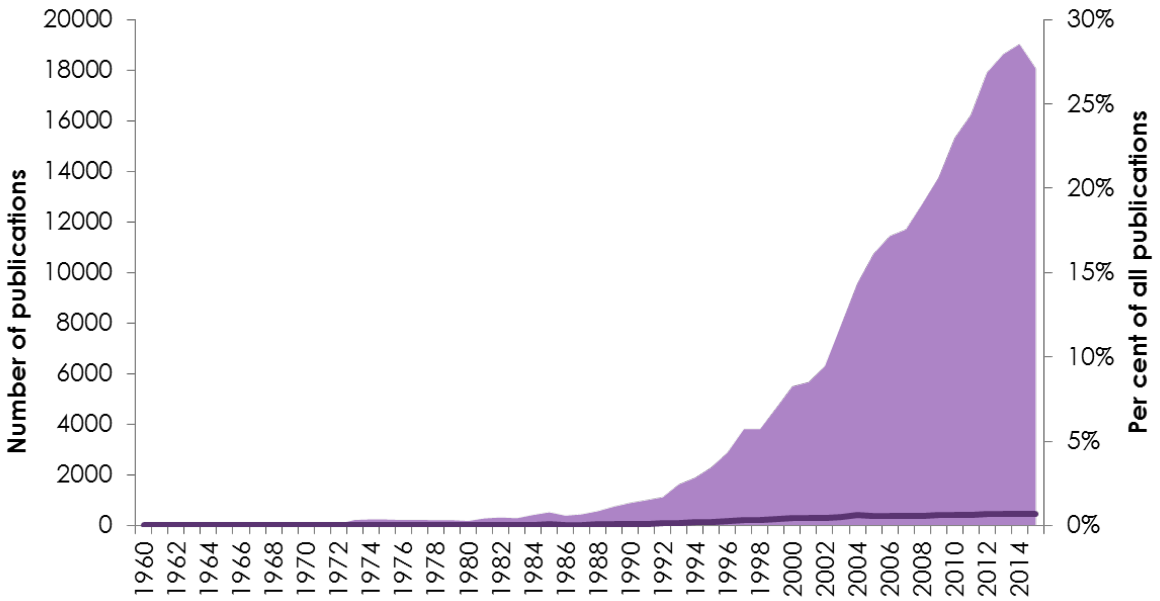

Figure 101: Number and proportion of publications affiliated with Singapore

According to analyses conducted by SCImago (2016p), in 2014, 60 per cent of Singaporean publications had cross-border co-authors. Figure 102 lists the ten economies with which Singaporean researchers most frequently co-authored publications. This indicates that between 2011 and 2015, 17 per cent of all papers affiliated with Singapore were co-authored with researchers from the United States, and 17 per cent with China.

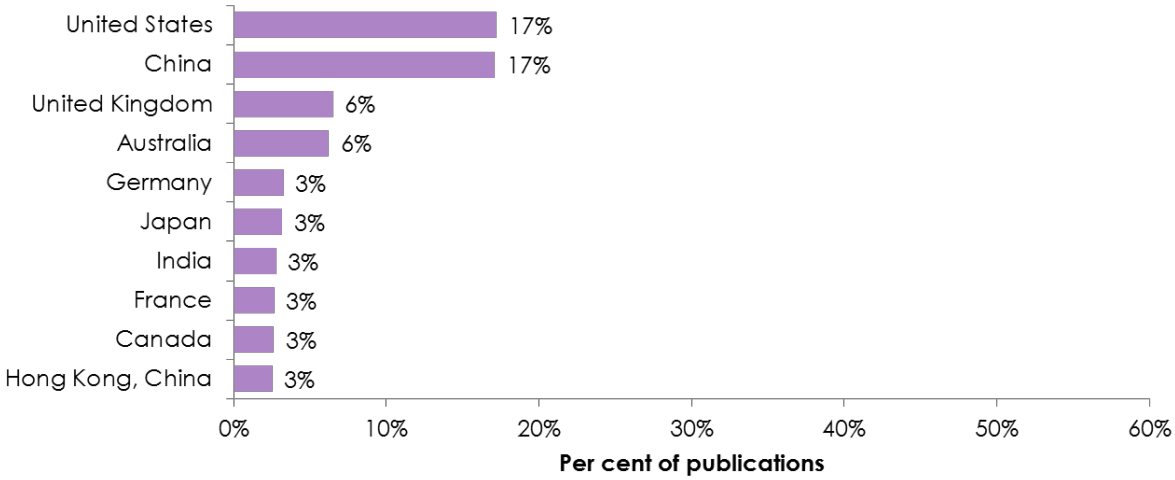

Figure 102: Most common cross-border co-authorship for Singaporean publications (2011-2015)

Figure 103 shows the number of publications that Singaporean researchers have co-authored with researchers from other APEC economies. This indicates that the amount of cross-border co-authorship with researchers in the APEC region has been increasing. As well as the growth in the overall number of publications co-authored with researchers from other APEC economies, the proportion of all Singaporean publication that this represents has been steadily increasing since the late 1970s, as shown

in Figure 103. Between 2011 and 2015, a total of 39 305 documents were co-authored by researchers from Singapore and from other APEC economies, representing 44 per cent of all Singaporean publications.

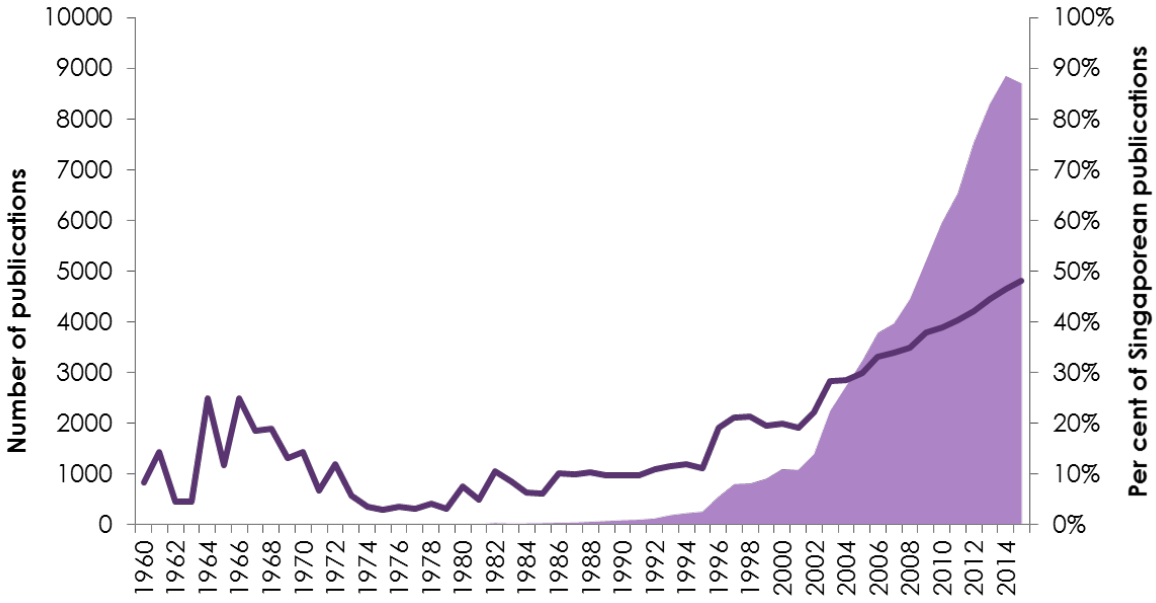

Figure 103: Number and proportion of Singaporean publications co-authored with other APEC economies

Table 22 lists the number of publications that Singaporean researchers have co-authored with researchers from each other APEC economy between 2011 and 2015. It also indicates the proportion of all Singaporean publications that these co-authored publications represent. This indicates that the most frequent cross-border co-authorship occurs with researchers from the United States and China.

Table 22: Number and proportion of Singaporean publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	5 552	6
Brunei Darussalam	84	0
Canada	2 350	3
Chile	104	0
China	15 256	17
Hong Kong, China	2 352	3
Indonesia	445	0
Japan	2 842	3
Korea	2 156	2
Malaysia	1 495	2
Mexico	231	0
New Zealand	824	1
Papua New Guinea	25	0

Other APEC Economies	Publications	
	#	%
Peru	46	0
Philippines	350	0
Russia	460	1
Chinese Taipei	1 604	2
Thailand	722	1
United States	15 101	17
Viet Nam	314	0

Figure 104 shows that the number of documents affiliated with Singapore is increasing annually, with a small drop seen in 2015. The number of documents that Singaporean researchers co-authored with researchers from other APEC economies is also increasing every year. Between 2011 and 2015, the number of publications co-authored by researchers from Singapore and other APEC economies has increased by 32 per cent.

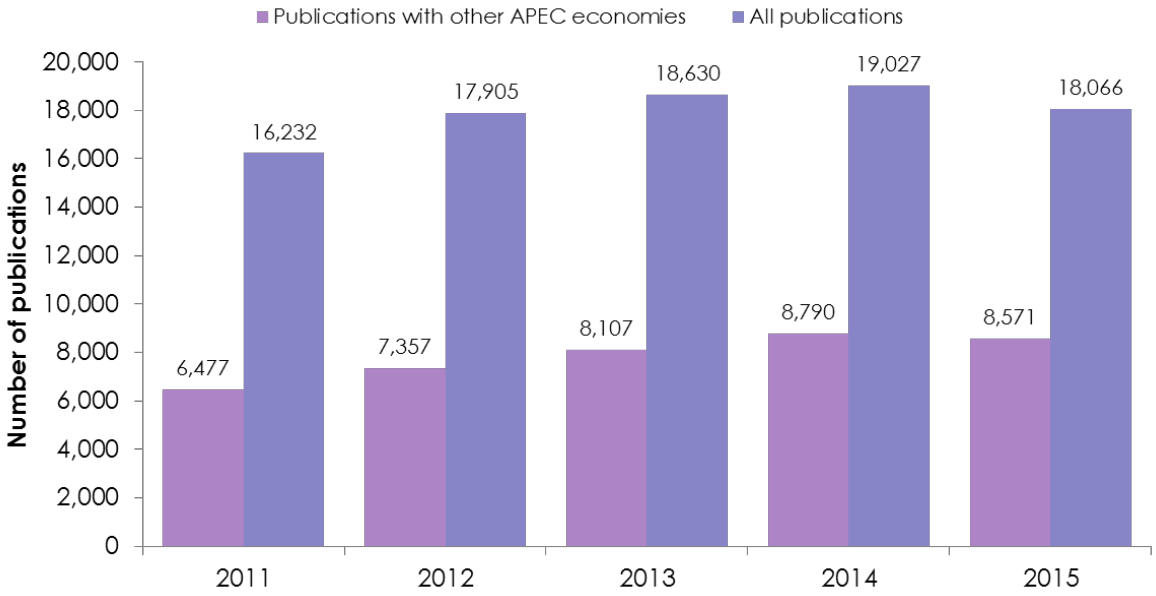

Figure 104: All Singaporean publications and Singaporean publications co-authored with another APEC economy

As shown in Figure 105, around 56 per cent of all publications affiliated with Singapore do not include co-authors from other APEC economies. Around 34 per cent include co-authors from just one other APEC economy, and around nine per cent include co-authors from two or more other APEC economies.

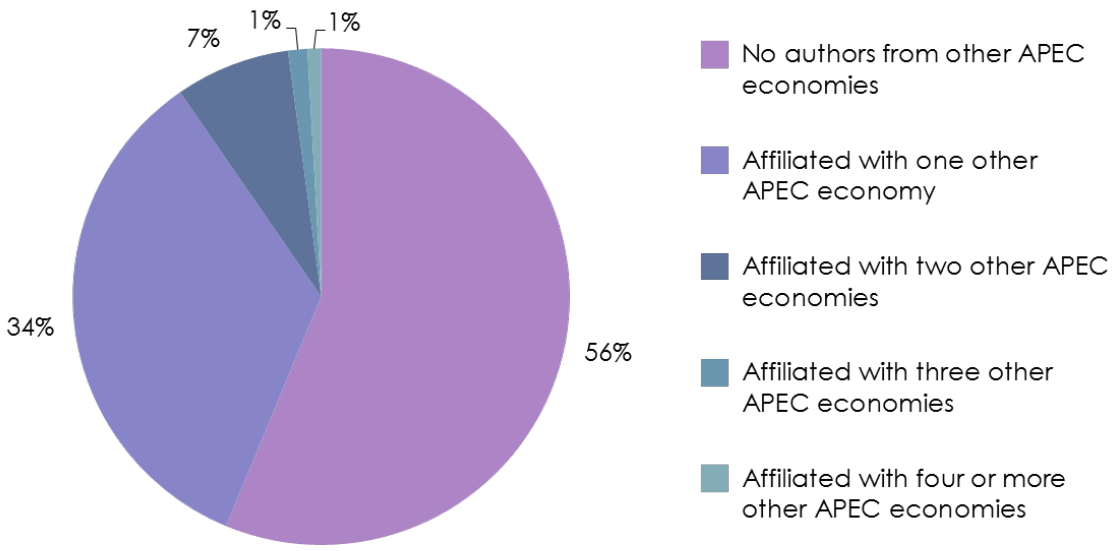

Figure 105: Proportion of all Singaporean publications co-authored with one or more other APEC economies (2011-2015)

The level of cross-border co-authorship with researchers from other APEC economies is greater for some subject areas than others, as shown in Figure 106. More than half of all publications affiliated with Singapore in the subject areas of decision sciences; earth and planetary sciences; dentistry; veterinary; neuroscience; agricultural and biological sciences; and multidisciplinary fields had cross-border co-authors from other APEC economies. Arts and humanities had the lowest level of collaboration with researchers from other APEC economies.

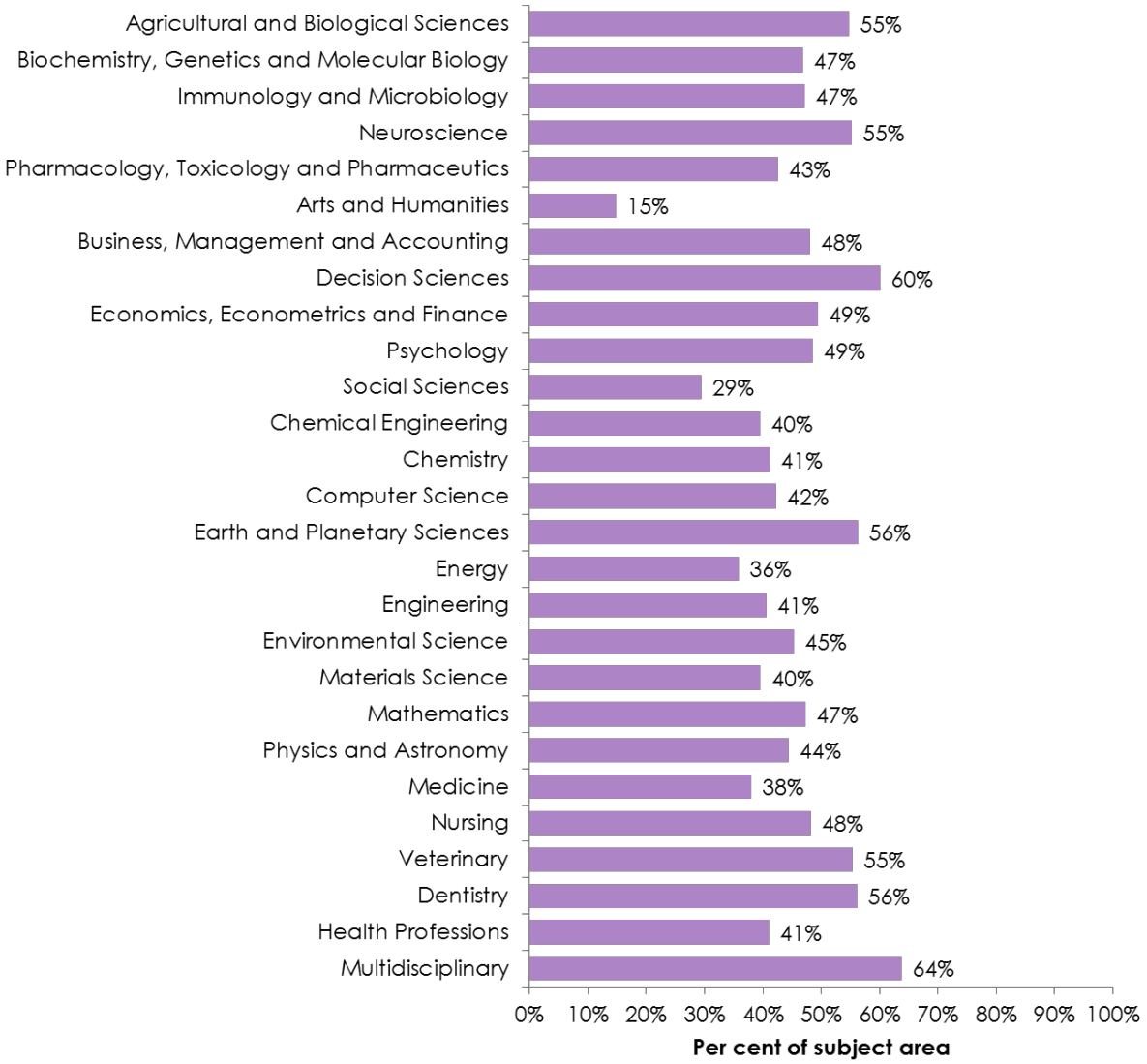

Figure 106: Proportion of Singaporean publications co-authored with another APEC economy by subject area (2011-2015)

Chinese Taipei

In the period from 1960 to 2015, more than 570 000 documents affiliated with researchers from Chinese Taipei were published and included in Scopus's index. Figure 107 shows the rapid increase in publication by Chinese Taipei researchers in the past few decades, which echoes the global increase in research publication. In addition to the growth in the overall number of documents being published by researchers from Chinese Taipei, the proportion of all documents published that this represents has also been increasing. Between 2011 and 2015, more than 200 000 publications were affiliated with Chinese Taipei, representing around 1.5 per cent of all publications.

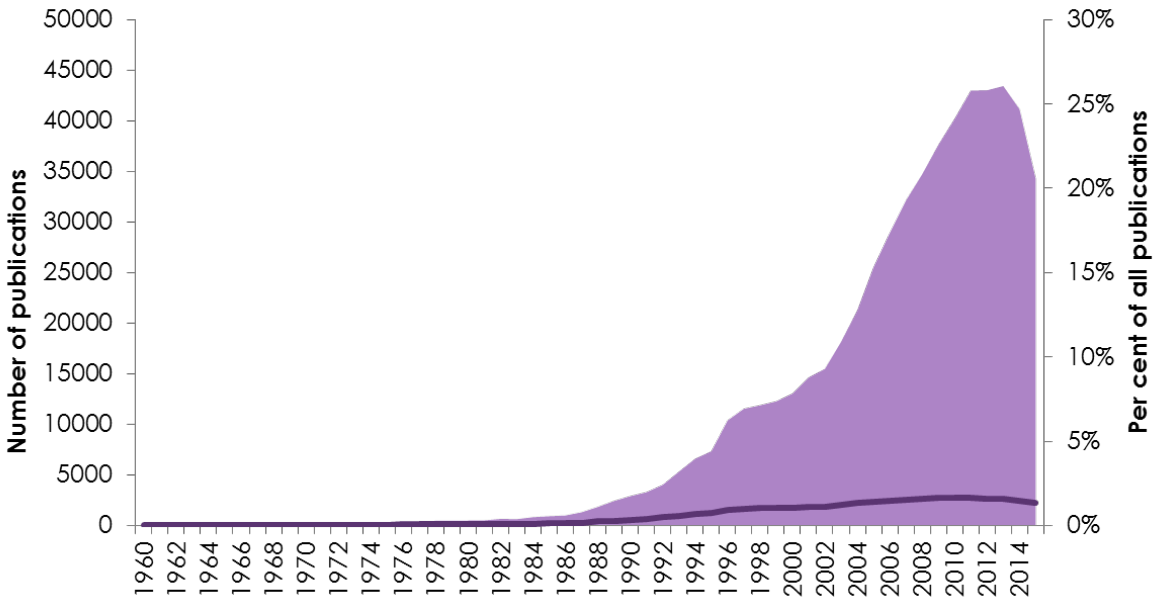

Figure 107: Number and proportion of publications affiliated with Chinese Taipei

In 2014, a quarter of all papers published by researchers from Chinese Taipei had cross-border co-authors (SCImago, 2016r). Figure 108 lists the ten economies with which Chinese Taipei researchers have co-authored the most publications. This indicates that between 2011 and 2015, 11 per cent of all publications by researchers from Chinese Taipei were co-authored with researchers from the United States.

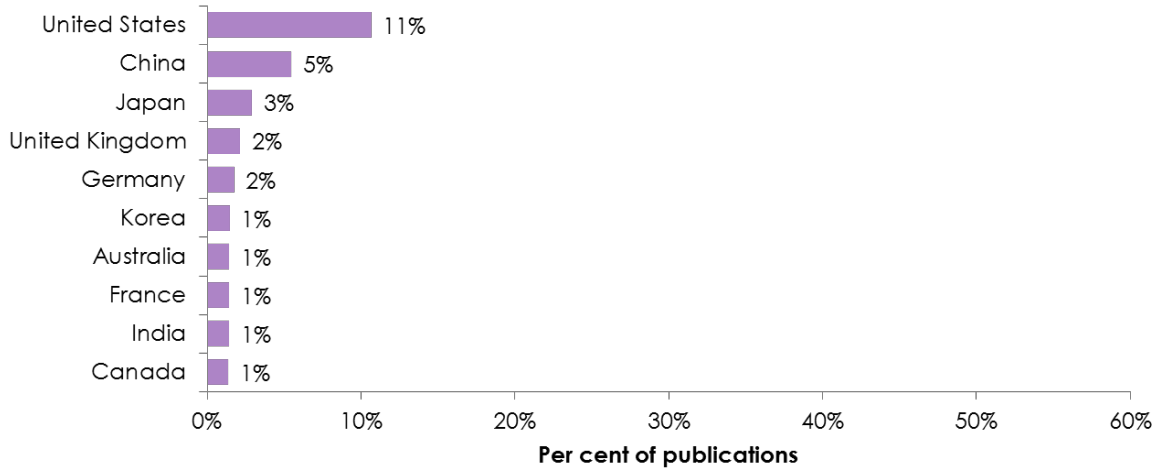

Figure 108: Most common cross-border co-authorship for Chinese Taipei publications (2011-2015)

Echoing the strong growth in overall research publication by researchers from Chinese Taipei is the strong growth in cross-border collaboration with researchers from other APEC economies (Figure 109). This also shows that the proportion of papers with cross-border co-authors from the APEC region has been steadily increasing in recent decades. Between 2011 and 2015, 39 907 documents were co-

authored with researchers from Chinese Taipei and other APEC economies, representing 19 per cent of all publications affiliated with Chinese Taipei.

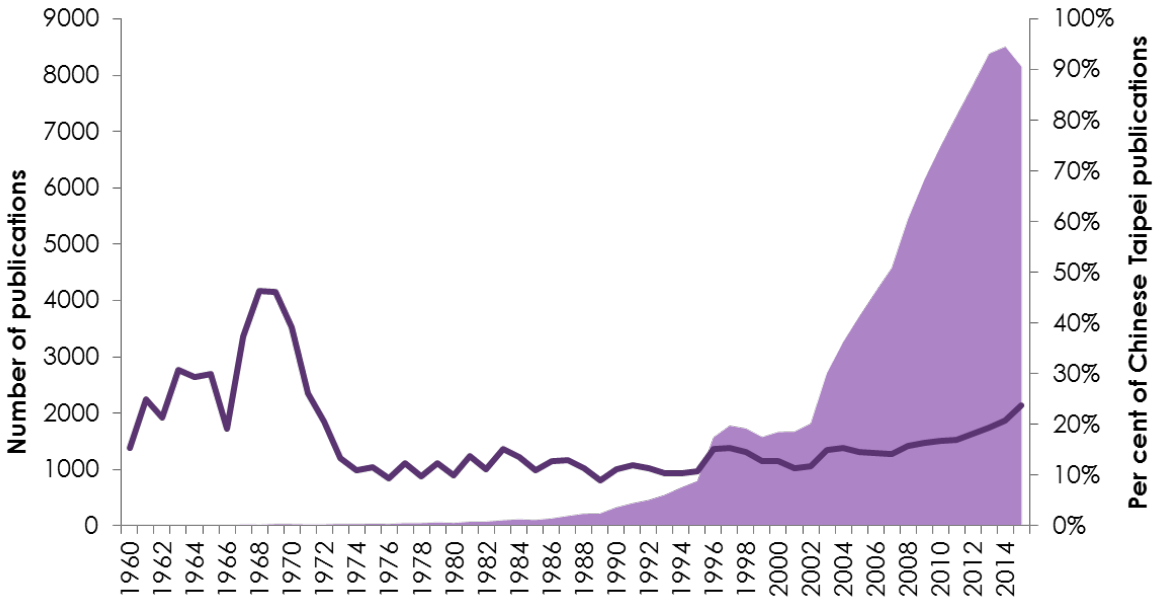

Figure 109: Number and proportion of Chinese Taipei publications co-authored with other APEC economies

Table 23 lists the number of papers that researchers affiliated with Chinese Taipei have co-authored with researchers from each of the other APEC economies. It also indicates the proportion of all Chinese Taipei documents that these numbers represent. This shows that the greatest level of cross-border co-authorship for researchers from Chinese Taipei takes place with researchers from the United States and China.

Table 23: Number and proportion of Chinese Taipei publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	2 940	1
Brunei Darussalam	23	0
Canada	2 787	1
Chile	827	0
China	11 245	5
Hong Kong, China	1 669	1
Indonesia	504	0
Japan	5 993	3
Korea	2 998	1
Malaysia	1 025	1
Mexico	864	0
New Zealand	808	0
Papua New Guinea	16	0

Other APEC Economies	Publications	
	#	%
Peru	47	0
Philippines	590	0
Russia	2 099	1
Singapore	1 604	1
Thailand	1 035	1
United States	21 641	11
Viet Nam	598	0

Figure 110 shows the number of documents published by researchers from Chinese Taipei and the number of documents co-authored with researchers from other APEC economies. There seems to be a slight dip in the number of documents affiliated with Chinese Taipei in the past two years. At the same time, the number of publications co-authored with researchers from other APEC economies appears to be increasingly gently. Between 2011 and 2015, the number of papers co-authored with researchers from other APEC economies increased by 12 per cent.

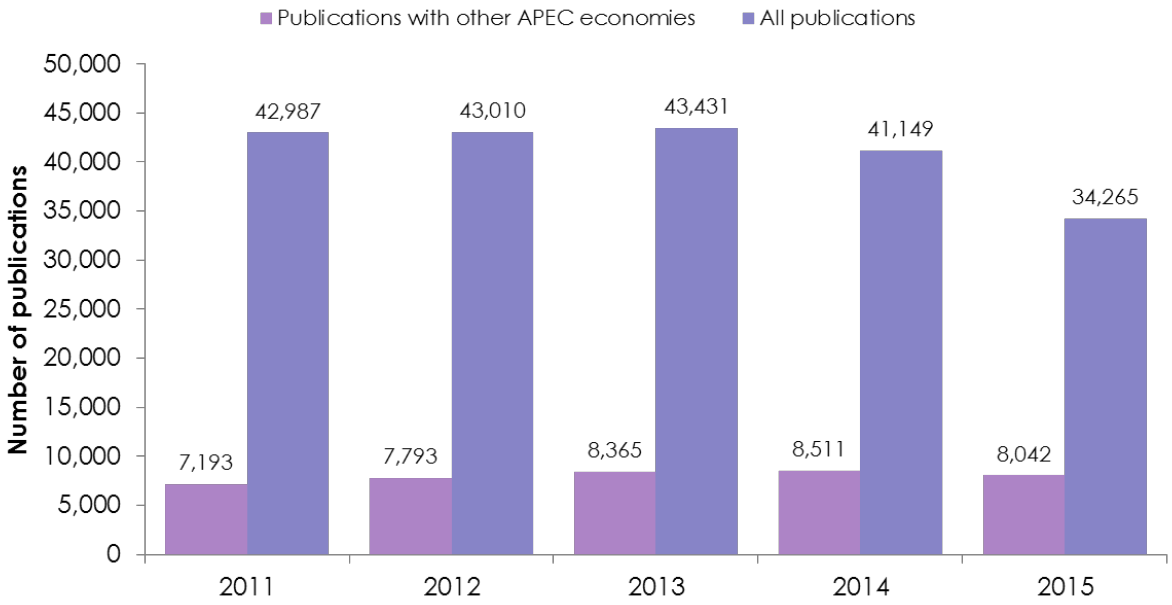

Figure 110: All Chinese Taipei publications and Chinese Taipei publications co-authored with another APEC economy

As shown in Figure 111, 81 per cent of all documents affiliated with Chinese Taipei did not have any co-authors from other APEC economies. Around 15 per cent of documents had co-authors from just one other APEC economy, and around five per cent had co-authors from two or more other APEC economies.

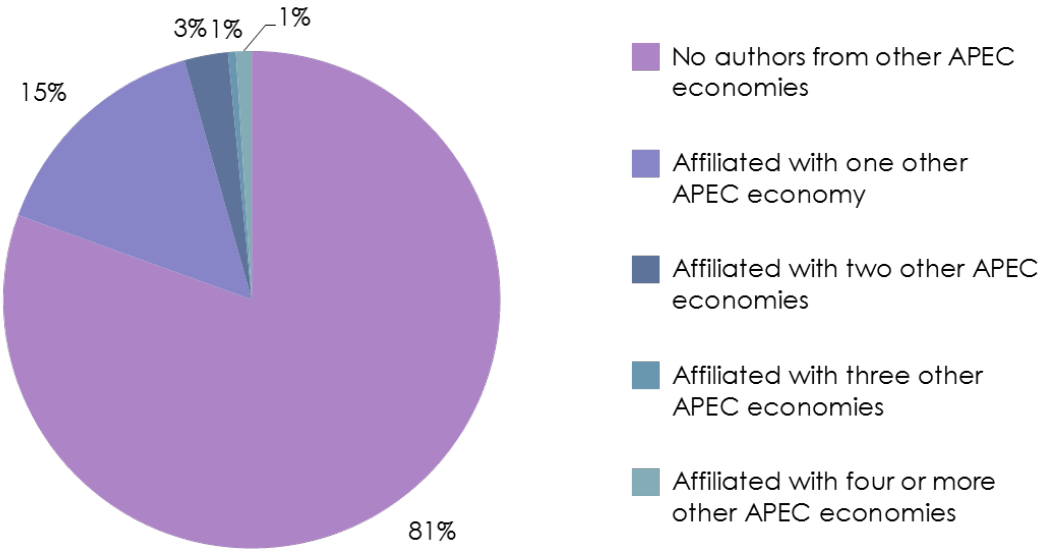

Figure 111: Proportion of all Chinese Taipei publications co-authored with one or more other APEC economies (2011-2015)

As for other economies, the level of cross-border co-authorship varies by subject area, as shown in Figure 112. Between 2011 and 2015, the greatest level of cross-border co-authorship with researchers from other APEC economies is seen for the subject area of earth and planetary sciences. The lowest level of cross-border co-authorship is seen for the arts and humanities field.

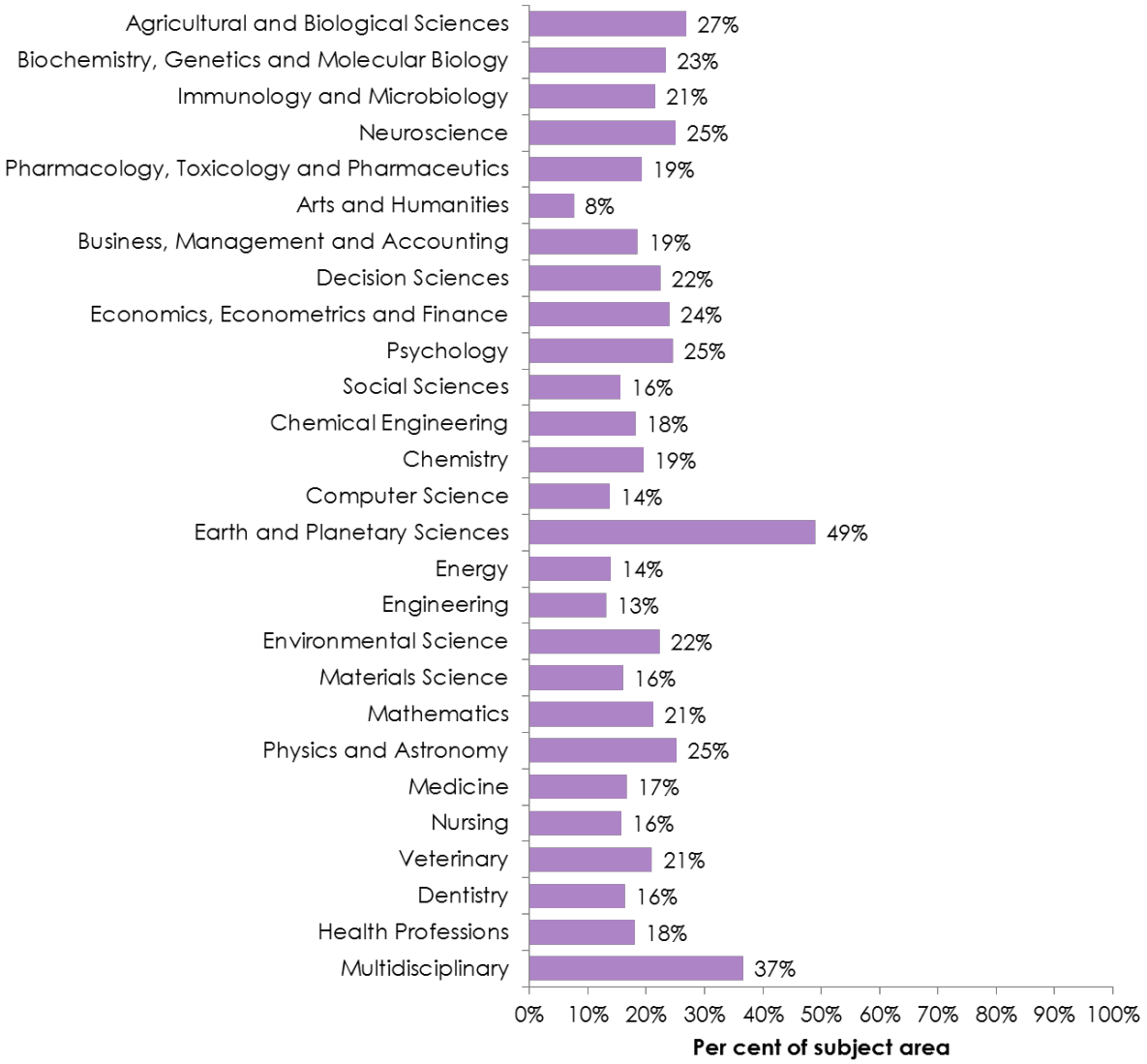

Figure 112: Proportion of Chinese Taipei publications co-authored with another APEC economy by subject area (2011-2015)

Thailand

Between 1960 and 2015, more than 130 000 documents affiliated with Thailand were published and indexed by Scopus. The number of documents published by Thai researchers has been growing rapidly in recent decades, and the proportion of all documents that are affiliated with Thailand have also increased slightly, as shown in Figure 113. Between 2011 and 2015, almost 60 000 documents had a Thai affiliation, representing around 0.4 per cent of all documents published.

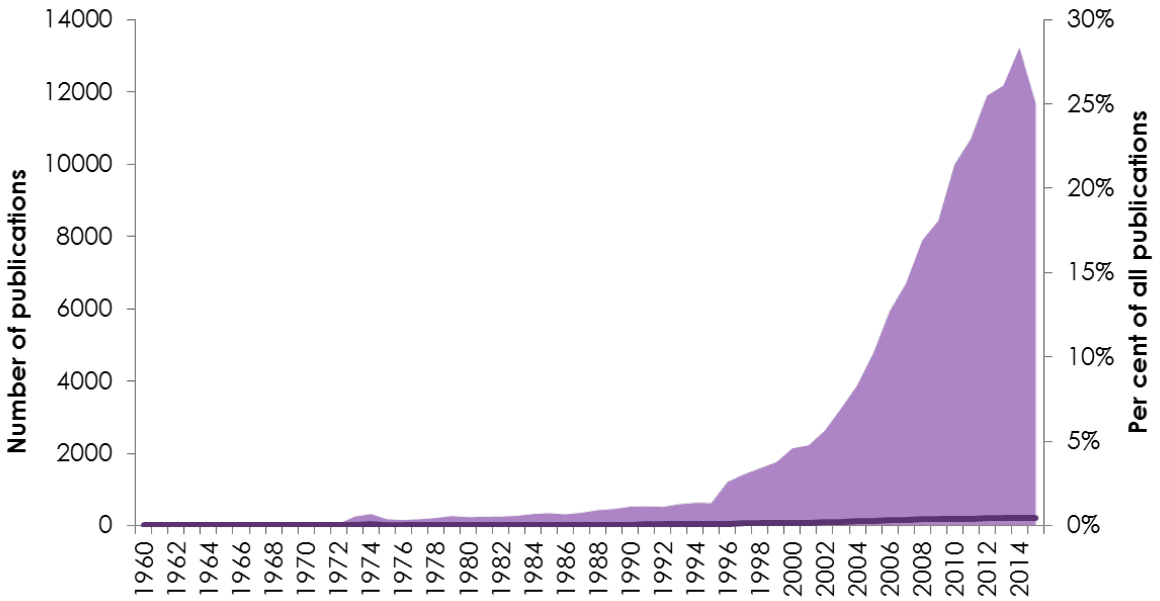

Figure 113: Number and proportion of publications affiliated with Thailand

According to analyses conducted by SCImago (2016s), in 2014, 39 per cent of all papers authored by researchers from Thailand had cross-border co-authors. As shown in Figure 114, in the period between 2011 and 2015, 12 per cent of all Thai publications were co-authored with researchers from the United States, and eight per cent were co-authored with researchers from Japan.

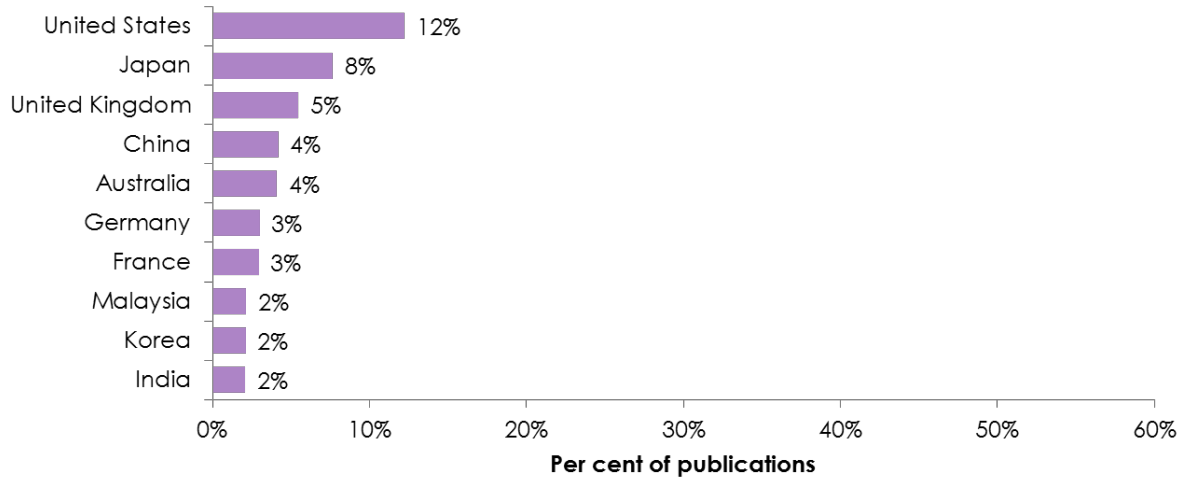

Figure 114: Most common cross-border co-authorship for Thai publications (2011-2015)

Echoing the recent strong growth in the number of documents published by researchers affiliated with Thailand is the growth in cross-border co-authorship between researchers from Thailand and from other APEC economies. This is shown in Figure 115 along with the per cent of all Thai publications that have been co-authored with other APEC economies. Between 2011 and 2015, 17 128 documents were co-authored by researchers affiliated with Thailand and researchers affiliated with other APEC economies. This represented 29 per cent of all Thai publications.

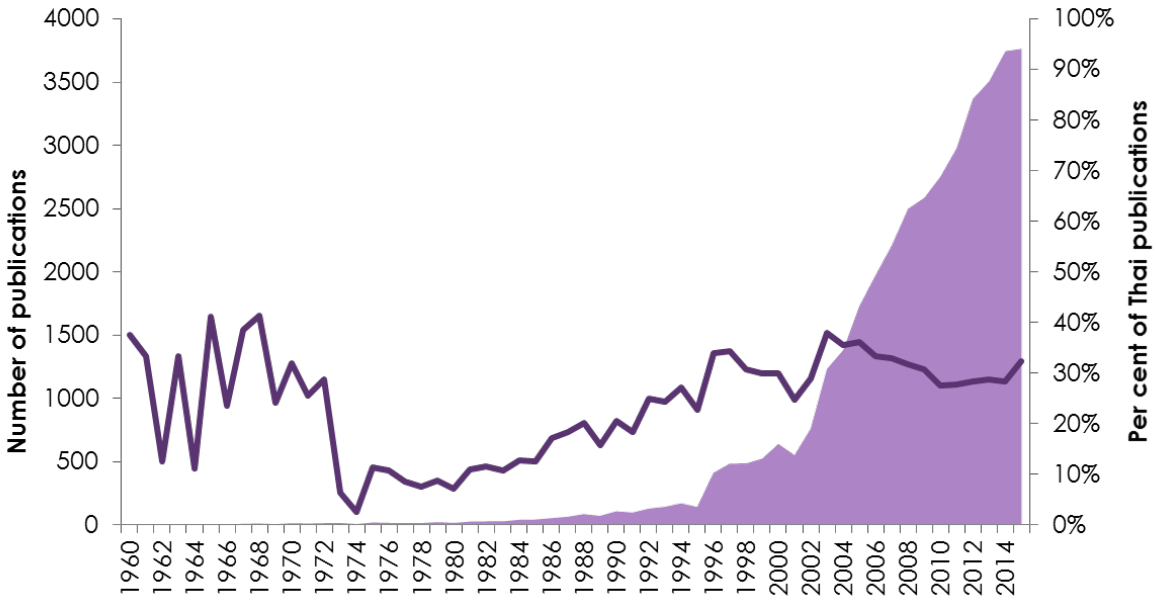

Figure 115: Number and proportion of Thai publications co-authored with other APEC economies

Table 24 lists the number of publications that Thai researchers have co-authored with researchers from each other APEC economy between 2011 and 2015. It also indicates the proportion of all Thai publications that were co-authored with each APEC economy during this time period. This shows that cross-border co-authorship takes place more frequently with researchers from the United States and Japan.

Table 24: Number and proportion of Thai publications co-authored with anther APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	2 429	4
Brunei Darussalam	15	0
Canada	1 027	2
Chile	79	0
China	2 472	4
Hong Kong, China	391	1
Indonesia	524	1
Japan	4 555	8
Korea	1 253	2
Malaysia	1 269	2
Mexico	471	1
New Zealand	591	1
Papua New Guinea	23	0
Peru	143	0
Philippines	444	1
Russia	490	1

Other APEC Economies	Publications	
	#	%
Singapore	722	1
Chinese Taipei	1 035	2
United States	7 346	12
Viet Nam	561	1

Figure 116 shows that the number of documents being published with a Thai affiliation in recent years is increasing year-on-year, with a dip shown in 2015. The number of documents co-authored by researchers from Thailand and other APEC economies is also increasing. Between 2011 and 2015, the number of publications co-authored with researchers from other APEC economies has increased by 26 per cent.

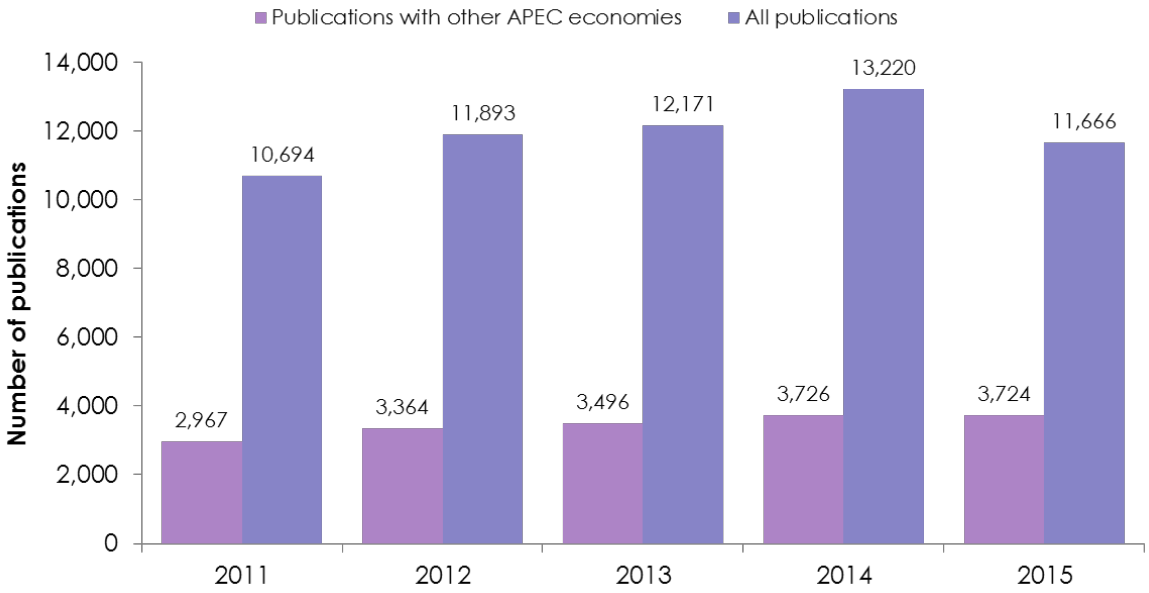

Figure 116: All Thai publications and Thai publications co-authored with another APEC economy

As shown in Figure 117, 71 per cent of all Thai documents did not include co-authors from other APEC economies. Around 23 per cent included co-authors from just one other APEC economy, and around seven per cent included co-authors from two or more other APEC economies.

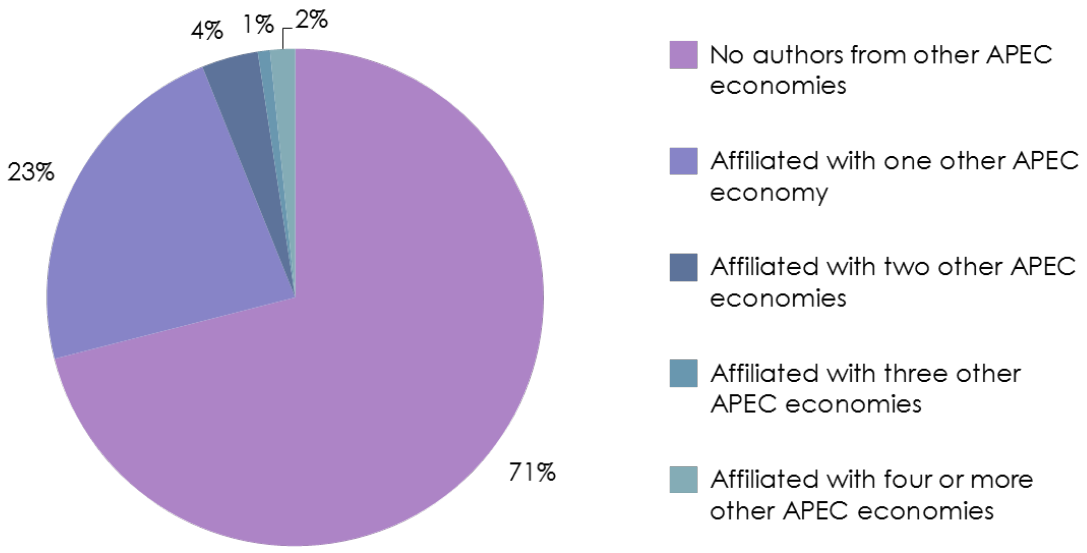

Figure 117: Proportion of all Thai publications co-authored with one or more other APEC economies (2011-2015)

The level of cross-border co-authorship varies by subject area. As shown in Figure 118, publications in the field of psychology had the greatest level of co-authorship with researchers affiliated with other APEC economies. However, as psychology was the subject area with the fewest publications published by Thai researchers, this only represents a relatively small number of publications. The greatest number of co-authored publications are seen for the subject area of medicine, where 5 902 documents were co-authored by Thai researchers and researchers from other APEC economies. The lowest rate of cross-border co-authorship is seen in the field of arts and humanities.

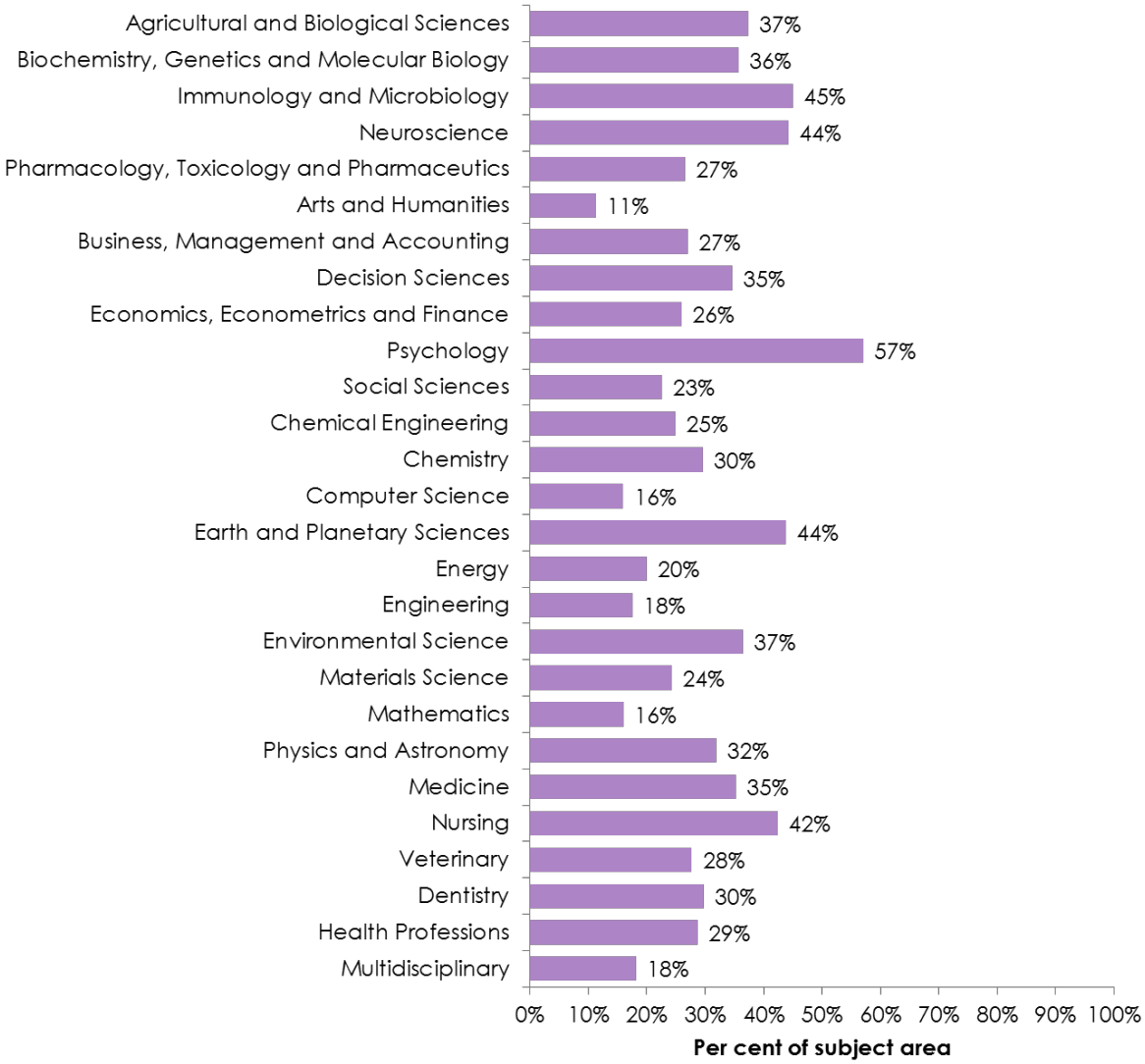

Figure 118: Proportion of Thai publications co-authored with another APEC economy by subject area (2011-2015)

The United States

The United States is the largest producer of peer-reviewed research publications globally. Between 1960 and 2015, more than 13 million documents affiliated with the United States were published and indexed by Scopus. Figure 119 shows the strong and continuous growth in the number of publications affiliated with the United States over the past several decades. Figure 119 also shows that the proportion of all documents affiliated with the United States has increased since the 1960s. Although the total proportion of all documents that are affiliated with the United States has waned somewhat since the 1990s, more than a fifth of all publications are still affiliated with the United States. Between 2011 and 2015, more than three million publications included at least one author affiliated with the United States, which represented 22.6 per cent of all publications.

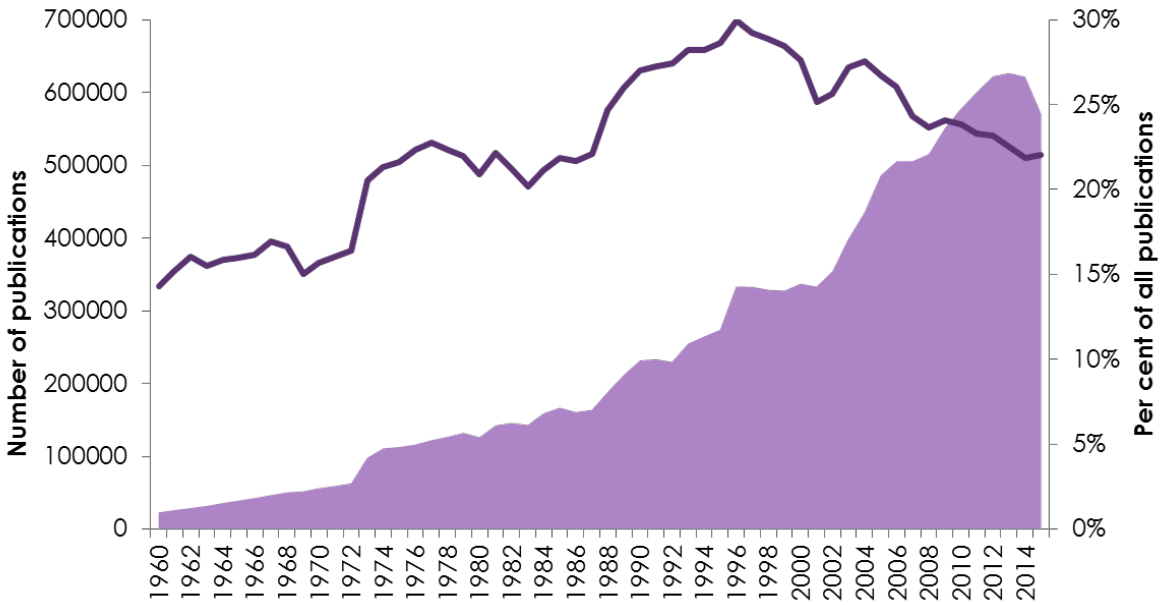

Figure 119: Number and proportion of publications affiliated with the United States

According to SCImago (2016t), in 2014, a third of all research publications by United States researchers included cross-border co-authors. As shown in Figure 120, in the period from 2011 to 2015, five per cent of all publications affiliated with the United States were co-authored with researchers from China, and four per cent with researchers from the United Kingdom.

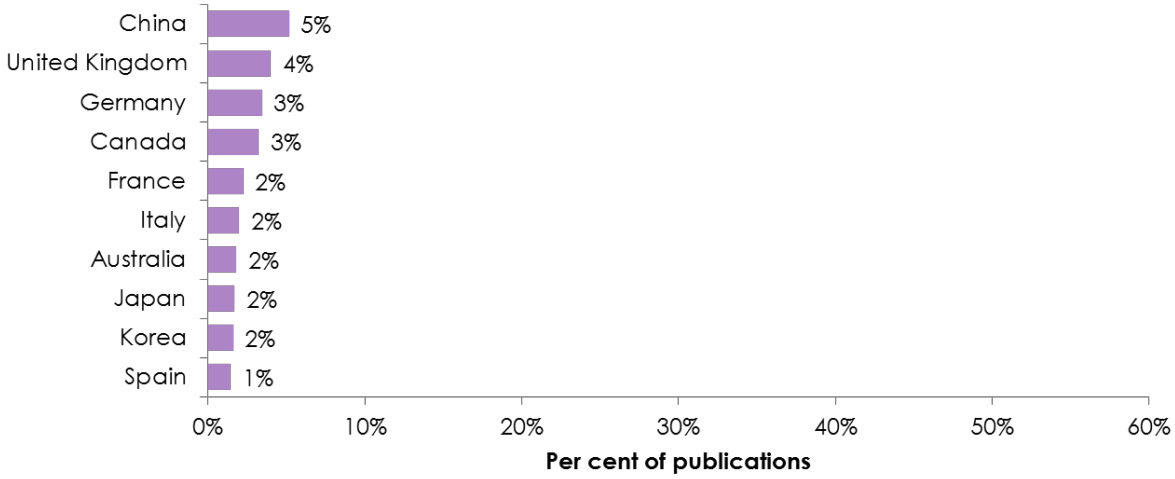

Figure 120: Most common cross-border co-authorship for American publications (2011-2015)

Recent decades have also seen a rapid increase in the number of documents co-authored by researchers from the United States and from other APEC economies, as shown in Figure 121. This also shows that the proportion of all United States publications that include cross-border co-authors from the APEC region has been steadily increasing. Between 2011 and 2015, 457 031 documents were co-authored by researchers from the United States and from other APEC economies, representing 15 per cent of all publications affiliated with the United States.

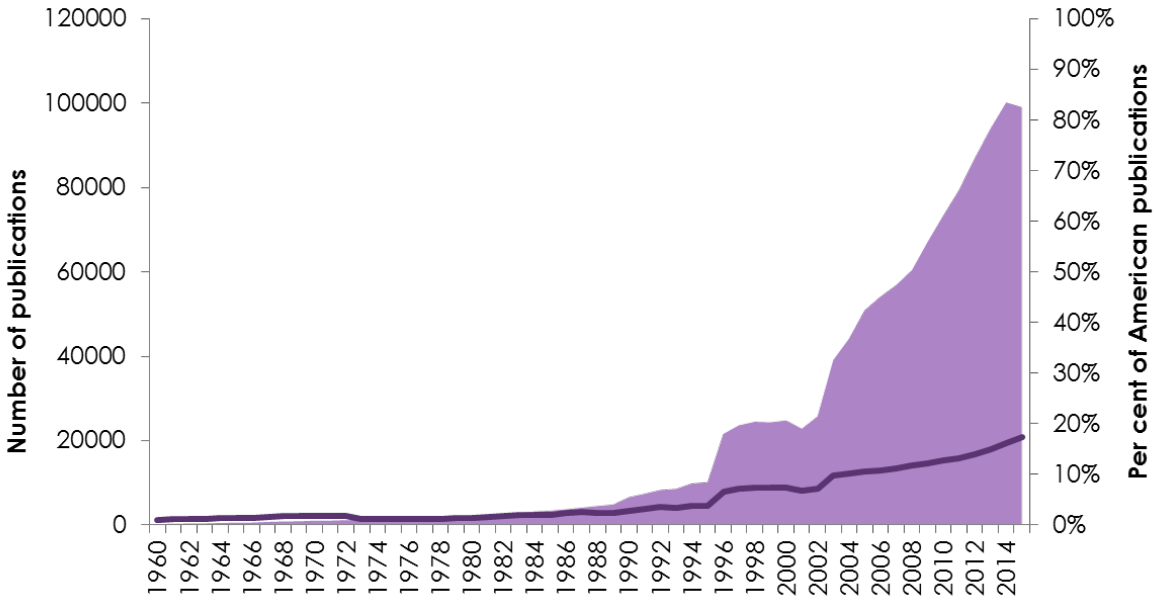

Figure 121: Number and proportion of American publications co-authored with other APEC economies

Table 25 lists the number of publications that American researchers co-authored with researchers from other APEC economies between 2011 and 2015. It also shows the proportion of all publications affiliated with the United States that these numbers represent. This shows that the most frequent cross-border co-authorship occurs with China and Canada.

Table 25: Number and proportion of American publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	54 934	2
Brunei Darussalam	91	0
Canada	98 642	3
Chile	9 120	0
China	156 826	5
Hong Kong, China	11 678	0
Indonesia	1 560	0
Japan	51 853	2
Korea	48 468	2
Malaysia	4 116	0
Mexico	14 662	0
New Zealand	10 634	0
Papua New Guinea	194	0
Peru	2 640	0
Philippines	1 648	0
Russia	17 227	1
Singapore	15 101	0

Other APEC Economies	Publications	
	#	%
Chinese Taipei	21 641	1
Thailand	7 346	0
Viet Nam	1 926	0

As shown in Figure 122, the number of documents affiliated with the United States has increased between 2011 and 2013, and dropped off somewhat in the past two years. Between 2011 and 2015, the number of documents co-authored by researchers from the United States and researchers from other APEC economies has increased by 23 per cent.

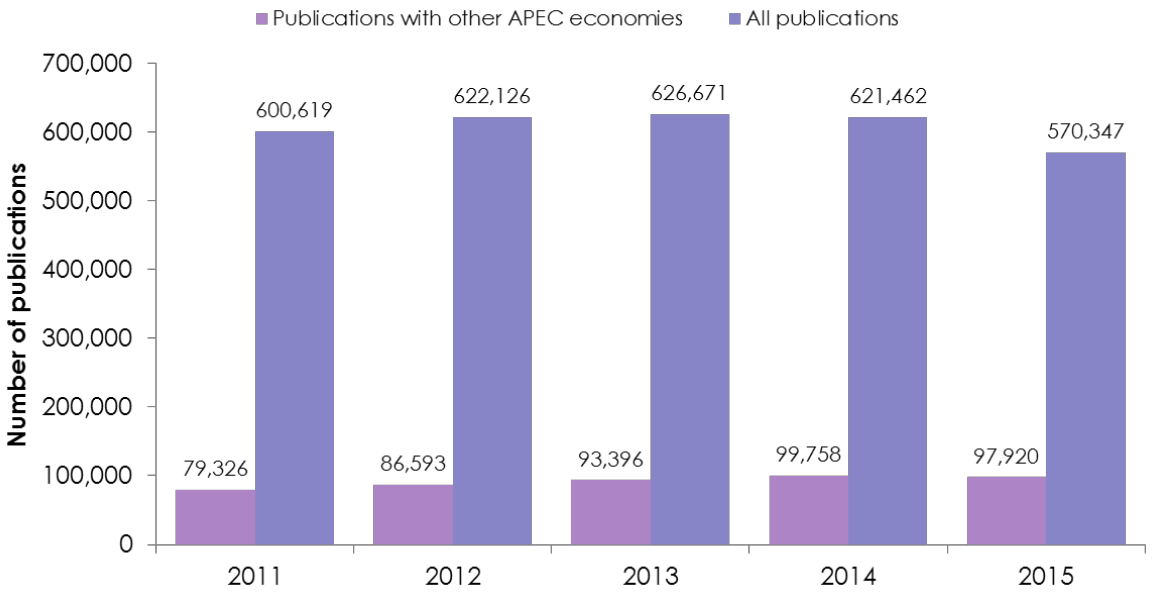

Figure 122: All American publications and American publications co-authored with another APEC economy

Figure 123 shows that 85 per cent of all documents affiliated with the United States do not include co-authors from other APEC economies. Around 13 per cent included co-authors from just one other APEC economy and around one per cent included co-authors from two or more other APEC economies.

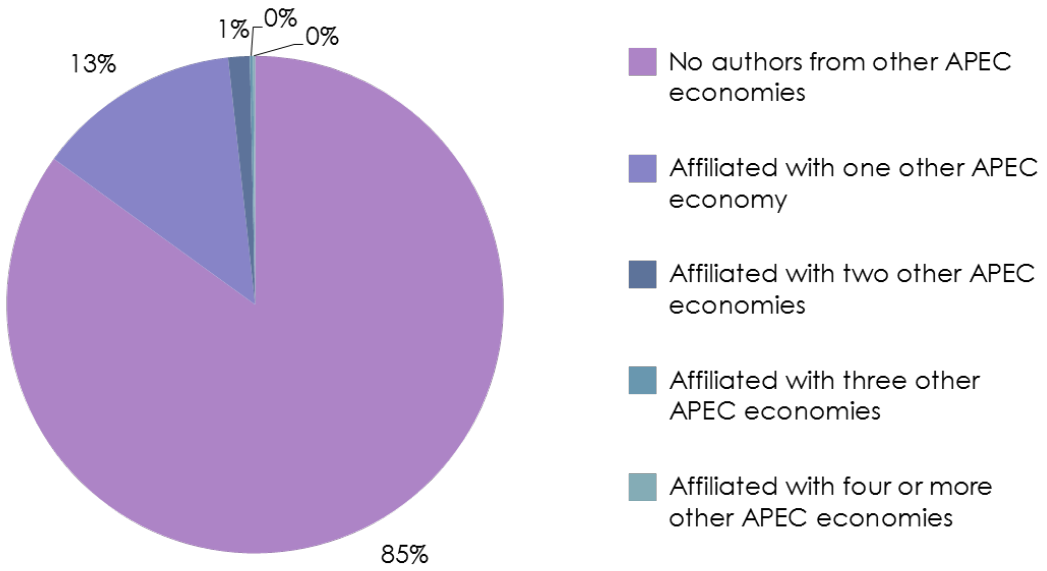

Figure 123: Proportion of all American publications co-authored with one or more other APEC economies (2011-2015)

The level of cross-border co-authorship between researchers affiliated with the United States and researchers from other APEC economies varies by subject area, as shown in Figure 124. Around a quarter of all publications in the multidisciplinary subject area and in earth and planetary sciences were co-authored with researchers from other APEC economies. Only two per cent of all publications in the field of arts and humanities had a co-author from another APEC economy.

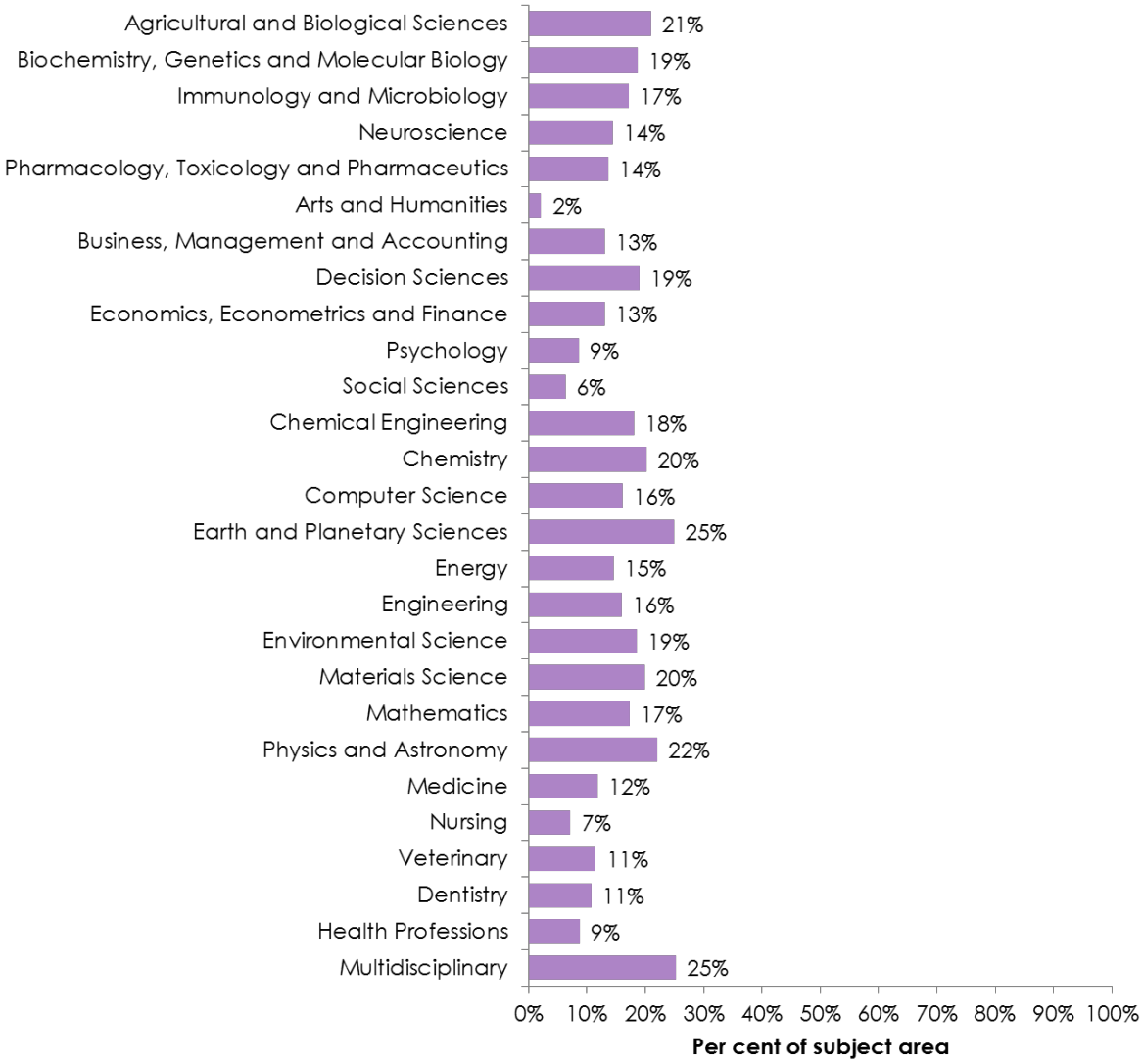

Figure 124: Proportion of American publications co-authored with another APEC economy by subject area (2011-2015)

Viet Nam

Between 1960 and 2015, more than 30 000 documents affiliated with researchers from Viet Nam were published and included in the Scopus index. As shown in Figure 125, very few documents were published by Vietnamese researchers before the mid-1990s. However, the level of publication has grown rapidly and since the early 2000s has trebled. The proportion of all documents published by Vietnamese researchers has also increased very slightly over the past decade. Between 2011 and 2015, more than 17 000 documents affiliated with Viet Nam have been published. This represents around 0.1 per cent of all documents published during this period.

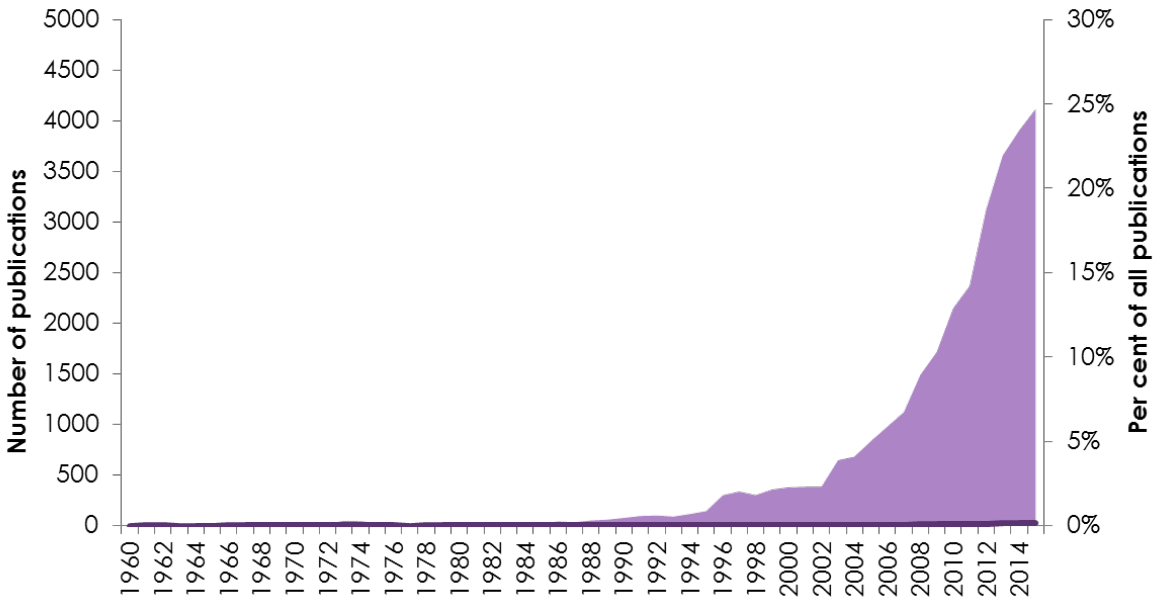

Figure 125: Number and proportion of publications affiliated with Viet Nam

In 2014, 72 per cent of all publications affiliated with Viet Nam had cross-border co-authors (SCImago, 2016u). As shown in Figure 126, between 2011 and 2015, 11 per cent of Vietnamese publications had co-authors from the United States, 11 per cent had co-authors from Japan and 10 per cent had co-authors from Korea.

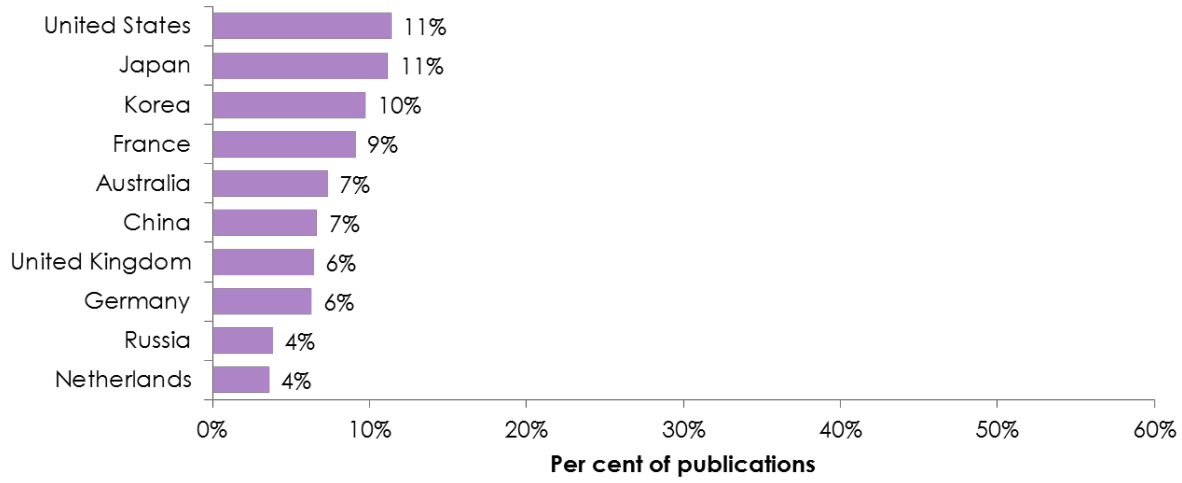

Figure 126: Most common cross-border co-authorship for Vietnamese publications (2011-2015)

As shown in Figure 127, recent years have seen a rapid growth in the level of co-authorship between researchers from Viet Nam and researchers from other APEC economies, mirroring the overall growth in publication by Vietnamese researchers. In addition to the growth in the number of publications with cross-border co-authors from other APEC economies, the proportion of all Vietnamese publications that were co-authored with researchers from other APEC economise has increased. Between 2011 and 2015, 8 251 documents were co-authored by researchers affiliated with Viet Nam and researchers

affiliated with other APEC economies. This represents around 48 per cent of all Vietnamese publications.

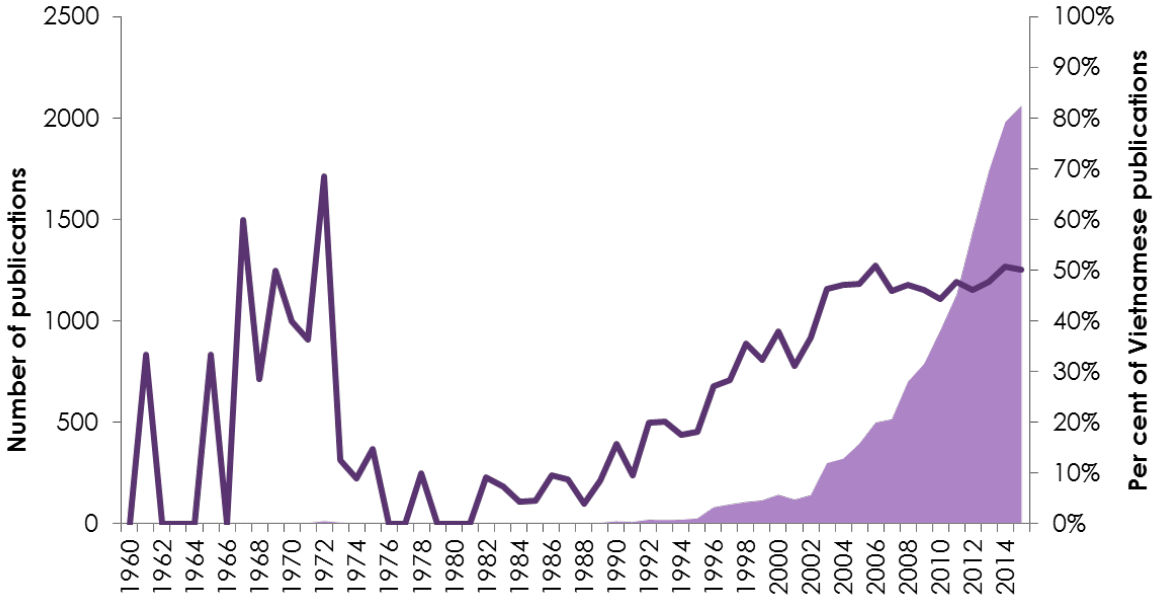

Figure 127: Number and proportion of Vietnamese publications co-authored with other APEC economies

Table 26 lists the number of publications that Vietnamese researchers co-authored with researchers in each APEC economy between 2011 and 2015. It also indicates the proportion of all Vietnamese publications that were co-authored with researchers affiliated with each APEC economy. This shows that the most frequent cross-border co-authorship occurs with the United States; Japan; and Korea.

Table 26: Number and proportion of Vietnamese publications co-authored with another APEC economy (2011-2015)

Other APEC Economies	Publications	
	#	%
Australia	1 232	7
Brunei Darussalam	10	0
Canada	340	2
Chile	39	0
China	1 125	7
Hong Kong, China	120	1
Indonesia	243	1
Japan	1 899	11
Korea	1 665	10
Malaysia	305	2
Mexico	92	1
New Zealand	132	1
Papua New Guinea	16	0

Other APEC Economies	Publications	
	#	%
Peru	41	0
Philippines	209	1
Russia	658	4
Singapore	314	2
Chinese Taipei	598	3
Thailand	561	3
United States	1 926	11

As shown in Figure 128, the number of documents being published by Vietnamese researchers is increasing every year. The number of documents co-authored with researchers from other APEC economies is also increasing. Between 2011 and 2015, the number of publications co-authored with researchers from other APEC economies has increased by 79 per cent.

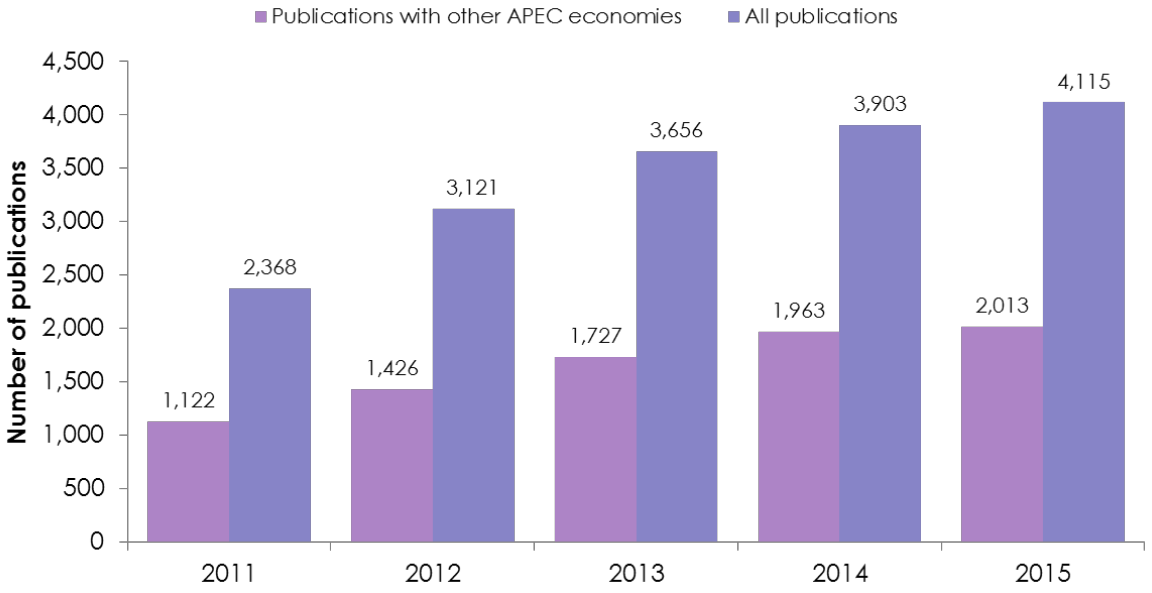

Figure 128: All Vietnamese publications and Vietnamese publications co-authored with another APEC economy

Figure 129 shows that 52 per cent of publications affiliated with Viet Nam do not include co-authors from other APEC economies. Around 38 per cent include co-authors from just one other APEC economy, and around 10 per cent include co-authors from two or more other APEC economies.

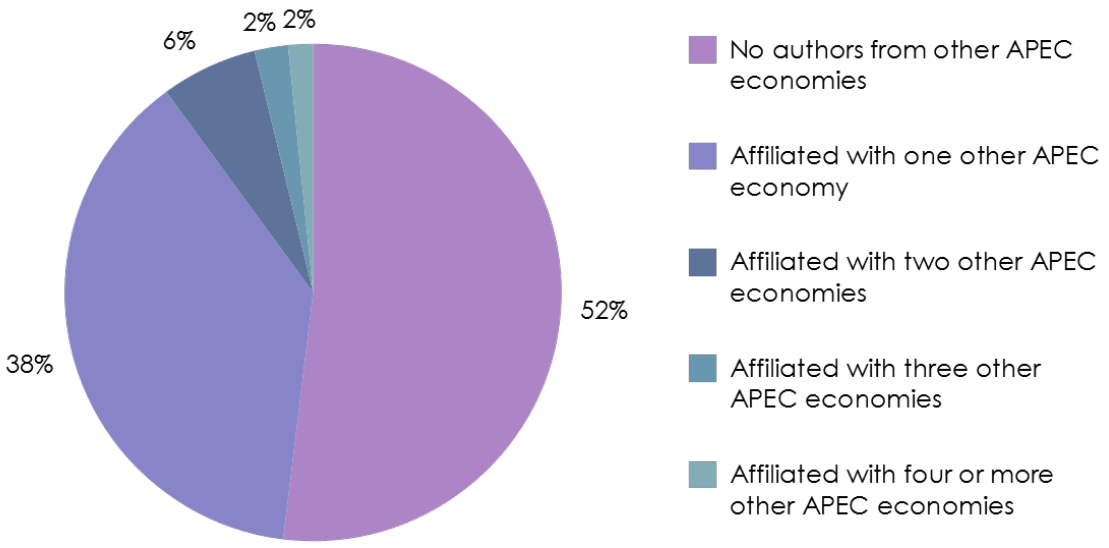

Figure 129: Proportion of all Vietnamese publications co-authored with one or more other APEC economies (2011-2015)

The level of cross-border co-authorship varies by subject area. As shown in Figure 130, at least half of all Vietnamese publications in eighteen different subject areas were co-authored with researchers from other APEC economies. In terms of the overall number of co-authored documents, engineering (1 659 documents), medicine (1 572 documents) and agricultural and biological sciences (1 436 documents) were the largest subject areas for cross-border co-authorship between Vietnamese researchers and researchers from other APEC economies.

Figure 130: Proportion of Vietnamese publications co-authored with another APEC economy by subject area (2011-2015)

Examples of successful research collaborations

All research collaborations that result in a piece of research being published in a peer-reviewed journal, conference proceedings or in a book could be considered 'successful'. However there are a number of ways to more formally measure or quantify research success. These include measuring the economic, social or environmental impact research has. More frequently, research success is determined through measures that are easier to quantify, such as the amount of funding received, number of grants won, and most frequently article- or journal-level metrics, such as journal rankings and journal impact, although the use of many of these measures is often viewed as contentious (Elsevier, 2016a).

Three different examples of successful research collaborations were selected to include as brief case studies in this report. There are numerous different cross-border research collaborations that could have been chosen. However, these three collaborations were selected because they brought together researchers from a large number of different economies, published research in high-impact journals, had publications with high citation counts, and the research collaborations were ongoing.

Global Burden of Disease

The Global Burden of Diseases, Injuries, and Risk Factor Study (GBD) is the largest scientific study to date that aims to identify global health trends including the level of health lost to disease, injuries and other factors (Institute for Health Metrics and Evaluation, 2016). This information is aimed to assist policymakers and researchers to better understand patterns of health and disease globally and regionally.

More than 1 600 researchers from multiple disciplines affiliated with more than 120 different economies have collaborated to collect and collate information about more than 300 diseases in 188 different economies (Institute for Health Metrics and Evaluation, 2016). The study is funded by the Bill and Melinda Gates Foundation.

Numerous publications have been written based on the findings from the data. These have included policy reports, regional reports and papers focused on specific diseases, injuries and risks. Many peer-reviewed research papers have also been produced based on the findings from the study, many of which have been published in high impact journals with very high numbers of citations.

One example publication that has resulted from this research collaboration is *Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: A systematic analysis for the Global Burden of Disease Study 2010* (Lozano et al., 2012). This particular paper includes researchers from ten different APEC economies, (Australia; Canada; China; Hong Kong, China; Japan; Mexico; New Zealand; Russia; Singapore; and the United States) and 20 other economies outside of the APEC region. This paper was published in *The Lancet*, an extremely prestigious and highly ranked journal, and has already been cited more than 4 000 times.

Particle Data Group

The Particle Data Group includes more than 200 contributors from authors in more than 20 different economies (Particle Data Group, 2016). This group summarises the area of particle physics, astrophysics and cosmology, including the measured properties of a number of particles, such as quarks, and hypothetical particles, such as Higgs bosons. They also publish many tables, figures and formulae for use in particle physics and related subject areas.

The group publishes a Review of Particle Physics on a biennial basis. The review published in 2012 (Beringer et al., 2012) was authored by researchers from eight different APEC economies (Australia; Canada; China; Japan; Korea; Mexico; Russia; and the United States) and included researchers affiliated with 22 different economies in total. So far this edition of the review has been cited more than 8 000 times. The group also publish a book and booklet with information that summarises these properties. The review – across all its editions – has been cited in more than 50 000 documents (Particle Data Group, 2016).

International Maize and Wheat Improvement Center

The International Maize and Wheat Improvement Center, also known as the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT), is a not-for-profit research and training institution that aims to increase the productivity and sustainability of maize and wheat production through the development of breeding materials and running courses and workshops on maize and wheat farming (CIMMYT, 2016). CIMMYT leads a global consortium of agricultural research centres as part of the Consultative Group on International Agricultural Research (CGIAR). CIMMYT claim that their research and training efforts lead to benefits worth more than $2 billion to farmers on an annual basis.

As part of their work, researchers working in CIMMYT collaborate with researchers globally and publish research in the field of agricultural and biological sciences. Between 2011 and 2015, 423 research documents affiliated with CIMMYT and co-authored by researchers from two or more APEC economies were published. These publications included co-authors from eighteen different APEC economies. The most frequent contributions were from researchers affiliated with Mexico, the United States, the People's Republic of China and Australia.

One recent publication affiliated with CIMMYT is *Aegilops tauschii draft genome sequence reveals a gene repertoire for wheat adaptation* (Jia et al., 2013). This publication involved collaboration by researchers affiliated with eight different economies, including four from the APEC region – Australia; the People's Republic of China; Hong Kong, China; and Mexico. This paper was published in *Nature*, a highly-ranked journal and has been cited more than 300 times.

Conclusion

Overview of findings

This report has summarised the overall patterns of publication and cross-border co-authorship among researchers in the APEC region. This highlighted the strong growth in overall research publication by researchers affiliated with the APEC region, with research published by researchers from APEC economies accounting for more than half of all research documents indexed by Scopus.

There has also been a strong level of growth in the number of publications with co-authors from two or more APEC economies. Between 2011 and 2015, more than 680 000 peer-reviewed research documents were co-authored by researchers from different APEC economies. During this period the number of publications co-authored annually by researchers from different APEC economies increased by around 24 per cent.

The level of cross-border co-authorship differs for each economy, ranging from 11 per cent of all Russian publications to 78 per cent of all publications affiliated with Papua New Guinea. The level of cross-border co-authorship also varies by subject area. The subject areas of earth and planetary sciences, decision sciences and multidisciplinary fields have the greatest level of cross-border co-authorship with researchers from other APEC economies. The subject area of arts and humanities has the lowest level of cross-border co-authorship with researchers from other APEC economies.

Directions for future work

This report has aimed to explore the scale and scope of cross-border research collaboration among researchers in APEC economies. Cross-border co-authorship was used as a proxy measure of research collaboration in this study. Future research could build upon these analyses by exploring measures of research impact by using article- and journal-level metrics to gain a better understanding of the scientific impact of this research output. Another direction for future research could be to undertake some limited social network analyses in order to better understand the nature of the research collaborations between groups of researchers across the APEC region.

One finding included in this report was that the level of cross-border co-authorship was much lower for the social sciences fields, in particular in the arts and humanities, than in other subject areas. Future work could focus on this subject area in order to better understand cross-border co-authorship and research collaboration more broadly in this field, and increase the level of collaboration in this field.

Different types of research collaboration that may not necessarily lead to a published research article, book or conference paper, could also be the focus of future research. Future research could also focus on different aspects of research collaboration, such as funding sources and amounts, research collaborations between research organisations or universities and industry, and formal agreements between universities and other research institutions from different APEC economies. This research could expand on work previously undertaken by Universities Australia (2014) which collected information from Australian universities on the formal agreements that they have with cross-border higher education institutions regarding research collaboration, staff mobility and exchange, and student exchange and study abroad programs.

Finally, future research could also focus specifically on researcher mobility rather than the broad concept of research collaboration. This research could collect information on the number of researchers who physically relocate from one APEC economy to another through migration, academic exchanges, scholarships or fellowships.

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Appendix A: List of figures and tables

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Appendix B: Building the data file

Initial searches conducted in Scopus suggested that there were a very large number of documents in the database – possibly close to two million – that have been authored by researchers in two or more APEC economies. These initial searches also showed that the level of cross-border co-authorships have grown dramatically in recent years.

In order to keep the data to a manageable size, and to focus the analyses on the most recent research collaborations, the data file used for most of the analyses will include documents published from 2011 to 2015. Further analyses of trends across a longer time period were conducted directly within the Scopus database.

Information from the Scopus database was extracted using the Scopus Search API (Elsevier, 2015). This approach was developed following consultation with Elsevier, the publisher who own and manage Scopus, and ACER's librarians and software developers who have experience using APIs. ACER's software developers wrote customised code to specify and retrieve the data through this existing API for this project. Because of limitations in the number of records that could be retrieved in each call using the API, around 750 different search queries were developed to ensure that all relevant records were extracted.

The data were extracted from the Scopus database into a SQL database in late March 2016. Around 1.4 million article records were extracted from the Scopus database using the API. In addition, around 16 million author affiliations were extracted from the Scopus database. Because of the huge amount of data, and large file size, the data could not be read directly into SPSS or Excel from the SQL database.

Instead, data were extracted from the SQL database as multiple CSV files. These were then split into smaller CSV files using UltraEdit text editor. An SPSS syntax file was created to read each CSV file into SPSS, do some initial cleaning of each file and then merge each of the files into a single SPSS data file.

Once the initial article-level file was built, duplicate records – identified by each record's electronic ID – were deleted. Then a separate data file that included the author affiliations was built. A variable was created for each economy that had an affiliation in the data file, this variable indicated the number of affiliations for that particular economy for each article in the file. This information was then merged into the article-level file.

A series of checks were carried out to ensure that each article had at least two different APEC economy affiliations. A large number of records – close to 100 000 – either had no, or only one APEC economy affiliation listed. Because of the way in which the data were extracted, it was clear that these records were affiliated with at least two APEC economies, but for some reason the affiliation information was not fully extracted.

In order to correct these records, multiple searches – using each record's electronic ID – were carried out in Scopus directly to extract the affiliation information. This missing information was then matched into the overall file.

Finally, the subject area information was added into the file. Scopus classifies journals, books and conference proceedings using the All Science Journal Classification (ASJC) (Elsevier, 2016b). The

ASJC includes 26 narrow subject areas which are grouped into four broad areas – life sciences, social sciences, physical sciences and health sciences. The classification also includes a general or multidisciplinary subject area. Each publication may be classified in one or more than one of these narrow subject areas.

The subject area information was listed in several Excel spreadsheets provided by Elsevier on the Scopus website (Elsevier, 2016b). Separate worksheets were listed for current journals, conference proceedings, books and book series. Each worksheet listed the subject area information in different ways, and included different source identification information (i.e. some linked subject area to ISSN, others to ISBN and others used a source ID variable). Because of this, each of the worksheets were read into SPSS separately and cleaned before matching this information into the overall data file.

Finally, the variables were renamed, some new variables were created, and variable labels and value labels were added. The final version of the data file includes 685 906 records. It includes information on document titles, first author, source title, source type, publication date, citation counts, economy affiliations, and subject area information.