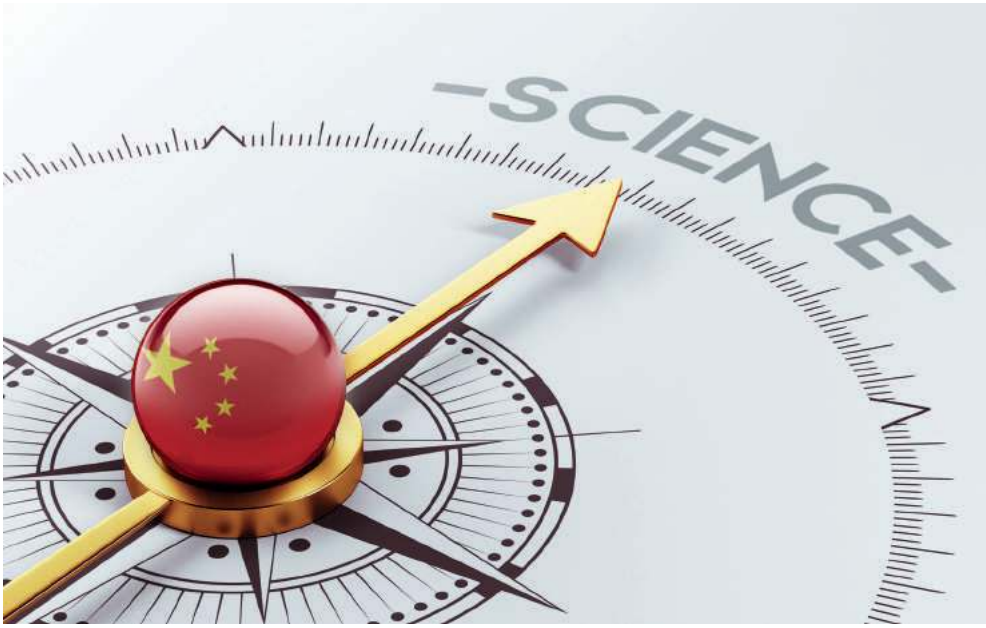


Academic collaboration: Sweden–China

STINT
The Swedish Foundation for International Cooperation in Research and Higher Education

R 18:01

Summary

This study of academic collaboration between Sweden and China is undertaken with the aim of informing policy decisions at institutional and national levels. The focus is on research collaboration, but teaching collaboration is also touched upon. Through an analysis of publications in the Scopus database, the study illustrates how research collaboration has developed at national, institutional and individual levels.

Overall, the co-publication volumes involving Sweden and China increase rapidly. They enjoy high citation impact, also when publications with 100 or more co-authors are not counted. Co-publication volumes are increasing rapidly, but the development is similar to that of other mature research countries' co-publications with China. In comparison to Australia, Canada, Denmark, Germany and the United Kingdom, only Germany shows a slower increase in co-publication volumes with China than Sweden.

The analysis shows that most co-publications (~50%) occur in the natural sciences, followed by engineering & technology, and the medical sciences. The disciplinary distribution is to some extent mirrored by the institutions with most Sweden – China co-publications, with KTH Royal Institute of Technology leading in Sweden and the Chinese Academy of Sciences in China.

Data for student mobility between Sweden and China indicate that the number of incoming students to Sweden has dropped substantially after the tuition fee reform. KTH Royal Institute of Technology is the largest receiver of Chinese students in absolute numbers. But as a share of all incoming international students to the university, two small universities have more than 15% Chinese students.

In the STINT – NSFC mobility programme, engineering & technology projects occur more frequently among the 75 projects granted funding than the co-publication profile would indicate. Similarly, projects in the natural sciences are underrepresented.

For several reasons, not least the high citation impact of Sweden – China co-publications, one recommendation is to further promote and support academic collaboration between the countries. One approach on the Swedish side could be to promote broader participation through the involvement of additional universities. Expanding research collaboration

in the humanities and social sciences could also be relevant. Another long-term method of fostering academic collaboration is through student mobility. It should also be considered how to promote innovations emanating from the academic collaborations.

Preface

The Swedish Foundation for International Cooperation in Research and Higher Education (STINT) was set up by the Swedish Government in 1994 with the mission of internationalising Swedish higher education and research. STINT promotes knowledge and competence development in the area of internationalisation and invests in internationalisation projects proposed by researchers, teachers and senior leadership at Swedish universities.

During the last 15 years, China has shown rapid scientific development, which has led STINT to focus increasingly on China in its activities. Since 2015, STINT has co-funded bilateral research projects together with the National Natural Science Foundation of China (NSFC). Today this programme is the largest academic mobility programme between Sweden and China, with a total of 75 currently ongoing projects. STINT has also recently started a project to increase understanding of the development of the higher education and research sector in China in order to assist Swedish universities, as well as related agencies and organisations, in their development of strategic cooperation with China.

In early 2018, the Swedish Government initiated a government remit to compile documentation for the government's work on increased and strategically targeted cooperation with China in innovation, science and higher education. STINT is contributing to the remit with its experience of and competence in academic cooperation regarding China.

One of the aims with this report is to support the ongoing government remit by providing data on research collaboration. It also includes data on educational collaboration to some extent. The study illustrates how research collaboration with China has developed at national, institutional and individual levels.

The author of the report is Hans Pohl, Programme Director at STINT.

Andreas Göthenberg
Executive Director
STINT

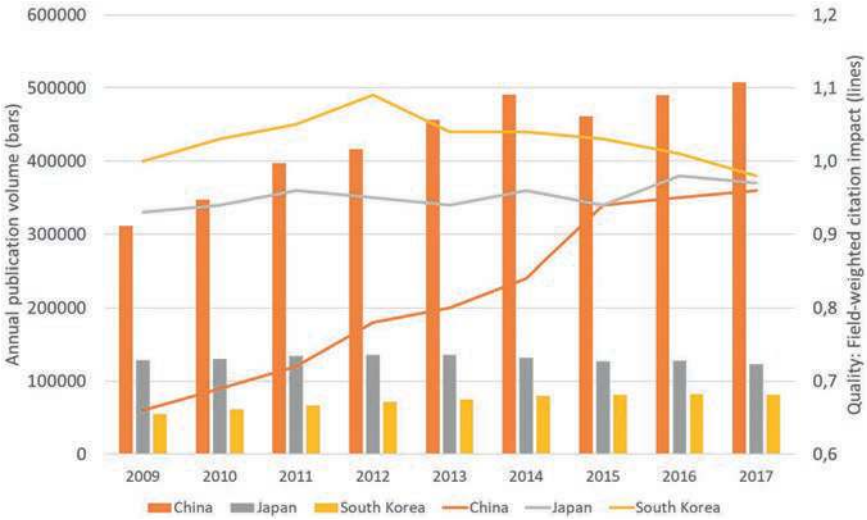
Stockholm, Sweden, May, 2018

Contents

1. Introduction

China's research production has been growing rapidly in the past two decades (c.f. STINT, 2017). Currently, it is the second largest country after the United States in terms of the total annual volume of publications in the Scopus database. The research output from China is not only growing in volume, but the publication citation impact has also increased significantly. Figure 1 compares the development in publication volume and citation impact since 2009 for China, Japan and South Korea. The volume of academic publications has increased more rapidly in China than in Japan or South Korea. In addition, the citation impact has increased rapidly from a much lower level than Japan's and South Korea's to nearly converge with these two countries in 2017.

Figure 1: **Publication volume and citation impact for China, Japan and South Korea (SciVal® database, Elsevier B.V., downloaded February 2018)**



Regarding Sweden's research collaboration with China, an analysis of publication data was carried out by the Swedish Governmental Agency for Innovation (VINNOVA) and the Swedish Research Council in 2011 in connection with a government directive to strengthen research and innovation cooperation with China (Sandström, 2011).

Since 2015, STINT has offered a bilateral mobility funding programme together with the National Natural Science Foundation of China (NSFC).

Every year, 25 new three-year projects are selected for funding.

The purpose of this study is to increase understanding of academic collaboration between Sweden and China, focusing on research but also including some student mobility data. The study concentrates on how collaboration is developing in terms of publication volume and quality, which scientific disciplines are collaborating, which higher education institutions (HEIs) collaborate, and which researchers are the most active. The aim is to inform policy decisions at institutional and national levels.

After this introduction, a section explaining the methodology for the study follows. Thereafter follows an overall description of the development of the research collaboration between Sweden and China, which in the next section is compared with how some other mature research countries have developed their collaboration with China. The research collaboration between Sweden and China is then studied more in detail, describing which scientific disciplines that are included, which institutions that participate and the most active researchers contributing to the co-publication volume. Next section describes how students move between China and Sweden and thereafter, the STINT-NSFC mobility programme is studied. After a section discussing the results, conclusions and recommendations follow.

2. Data and methodology

This report mainly makes use of publication data to examine research collaboration between Sweden and China. The data come from Scopus, the largest publication database, and some analyses were performed using Elsevier's SciVal tool (Elsevier, 2017).

The analysis mainly concerns the period 2012–2017. All data were extracted during February 2018. It should be noted that publication data for 2017 are not yet complete and therefore the figures for 2017 (volumes and citations) should be interpreted with care: the final volumes will be higher and the citation impacts will differ from what is presented here. Elsevier states that publication data for 2017 will be 95% complete in May 2018. Nevertheless, data for 2017 are included in this analysis.

One good quality indicator for publications is the Field-weighted citation impact (FWCI). Citations are formal references to earlier work made in an article or patent, frequently to other journal articles. A citation is used to credit the originator of an idea or finding and is usually used to indicate that the earlier work supports the claims of the work citing it. The number of citations an article receives in subsequently published articles provides an indication of the quality or importance of the reported research. When calculating the FWCI, the number of citations a publication receives is normalised with respect to the scientific discipline, the publication year and the type of publication. A FWCI equalling 1 indicates that the publication enjoys world average citation impact. A higher FWCI indicates higher impact (Elsevier, 2014).

A co-publication between China and Sweden has at least two authors and at least one affiliation in each of the countries. In line with this, a publication with two co-authors, one with one affiliation in Sweden, and one with two affiliations, one in Sweden and one in China, is considered an international co-publication. This is further discussed below in the section 10.

Another aspect to note is so-called hyper-authored publications. These publications often have thousands of co-authors from a large number of countries. Collaboration in such networks, typically in the natural sciences, has limited relevance when studying collaboration between two specific countries or two institutions. As the same network may produce hundreds of publications per year, the co-publication volume may appear much greater than the actual extent of bilateral collaboration. Some of

these publications receive very high numbers of citations and they may therefore also distort quality indicators. In order to address this, publications with fewer than 100 co-authors were studied separately.

For this study, we use a classification of different scientific disciplines from the Frascati Manual of the Organisation for Economic Co-operation and Development (OECD). The classification comprises the following six main categories:

– Agricultural Sciences (Agri)
– Engineering & Technology (Eng)
– Humanities (Hum)
– Medical Sciences (Med)
– Natural Sciences (Nat)
– Social Sciences (Soc).

There are also 42 subcategories in the classification.

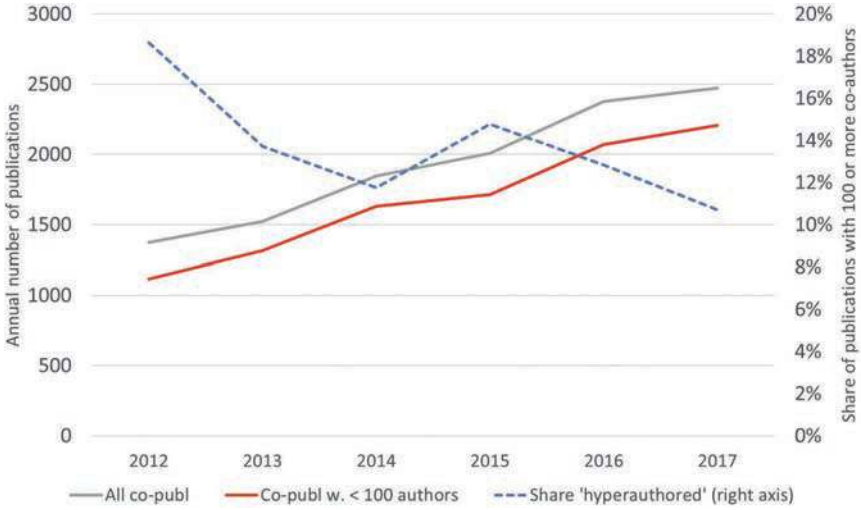
Student mobility data are mainly taken from two sources: UKÄ (2017) and UNESCO (2018).

3. Overall development of research collaboration

Figure 2 indicates that the annual volume of co-publications between Sweden and China has increased steadily during the last five years and will reach more than 2,500 publications in 2017 (when all 2017 publications have been included in the data set). The number of co-publications with more than 100 authors has remained relatively constant, thus accounting for a decreasing share of the total volume.

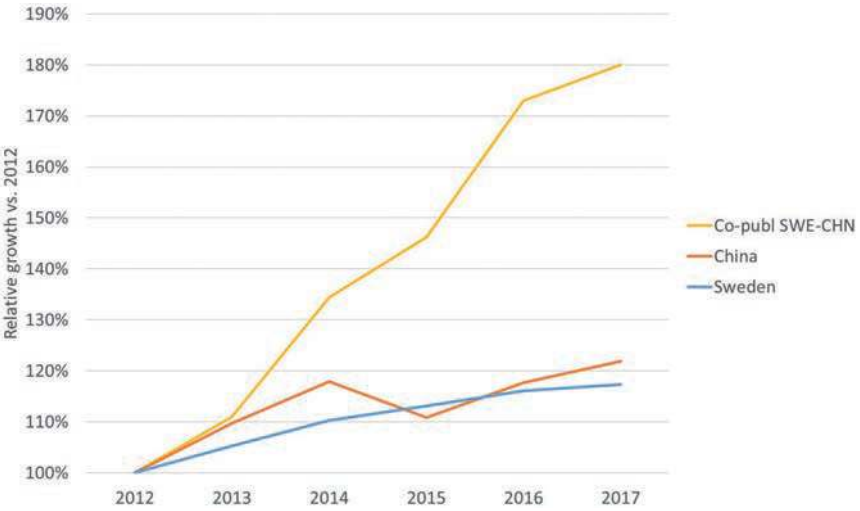
Adding the time series from Sandström (2011) yields volumes starting at 175 co-publications in 2000 and ending at 700 co-publications in 2010, based on Thomson Reuters (now Clarivate) Web of Science data.

Figure 2: **Annual co-publication volumes Sweden – China**



As mentioned in the introduction, China has had a tremendous publication growth during recent decades. However, this growth has slowed and as Figure 3 shows, it has not been very different from Sweden's since 2012. Figure 3 also indicates that in comparison to the development of the total volume of publications, the number of co-publications has increased much more rapidly, when using 2012 as the reference year.

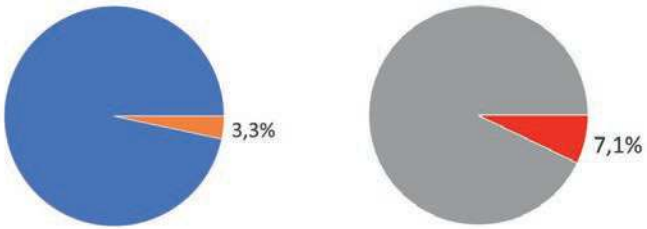
Figure 3: **Relative publication volume growth since 2012**



In a previous study (STINT, 2017), a new indicator was introduced, the Normalised Collaboration Intensity Index (NCII). It compares the actual and expected numbers of co-publications between two countries. The expected numbers of co-publications are calculated on the assumption that all countries collaborate in proportion to their share of the global volume of international co-publications.

Figure 4 provides a slightly simplified example: Sweden's co-publications with China for the period 2012–2016 represent a 3.3% share of all international co-publications including Sweden (gross volume).

Figure 4: **Example showing how Sweden's NCII with China is calculated**



This share is then compared with China's share of the global volume of international co-publications, which was 7.1%. Obviously, China's representation in the Swedish international co-publication portfolio does not

correspond to its total volume of international co-publications. The NCII is calculated as 3.3/7.1 = 46%. An index of 100% indicates an average collaboration intensity. South Korea is even lower with 40%, whereas Japan has an NCII of 66% (STINT, 2017).

When comparing the NCII of Sweden and China for a selection of countries, it is clear, as might be expected, that China has more collaborations with eastern countries such as Japan, Singapore and South Korea, whereas Sweden collaborates much more with its neighbouring countries (Figure 5). A comparison of co-publications with China among the Nordic countries shows that China collaborates to the same extent with Denmark and Sweden, and slightly less with Finland.[1]

In relative terms, China clearly has larger shares of co-publications with Australia, Canada and the United States, compared to the Swedish collaboration pattern.

Figure 5: **Normalised Collaboration Intensity Index for Sweden and China**

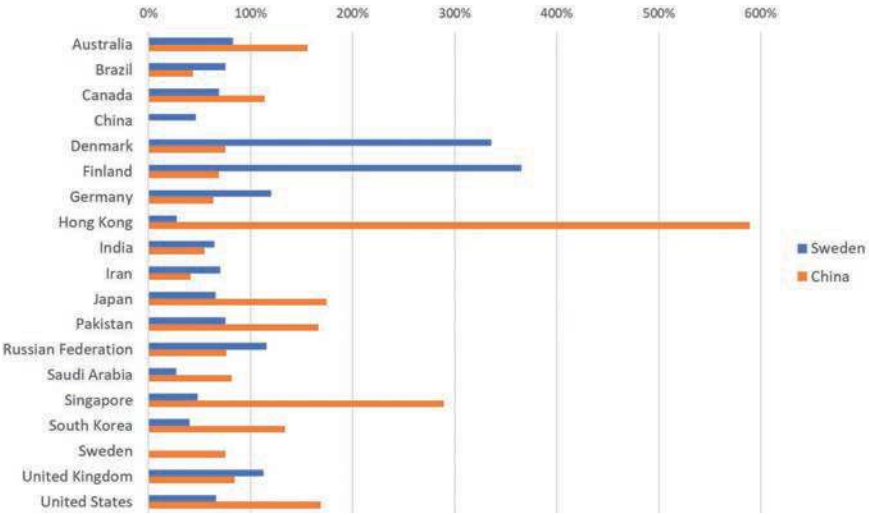
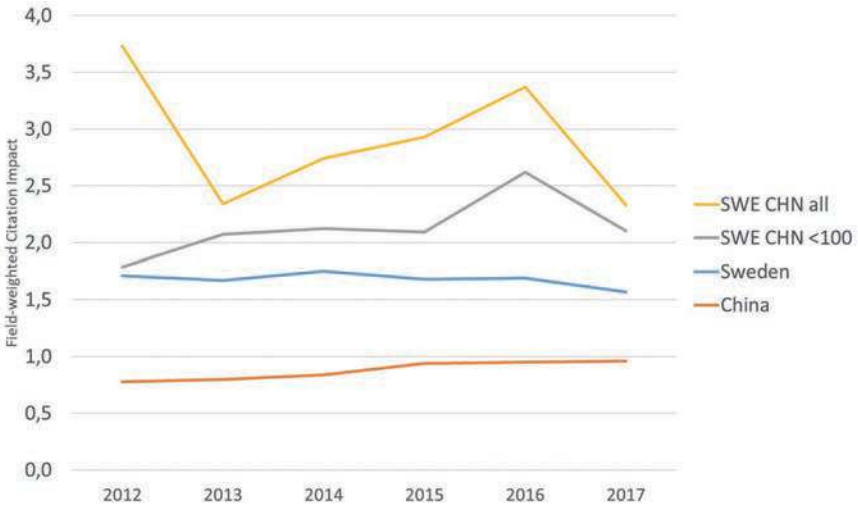


Figure 6 shows the higher citation impact of Sweden – China co-publications compared to national publications (including international co-publications). Figure 6 also includes a time series for co-publications with

[1] NCII is asymmetric as the index is normalised using the international co-publication volume of the country for which it is being calculated. Therefore, the Swedish NCII with China (46%) differs from the Chinese NCII with Sweden (75%)

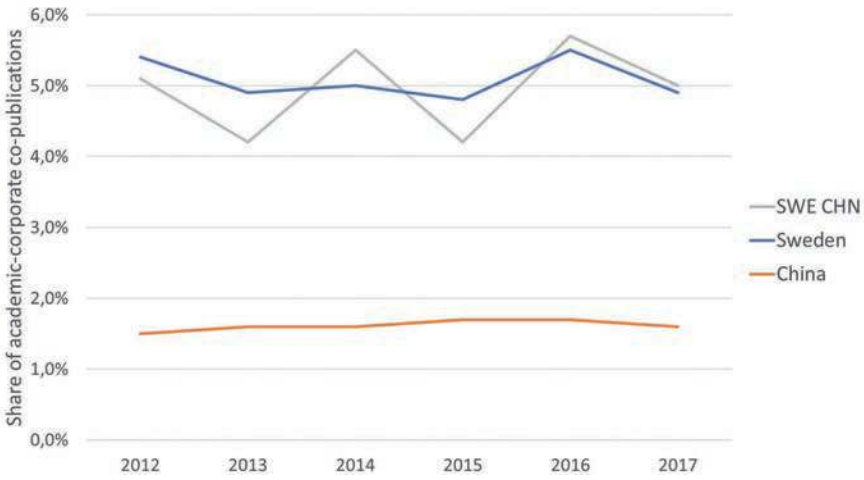
fewer than 100 co-authors. The impact of hyper-authored publications becomes very clear. Again, please note that data for 2017 are still incomplete.

Figure 6: **Publication FWCI development for co-publications Sweden – China**



Another perspective on the data is the extent to which corporate entities are involved in the collaborations. One indicator for this is the share of publications with at least one affiliation at a corporate entity. In Figure 7, the shares for Sweden, China and the co-publications between the countries are compared. It shows that corporate participation in the Sweden – China publications is close to the average for Sweden and much higher than the Chinese average. In a more general international comparison, Sweden has a relatively high share of academic-corporate co-publications.

Figure 7: **Sweden–China co-publications involving corporate entities**



With 84 publications, AstraZeneca (Sweden) is the corporate organisation with the highest number of publications among all Sweden–China publications with fewer than 100 authors for the period 2012–2017.

4. Comparison with other countries

In this section, a few other countries' collaboration with China is compared to that of Sweden. When comparing the co-publication volumes with China with each country's total publication volume, the share of such co-publications is the highest for Australia and the lowest for Germany (Figure 8).

Figure 8: **Co-publications with China as a share of all publications for each country (2012 – 2017)**

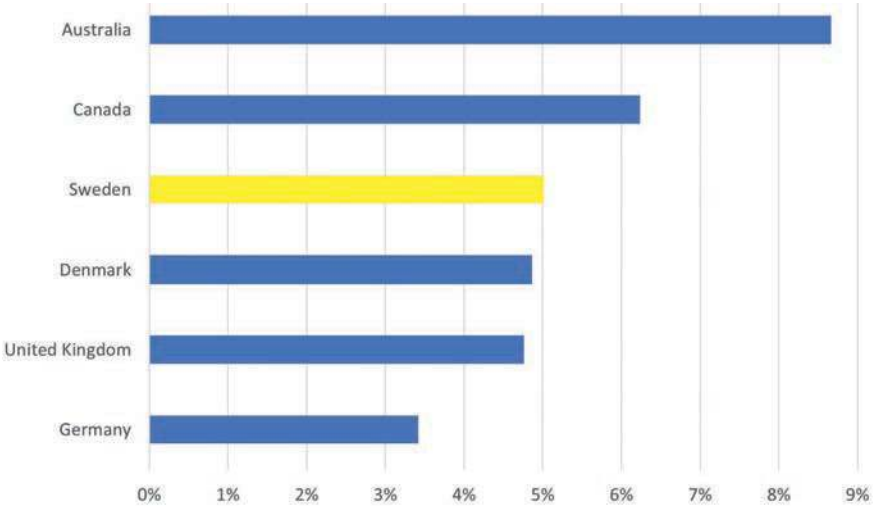
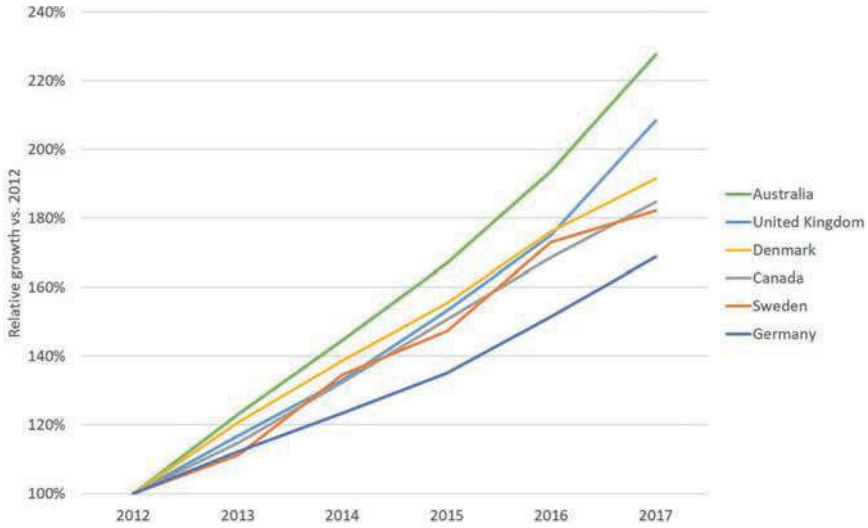


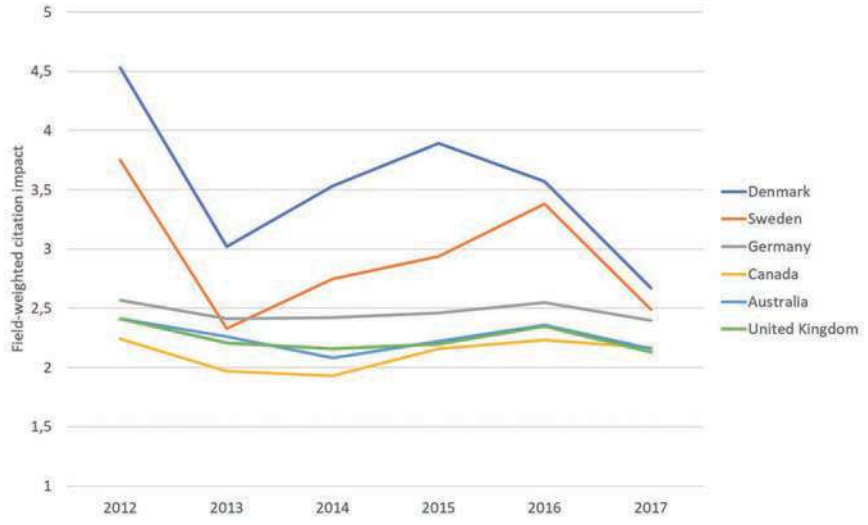
Figure 9 shows the development in co-publication volume since 2012. While the growth for Sweden is impressive, as presented above, most of the reference countries have shown more rapid growth.

Figure 9: **Co-publication growth with China**



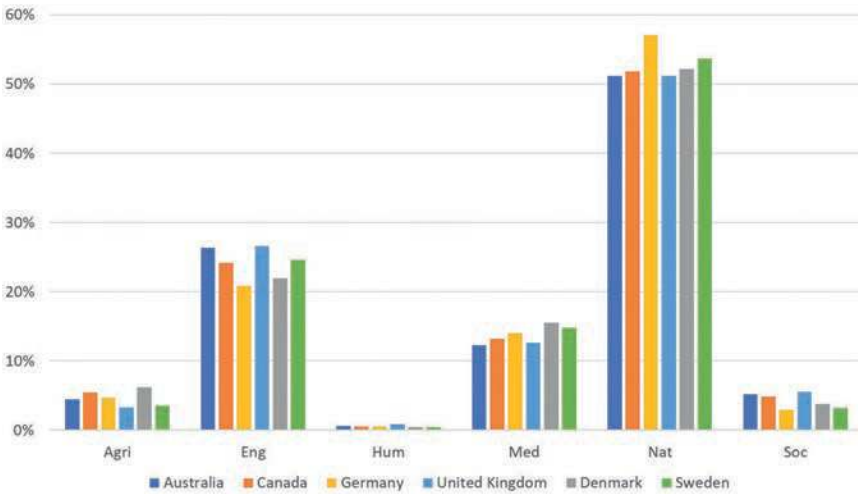
One indicator for co-publication quality is presented in Figure 10. All co-publication sets have clearly higher FWCI than the corresponding figures for national publication sets. Sweden–China co-publications enjoy higher FWCI than most comparison countries. The dip in 2013 depends to a large extent on hyper-authored publications, which had lower FWCI in 2013 (compare Figure 6).

Figure 10: **FWCI (quality) for co-publications with China**



The distribution of co-publications over the disciplines depends for instance on the profiles of the collaborating countries. As China is the partner country for all countries, the distribution does not differ that much. Obviously, most collaborations require that peers within a similar research area exist in both countries. Therefore, as China has a comparatively low share of research in the humanities, this reduces the opportunities for collaboration. This is further addressed in the next section, c.f. Figure 14. Collaborations with Denmark and Sweden show some emphasis on medicine, whereas collaboration with Germany appears to focus on the natural sciences (cf. Figure 11).

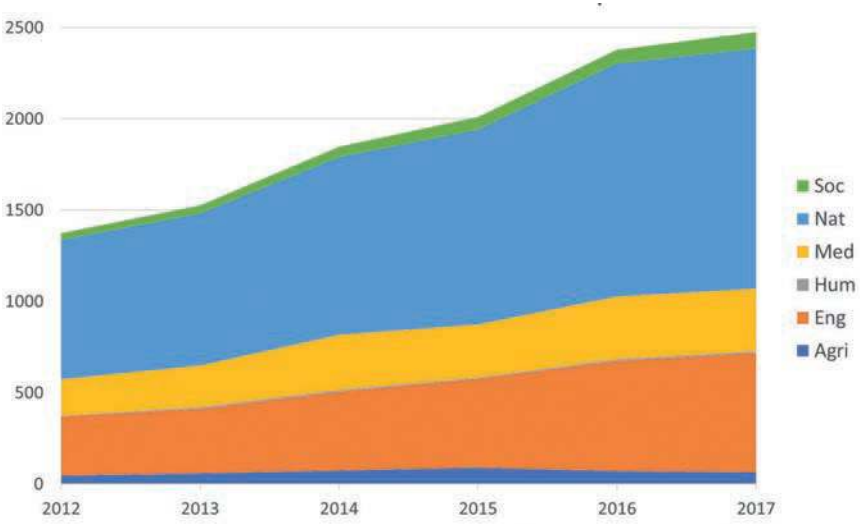
Figure 11: **Scientific profiles of co-publications with China**



5. Which scientific disciplines are involved in collaborations?

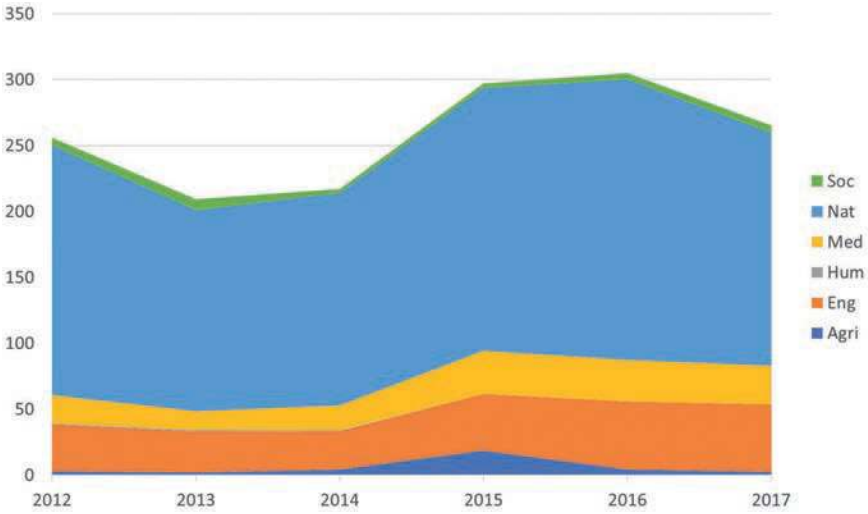
The natural sciences represent more than 50% of all co-publications (Figure 12). Engineering & technology form the second largest collaboration discipline, followed by medical sciences. The smallest discipline is the humanities, with 7–15 co-publications per year.

Figure 12: **Sweden – China co-publications per scientific discipline**



In Figure 13, only co-publications with more than 100 co-authors are included. Most hyper-authored publications are in the natural sciences, followed by engineering & technology.

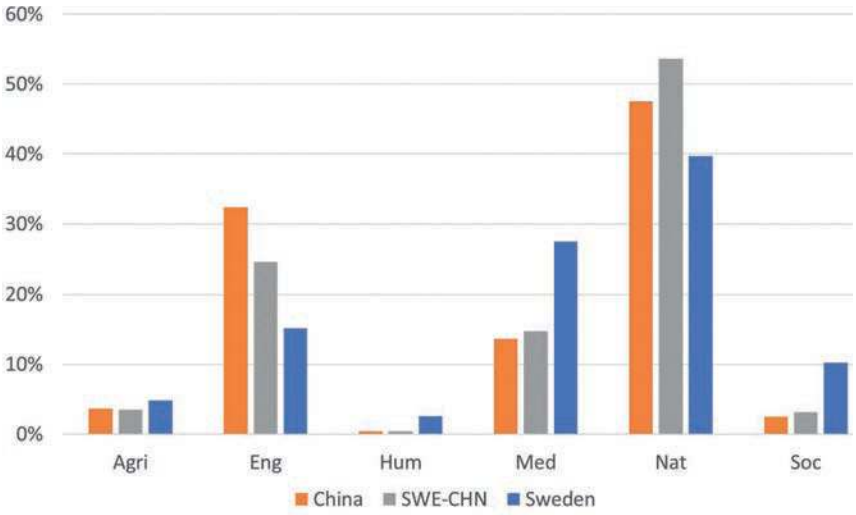
Figure 13: **Hyper-authored Sweden–China co-publications per scientific discipline**



The scientific profile of collaboration depends on the profiles of the collaborating countries. In Figure 14, the total volume of publications for the period 2012–2017 was used to calculate the share of publications in each scientific discipline for Sweden, China and co-publications involving Sweden and China. China has higher shares of publications in engineering & technology and the natural sciences, whereas Sweden has much higher shares in the humanities and social sciences and also higher shares in medical sciences.

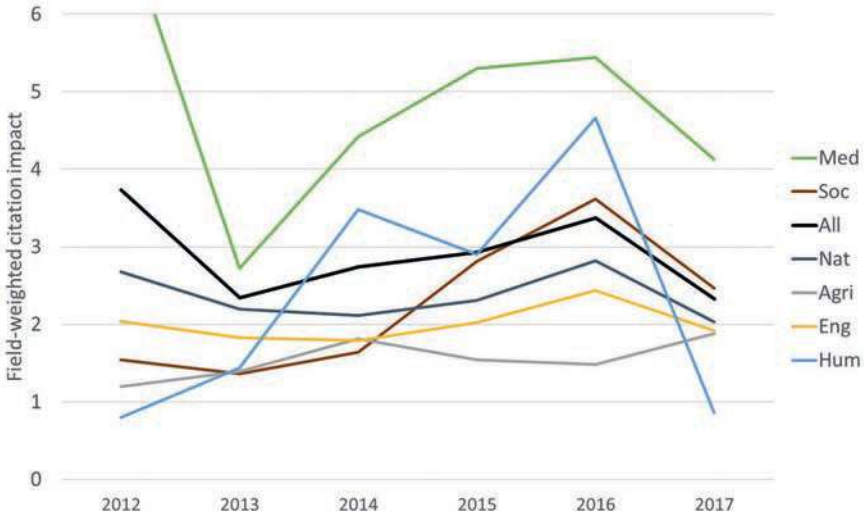
The co-publication shares in each discipline typically fall in the range between the shares for the collaborating countries. This is also the case in some disciplines, as indicated in Figure 14. However, the natural sciences have a higher share of co-publications. One of the contributing factors is that the natural sciences are very international, with high shares of international co-publications. Another factor is hyper-authored publications, which to a large extent occur in the natural sciences.

Figure 14: **Scientific profiles for China, Sweden and their co-publications**



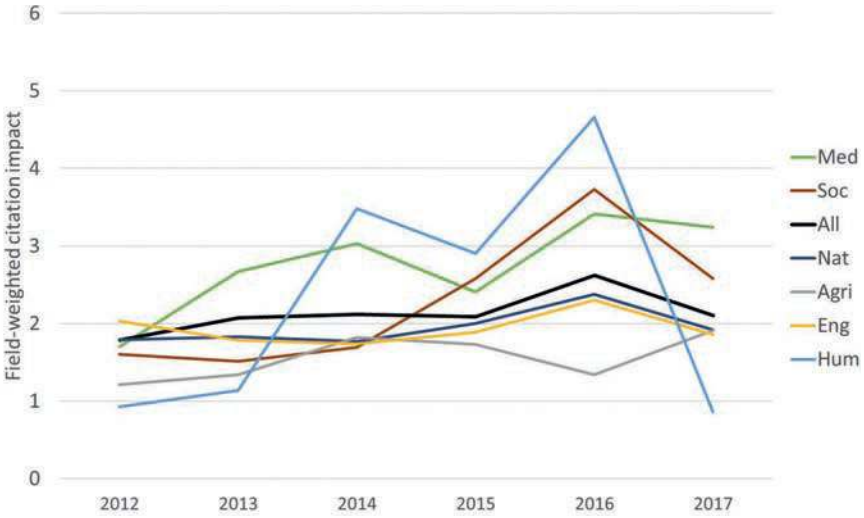
In terms of quality, the co-publications in all scientific disciplines have high or very high citation impacts (Figure 15). Again, as explained in the methodology section, the FWCI for the most recent period will change as more citations are accumulated and the lower values for 2017 may not remain.

Figure 15: **Field-weighted citation impact for all Sweden – China co-publications**



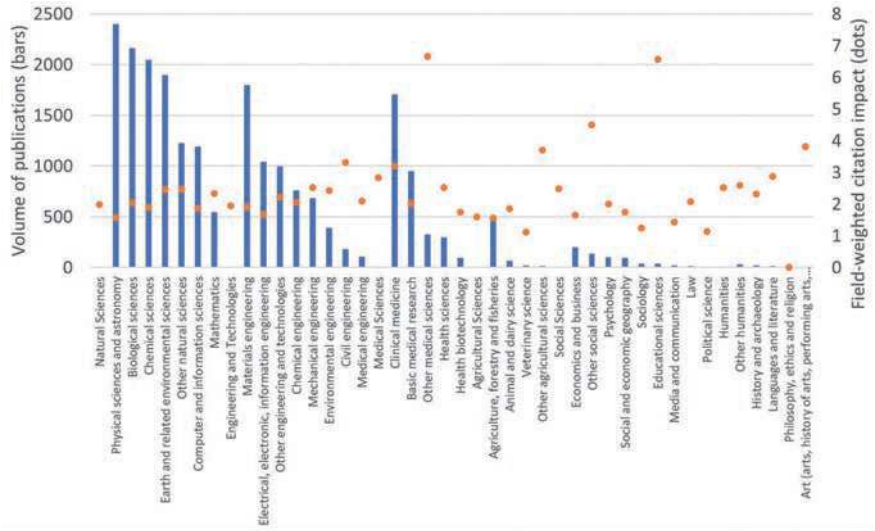
If only publications with fewer than 100 co-authors are considered, it becomes clear that hyper-authored publications have a large impact on the total citation impact for medical sciences (Figure 16).

Figure 16: **Field-weighted citation impact for Sweden – China co-publications with fewer than 100 authors**



A closer look at the subcategories indicates that several disciplines in the natural sciences yield high numbers of co-publications (Figure 17). Medical sciences are more focused on clinical aspects. A few subcategories have very high citation impact, among them the educational sciences.

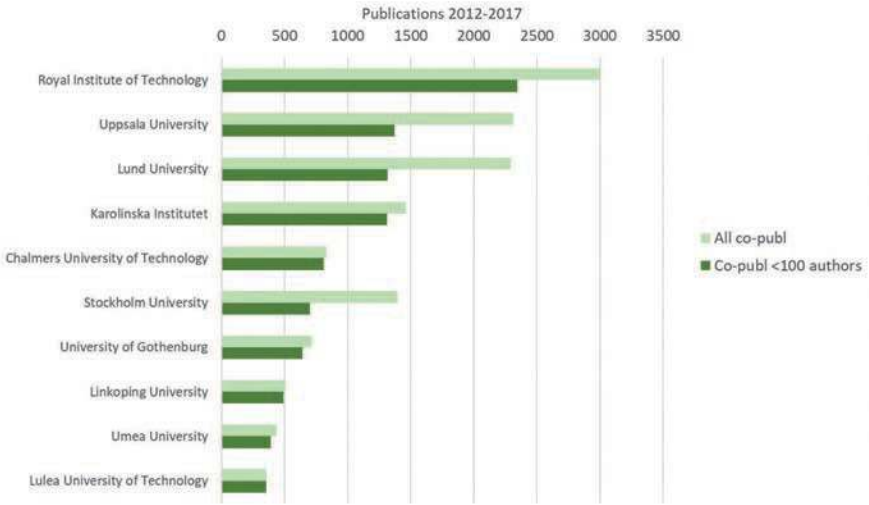
Figure 17: **Publication volume and citation impact per subcategory**



6. Collaborating institutions

One advantage of publication data is that it can be used at all levels of aggregation, from the global perspective down to individual researchers. In this section, we focus on the ten higher education institutions (HEIs) in Sweden with the largest numbers of co-publications with China with fewer than 100 authors (and vice versa). As can be seen in Figure 18, hyper-authored publications form a substantial share of all co-publications for Uppsala University, Lund University and Stockholm University.[2]

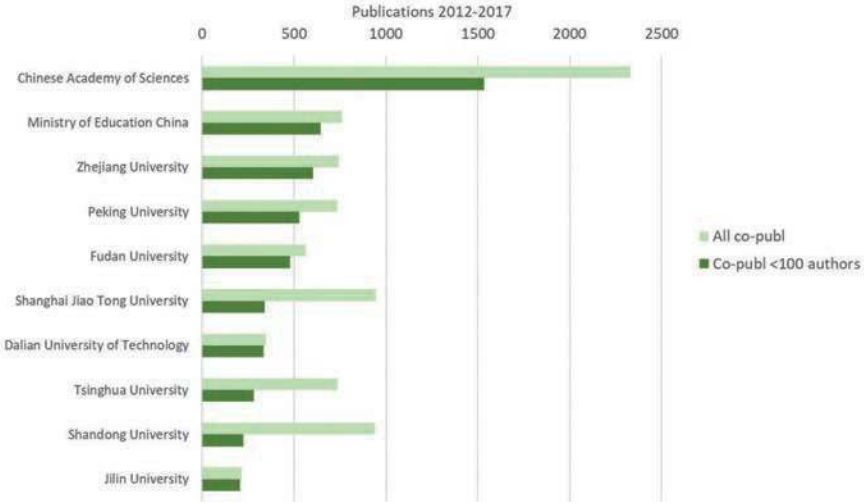
Figure 18: **Swedish HEIs' co-publications with China**



The corresponding data for Chinese HEIs are presented in Figure 19. Also in China, it appears that the top ten collaborators with Sweden participate in large networks of researchers. Here it should be noted that the Ministry of Education is the main affiliation for researchers at the ministry's Key Labs at various institutions in China. Accordingly, these researchers tend to state at least two affiliations in China, one at the ministry and one at the institution hosting the Key Lab.

[2] University names from SciVal are used in figures and tables

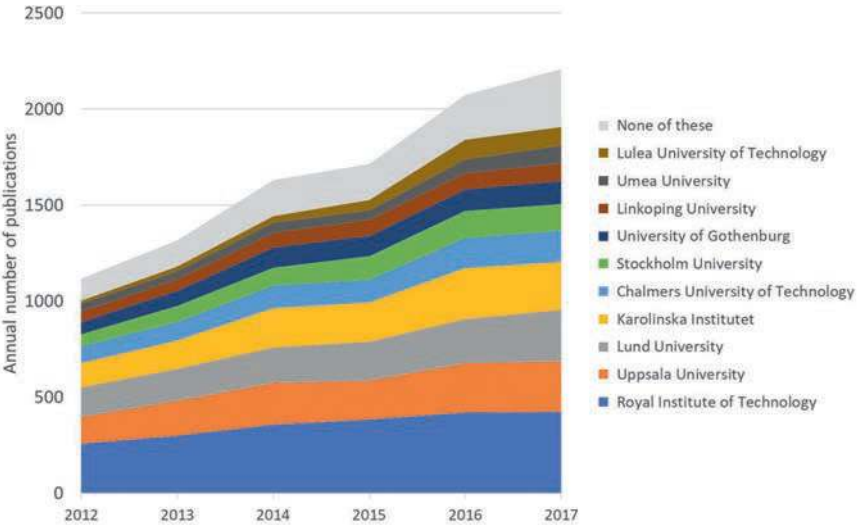
Figure 19: **Chinese HEIs' co-publications with Sweden**



As demonstrated above, hyper-authored publications have a large impact at the institutional level and they are thus not included in the rest of this section.

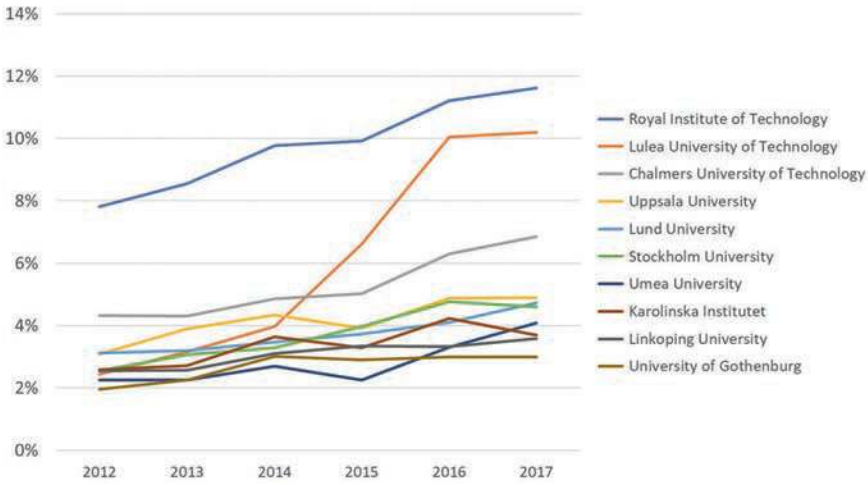
The top ten HEIs in Sweden cover a large share of the total co-publication volume (Figure 20).

Figure 20: **Top ten Swedish HEIs with the highest numbers of co-publications with China**



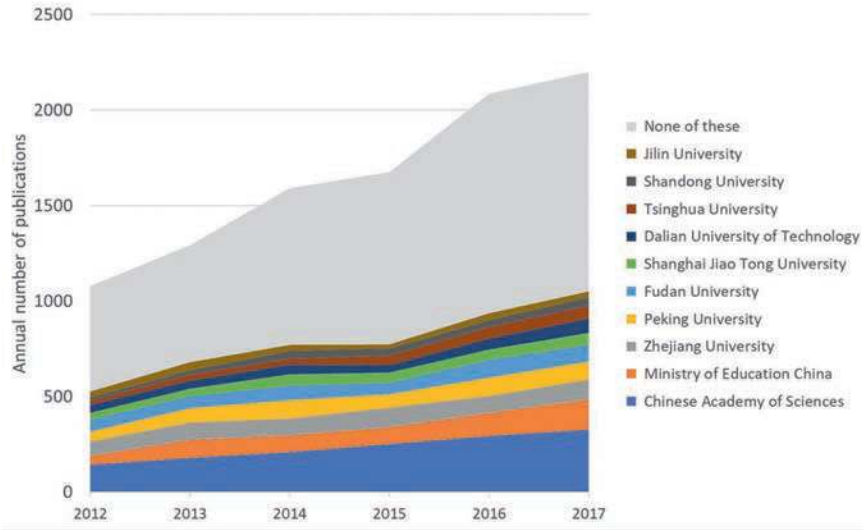
The volumes are increasing, also in comparison to the total publication volume at each HEI (cf. Figure 21). Three universities of technology enjoy the largest shares of co-publications with China.

Figure 21: **Share of co-publications with China in relation to all publications at the HEI**



China has many more HEIs and thus the top ten are involved in a smaller share of the total, about 50% (Figure 22). The 'None of these' share is also increasing, thus indicating that the collaboration is growing more extensive and involves more Chinese institutions.

Figure 22: **Top ten Chinese HEIs with the highest numbers of co-publications with Sweden**



When comparing the Chinese HEIs' co-publications with Sweden to their total publication output, the shares are small but increasing (Figure 23).

Figure 23: **Share of co-publications with Sweden in relation to all publications at the HEI**

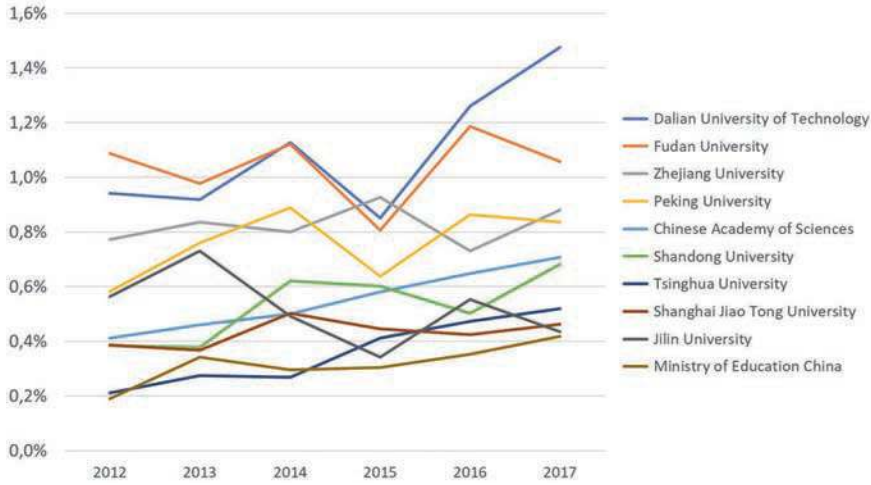


Table 1: **Absolute and relative growth in co-publications with fewer than 100 authors**

Growth 2012–2017 (2017 incomplete)		
	Absolute	**Relative**
Lulea University of Technology	87	583%
Umea University	56	222%
Stockholm University	82	219%
Karolinska Institutet	136	197%
Uppsala University	137	191%
University of Gothenburg	63	191%
Chalmers University of Technology	84	188%
Lund University	123	172%
Royal Institute of Technology	182	164%
Linkoping University	39	164%
Ministry of Education China	122	344%
Tsinghua University	49	313%
Chinese Academy of Sciences	203	230%
Shandong University	28	222%
Peking University	48	186%
Dalian University of Technology	37	182%
Shanghai Jiao Tong University	28	168%
Fudan University	29	143%
Zhejiang University	30	135%
Jilin University	-1	97%

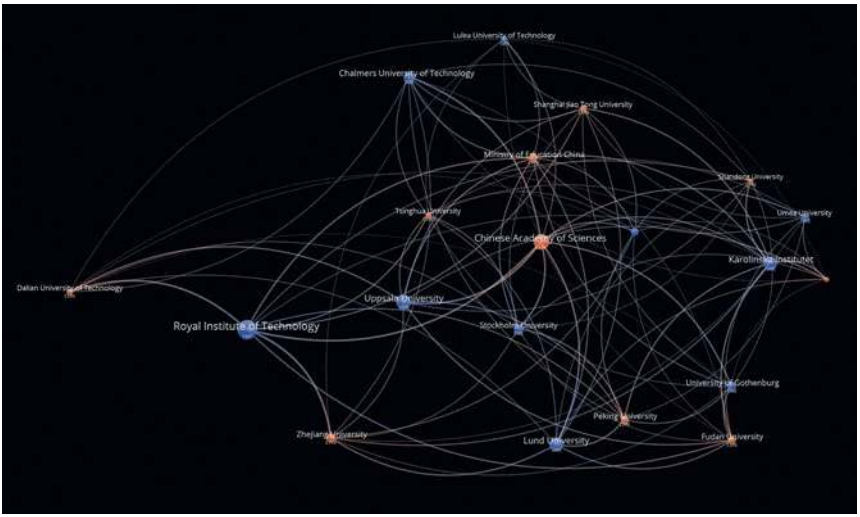
The co-publication matrix based on publications 2012–2017 in Figure 24 indicates that the Chinese Academy of Sciences dominates in almost all Swedish HEIs' co-publications with China. Karolinska Institutet shows a slightly different pattern, probably because of its focus on medical sciences.

Figure 24: **Co-publication matrix for the top ten HEIs (<100 authors)**

	Chinese Academy of Sciences	Ministry of Education China	Zhejiang University	Peking University	Fudan University	Shanghai Jiao Tong University	Dalian University of Technology	Tsinghua University	Shandong University	Jilin University	TOTAL CO-PUBL. W. CHINA
Royal Institute of Technology	270	119	331	56	91	68	257	81	25	11	**2345**
Uppsala University	263	103	35	63	83	37	101	47	20	25	**1372**
Lund University	199	60	97	120	70	32	15	27	14	24	**1315**
Karolinska Institutet	62	83	49	93	132	89	3	11	108	92	**1312**
Chalmers University of Technology	205	75	18	22	4	35	16	26	12	3	**810**
Stockholm University	176	65	18	95	11	16	16	46	6	20	**700**
University of Gothenburg	135	37	11	43	68	18	1	12	13	3	**640**
Linkoping University	66	39	33	33	11	24	2	9	19	8	**491**
Umea University	81	23	5	13	19	11	0	9	10	24	**388**
Lulea University of Technology	27	26	4	0	2	23	4	7	3	1	**353**
TOTAL CO-PUBL. W. SWEDEN	**1535**	**644**	**604**	**529**	**479**	**340**	**333**	**282**	**225**	**207**	

Based on the same data, collaboration can be visualised using clustering tools. In this case, Vosviewer is used, which clusters entities based on the strength of each link (Vosviewer, 2017). The size of the circles represents the total co-publication volume, whereas the thickness of the links represents the numbers of co-publications (Figure 25). Co-publications between Swedish or between Chinese HEIs are not indicated.

Figure 25: **Cluster map of the top ten HEIs' collaborations**



Technology dominates the left-hand side of Figure 25, whereas the medicine cluster is represented on the right. The central position of the Chinese Academy of Sciences reflects the fact that it has the highest number of co-publications with 9 out of 10 Swedish HEIs. KTH Royal Institute of Technology has the highest number of co-publications with China, but they are more concentrated on a few HEIs, thus the position in the map.

7. Collaborating researchers

Approximately 9,000 researchers in Sweden and 21,000 in China have been involved in co-publications between China and Sweden during 2012–2017. Again, it is most relevant to look at co-publications with fewer than 100 authors. The ten most productive researchers of co-publications with fewer than 100 authors are listed in Table 2.

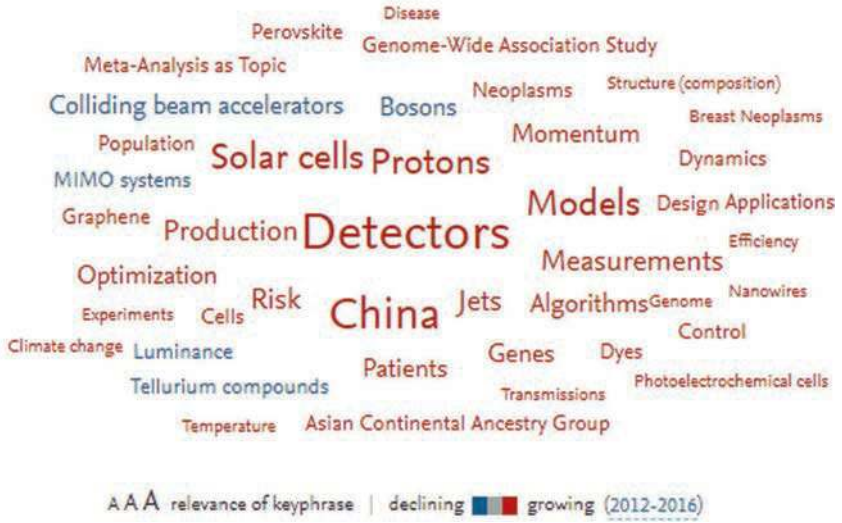
Table 2: **Researchers with the highest numbers of Sweden–China co-publications during 2012–2017**

No. of publ.	Author	Scopus main affiliation	Second affiliation	Research area publ.
215	Sun, Licheng	KTH Royal Institute of Technology	Dalian University of Technology	Catalysts, solar cells...
204	He, Sailing	KTH Royal Institute of Technology	Zhejiang University	Metamaterials, antennas...
141	Sundén, Bengt	Lund University		Heat transfer, fuel cells...
115	Liu, Johan	Shanghai University	Chalmers University of Technology	Thermal insulating materials, graphene...
89	Wang, Shumin	Shanghai Institute of Microsystem and Information Technology Chinese Academy of Sciences	Chalmers University of Technology	Semiconductors...
86	Vasilakos, Athanisos V.	Lulea University of Technology		Wireless networks, cloud computing...
82	Li, Xin	KTH Royal Institute of Technology		Solar cells, fluorescence...
82	Yan, Jinyue	KTH Royal Institute of Technology	Mälardalen University	Solar cells, energy...
82	Zhu, Bin	China University of Geosciences	KTH Royal Institute of Technology	Fuel cells...
77	Luo, Yi	Hefei National Laboratory for Physical Sciences at Microscale	KTH Royal Institute of Technology	Materials science, chemical engineering...

Seven of these researchers have multiple affiliations and six have one affiliation in Sweden and another in China. A detailed study of Licheng Sun's affiliations shows that 208 of his 215 publications indicate KTH Royal Institute of Technology as an affiliation and 211 Dalian University of Technology. Most of his publications have 5–10 co-authors. For the next researcher, Sailing He, 192 publications list KTH Royal Institute of Technology as an affiliation and 167 Zheijang University. Most of his publications have 3–7 co-authors.

Using Elsevier Fingerprint engine (cf. Elsevier, 2016) to analyse the metadata and abstracts of the publications, the key phrases in the publication set comprising all co-publications between Sweden and China are depicted in Figure 26. As explained in the figure, the colours specify the growth or decline during the full years 2012–2016, and the font size indicates relevance.

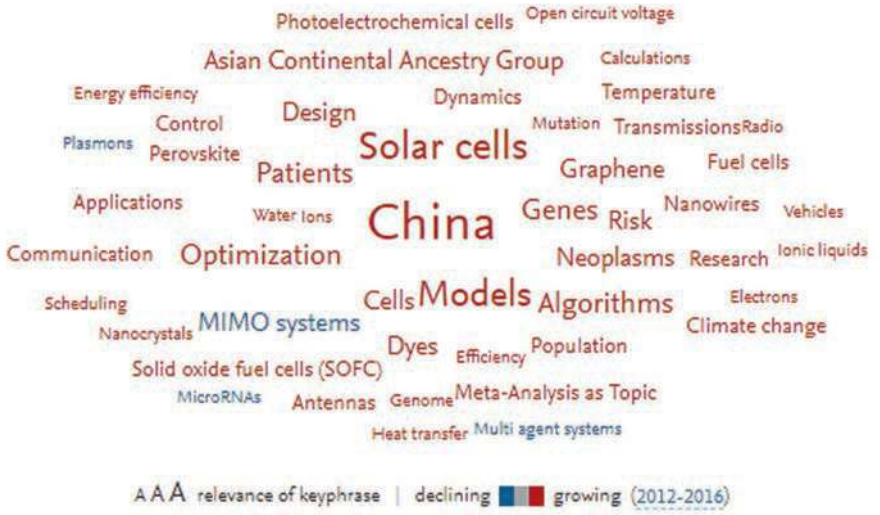
Figure 26: **Key phrase map for all Sweden – China co-publications, 2012 – 2016**



In Figure 27, co-publications with fewer than 100 authors are used to create a map of key phrases. Some key phrases such as Detectors, Protons and Bosons are obviously most relevant for hyper-authored publications whereas Solar cells, China and Models are relevant in both sets.

The key phrases match the scientific areas of the researchers in Table 2. However, the key phrase China is not a part of their research interests. The absence of Sweden as a key phrase indicates that China is more dominant in the definition of research areas to address.

Figure 27: **Key phrase map for Sweden – China co-publications with fewer than 100 authors, 2012 – 2016**



8. Student mobility

The most reliable data for student mobility to and from Sweden are provided by the Swedish Higher Education Authority (UKÄ, 2017). In Table 3, data for student mobility between China and Sweden are summarised.

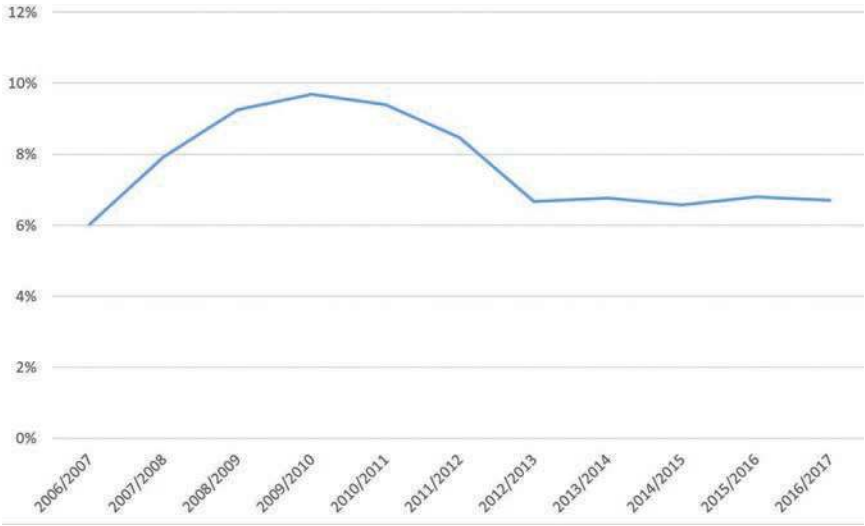
Table 3: **Student mobility, Sweden–China**

Year	2012/13	2013/14	2014/15	2015/16	2016/17
From China to Sweden					
Exchange	741	855	923	985	978
Free mover	1597	1384	1280	1416	1460
Share of all inbound to Sweden	6,8%	6,9%	6,6%	6,8%	6,8%
Share of all outbound from China*	0,33%	0,31%	0,29%	0,29%	0,29%
From Sweden to China					
Exchange	406	478	492	503	457
Free mover	108	133	128	129	94
Share of all outbound from Sweden	2,6%	2,8%	2,6%	2,6%	2,3%

Even though exchange students to some extent indicates a balance, the inbound exchange students from China to Sweden are twice as many as the outbound students from Sweden to China. But the difference in free mover students is much larger, about one order of magnitude. China receives the largest number of students from Sweden in Asia, closely followed by Japan and Singapore. However, several European countries as well as the USA, Canada and Australia receive higher numbers of Swedish students than China.

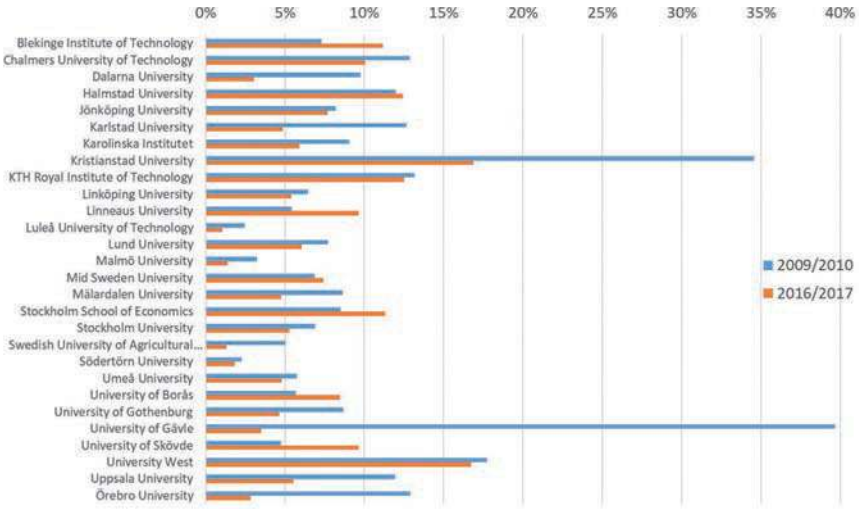
Based on data from UKÄ, it is also possible to extract a longer time series for student mobility (UKÄ, 2018). Figure 28 shows that the share of Chinese students in the total population of international students in Sweden peaked in the year 2009/2010. Here the impact of the reform that introduced tuition fees for non-European students from 2011 is clearly visible. One consequence of the reform was that the number of students from outside of Europa (e.g. China) dropped dramatically.

Figure 28: **Chinese students to Sweden as a share of the total number of incoming students**



Per institution and in absolute numbers, KTH Royal Institute of Technology hosted most Chinese students in 2009/2010 with 622, followed by Uppsala University (380), the University of Gävle (366) and Lund University (354). In 2016/2017, KTH Royal Institute of Technology still had the largest number (383), followed by Lund University (308), Stockholm University (202) and Uppsala University (194). Comparing the peak year with the latest year reveals substantial changes not only in the absolute numbers but also in the share of Chinese students in the total number of international students for some HEIs, among them the University of Gävle and Kristianstad University (Figure 29). A few HEIs have seen an increase in the share of Chinese students, including Blekinge Institute of Technology and the University of Skövde.

Figure 29: **Chinese incoming students in relation to all international students per HEI**



A rough comparison between the volumes of incoming students from China in Sweden and other countries is presented in Table 4. Here, the total number of incoming students from China according to UNESCO is divided by the country's population in 2015 (World Bank, 2017). In comparison to Denmark and Norway, Sweden receives slightly more students per capita, whereas Australia receives 20 times more students from China than Sweden.

Table 4: **Number of incoming students from China in relation to total population**

Incoming Chinese students in relation to population size	
Australia	0,472%
New Zealand	0,362%
Canada	0,170%
United Kingdom	0,140%
United States	0,091%
Korea, Rep.	0,068%
Japan	0,062%
France	0,038%
Finland	0,032%
Germany	0,029%
Sweden	0,024%
Denmark	0,023%
Switzerland	0,018%
Norway	0,013%
Austria	0,007%
Belgium	0,005%
Brazil	0,000%

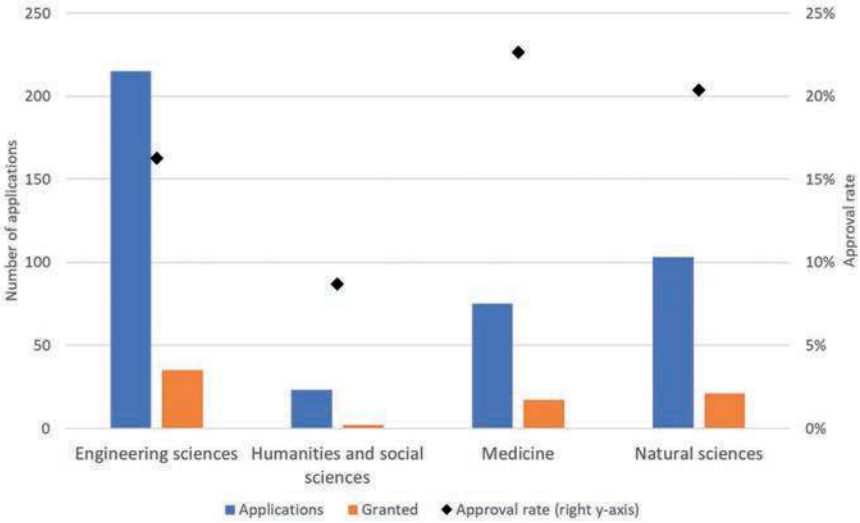
In a study of Swedish HEIs' international collaborations in education, China is number eleven in terms of the number of agreements (278). Most agreements are with Germany (1,227) and of the other ten countries above China, only the United States is located outside of Europa. Data refer to the year 2014/15 and come from a questionnaire distributed to all Swedish HEIs (UKÄ, 2015).

9. The STINT–NSFC mobility programme

Since 2015, STINT has offered a bilateral programme together with the National Natural Science Foundation of China (NSFC). The funding is for mobility only. Applications are submitted in Sweden and China, to be reviewed in a parallel process. The results of the review are compared and every year 25 new three-year projects are jointly selected for funding. From the Swedish side, the programme is open to applicants from all disciplines and in China, there is a requirement that the applicant must have research funding from the NSFC and the programme is thus limited to disciplines supported by the NSFC.

Three complete cycles have been carried out with a total of 416 applications and 75 ongoing projects. In Figure 30, the distribution over the four disciplinary classifications that STINT uses is shown for applications as well as granted projects.

Figure 30: **Scientific profile of applications to the STINT-NSFC programme**



In terms of institutions applying, there is a large difference between the countries. In Sweden, a total of 22 HEIs have submitted at least one application, and projects hosted by 14 institutions have been granted funding. In China, approximately 160 HEIs have participated, of which 51 have hosted granted projects. In Figure 31 and Figure 32, the top eleven institutions are indicated.

Figure 31: **Most active HEIs in Sweden**

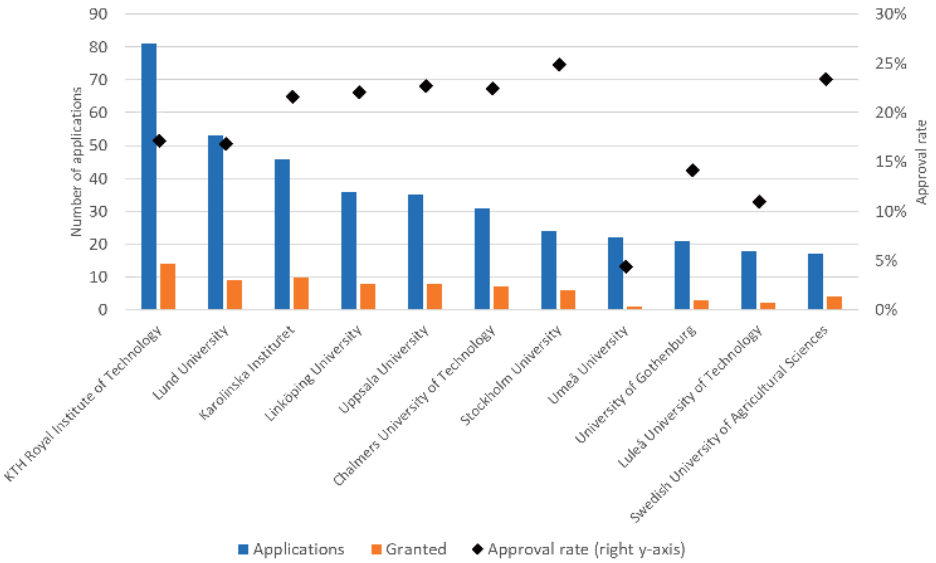
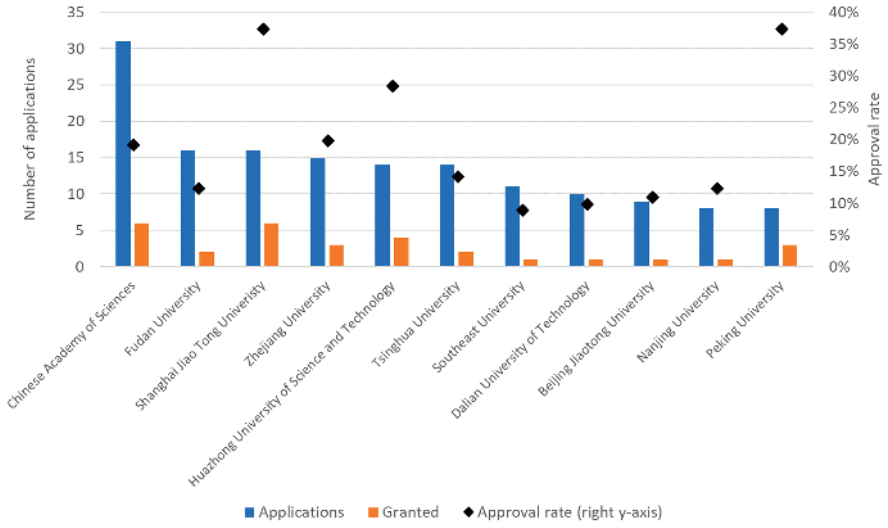
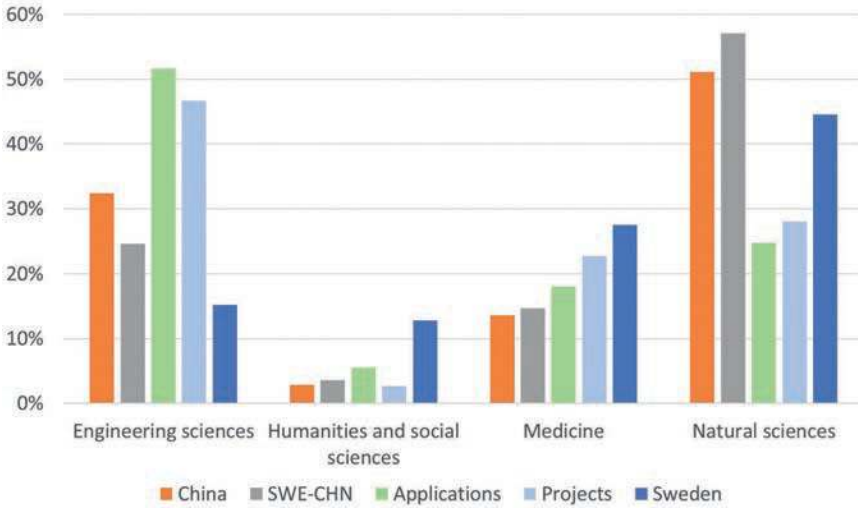


Figure 32: **Most active HEIs in China**



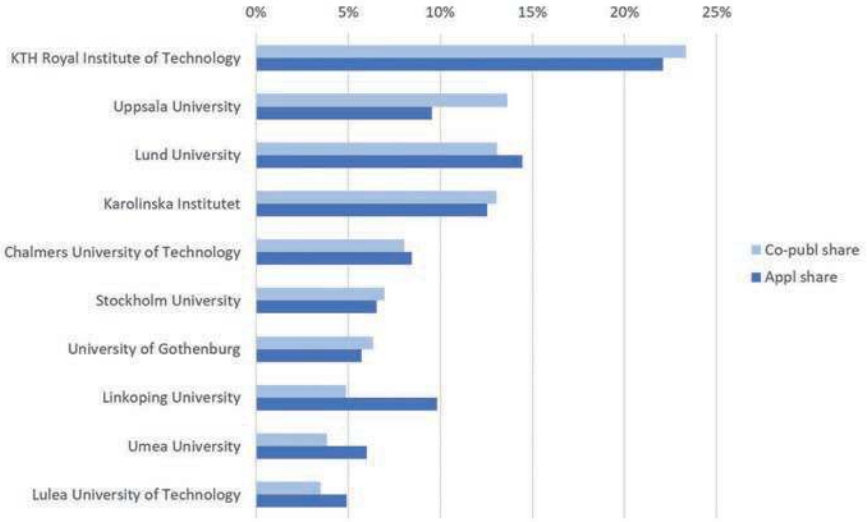
In Figure 33, the scientific profile of the STINT–NSFC mobility programme is compared to the profile of the total volume of co-publications. It shows that the programme has approximately the same distribution over the disciplines as the publications in medicine and the humanities and social sciences. Engineering sciences is overrepresented in the STINT–NSFC programme at the expense of the natural sciences.

Figure 33: **Scientific profiles of publications, applications and funded STINT–NSFC projects**



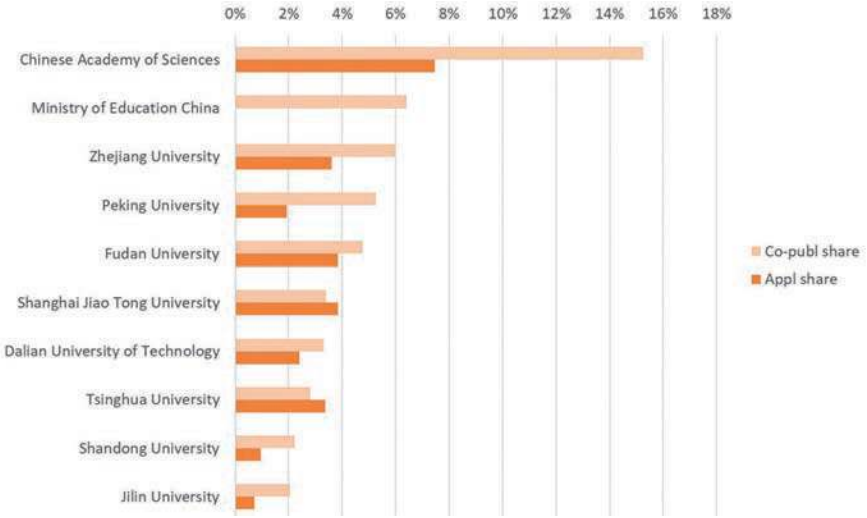
There is high correlation between the production of co-publications and the activity in the STINT–NSFC programme on the Swedish side (cf. Figure 34). Linköping University is more active in the programme than its share of co-publications suggests and Uppsala University slightly less.

Figure 34: **STINT–NSFC applications and SWE–CHN co-publications comparison: Sweden**



Among the Chinese HEIs, the differences are larger (Figure 35). However, it is not surprising that the Ministry of Education does not apply for NSFC funding. It should also be noted that many more HEIs are involved on the Chinese side in co-publications as well as in applications, which makes the comparison less relevant.

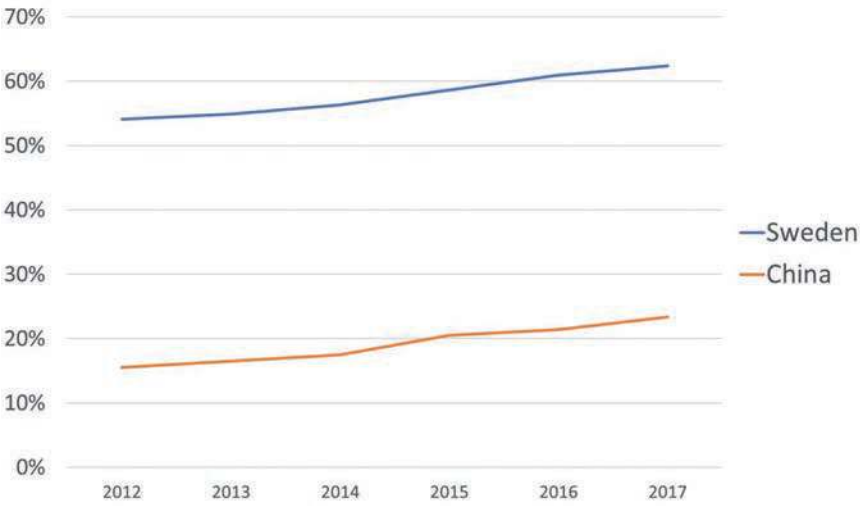
Figure 35: **STINT–NSFC applications and SWE–CHN co-publications comparison: China**



10. What does this study tell us?

The overall data indicate a rapid increase in the number of co-publications involving Sweden and China. Several factors might contribute to this increase. One factor is a global trend towards more international co-publications. Figure 36 shows that the share of international co-publications is steadily increasing in Sweden as well as in China.

Figure 36: **Shares of international co-publications for Sweden and China**



Another factor is that Sweden has hosted many Chinese students at Master and PhD level. Some of them continue as researchers in Sweden or China and their networks and language skills naturally foster collaboration between the countries. A third factor is that China's research profile centres on disciplines that typically engage in extensive international collaboration.

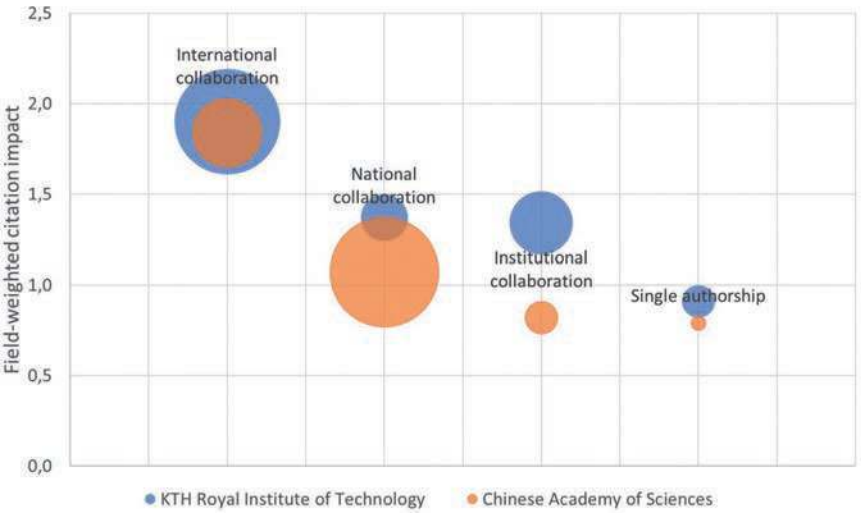
The development of Swedish co-publications with China does not differ much from that of the other countries studied. In relation to all publications involving China, Australia and Canada clearly show higher shares of co-publications with the country, as well as a higher growth rate. As the numbers of Chinese students to these countries also are high, this may be expected. However, the United Kingdom does not show the same relationship: the number of Chinese students is relatively high, but the share of co-publications with China is more modest.

The study of the scientific disciplines represented in the co-publications confirms this focus on the natural sciences, in all and particularly in the hyper-authored publications. All disciplines except the humanities show a growth over the period studied.

In terms of quality, international co-publications often enjoy slightly higher citation impact than national (co-)publications. As an example, Figure 37 shows the shares of each type of publication (bubble size) and the field-weighted citation impact it enjoys (vertical position) for the top Swedish and Chinese institutions in Sweden–China collaboration. All publications during the period 2012–2017 were included.

The bubbles for international collaboration are positioned approximately at an FWCI of 1.8 on the vertical axis for KTH Royal Institute of Technology (KTH) and the Chinese Academy of Sciences (CAS). The size of the bubble is larger for KTH, whereas CAS engages in a lot more national collaboration. Comparatively, the FWCI for CAS's international co-publications differs more from other types of collaboration than that of KTH.

Figure 37: **Relationship between type of publication and its field-weighted citation impact**



A bit more complicated comparison is presented in Figure 38. Here, the bubble size represents the volume of co-publications between Sweden and the country indicated during 2012–2017, and the position indicates

how much better the FWCI is for the co-publications in comparison to all publications involving that country. A position far to the right indicates a high relative citation impact benefit for Sweden, whereas a position at the top of the diagram indicates high relative citation impact benefit for the partner country.

Figure 38: **Relative benefit of collaboration**

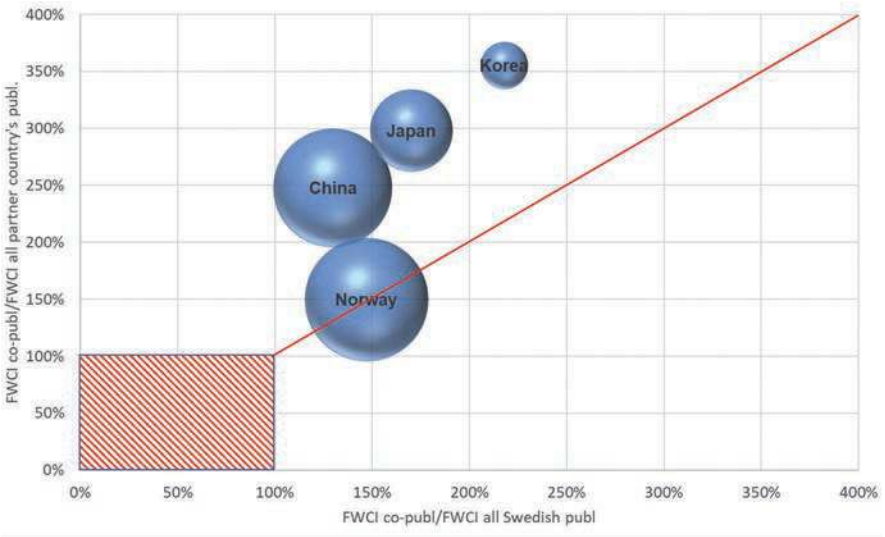


Figure 38 tells us that the number of co-publications with fewer than 100 authors is approximately the same for Sweden – China and Sweden – Norway. All bubbles are outside the red area, which means that all collaborations are resulting in higher citation impacts than the average publications for the countries. A position above the red line means that the relative citation impact benefit is higher for the partner country, whereas a position below means that Sweden benefits the most. Norway is on the red line and the other bubbles are above and thus more beneficial to the partner countries than to Sweden. Among these four countries, collaborations with Korea have been the fewest but also the most rewarding for Korea as well as for Sweden.

As the co-publications between Sweden and China give a relatively high and increasing FWCI, many of the institutions and researchers involved appear to produce high quality research. A look at the most productive researcher, Licheng Sun, confirms this, as he has an FWCI of 2.84 for

publications in 2012–2017.

The analysis highlights that several international co-publications are generated thanks to authors with double or multiple affiliations, of which at least one is in Sweden and one in China. It could be argued that this type of publication does not reflect a true international collaboration. But it could also be argued that such researchers embody an interesting and close international collaboration, as they probably have strong networks in both countries. A detailed study of the most productive researchers indicates that other researchers in China and Sweden often are listed as co-authors in their publications.

Having affiliations in two countries makes it possible to apply for funding in two systems. This might reduce researchers' dependency on mobility funding schemes.

Student mobility data show relatively small changes in the period 2012–2017. Sweden receives approximately four times more students from China than it sends to China. In comparison to other European countries, Sweden is about average when normalising the Chinese incoming student number with the size of the country's population. In comparison to countries with a strong tradition of delivering education to international students, Sweden receives small numbers of Chinese students.

11. Conclusions and recommendations

Publication data indicate that collaboration between Sweden and China has developed rapidly but not very differently from other mature research countries' collaborations with China. Sweden – China research collaboration generates publications with high citation impact. Natural sciences and engineering & technology dominate and this is also reflected in the type of HEIs in Sweden that enjoy the largest shares of co-publications with China, namely universities of technology.

The STINT–NSFC mobility programme does not appear to contribute to a change in the institutional collaboration pattern between Sweden and China, at least not on the Swedish side. However, it appears to intensify collaboration within the engineering sciences.

Given the relatively low overall volume of co-publications between Sweden and China, and the high citation impact such research collaboration yields, the obvious policy recommendation is to support continued growth. This recommendation applies to both countries, even though the relative citation impact benefits so far have been higher on the Chinese side.

On the Swedish side, one approach to supporting growing collaboration could be to involve additional HEIs. Data indicate that more than 90% of the collaboration is facilitated by 10 HEIs and that the top 4 HEIs produce approximately 60% of the co-publications. If not only publications with fewer than 100 co-authors are counted, the dominance of a few HEIs would be even stronger. Closely linked to this, ways of expanding research collaboration between Sweden and China in the humanities and social sciences should also be discussed.

Another aspect to consider is how to promote innovations emanating from these academic collaborations. The share of academic-corporate co-publications among all China-Sweden co-publications is at the same level as for all publications in Sweden and more than twice as high as for all publications in China. Given the size of the Chinese market, the economic potential for successful new products and services is very large.

Finally, student mobility and collaboration in education at all levels is another type of academic collaboration that can be further developed. Several of the large hosts of Chinese students in Sweden have drastically lower numbers of students now than ten years ago. To some extent, student mobility also nurtures research collaborations.

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The Swedish Foundation for International Cooperation in Research and Higher Education, STINT, was set up by the Swedish Government in 1994 with the mission to internationalise Swedish higher education and research.

STINT promotes knowledge and competence development within internationalisation and invests in internationalisation projects proposed by researchers, educators and leaderships at Swedish universities.

STINT promotes internationalisation as an instrument to:

- Enhance the quality of research and higher education
- Increase the competitiveness of universities
- Strengthen the attractiveness of Swedish universities

STINT's mission is to encourage renewal within internationalisation through new collaboration forms and new partners. For example, STINT invests in young researchers' and teachers' international collaborations. Moreover, STINT's ambition is to be a pioneer in establishing strategic cooperation with emerging countries in research and higher education.

STINT
The Swedish Foundation for International Cooperation in Research and Higher Education

Mäster Samuelsgatan 60, 9 tr
P.O. Box 3523, SE-103 69 Stockholm, Sweden
Telephone +46 8 67119 90. Fax +46 8 67119 99
info@stint.se www.stint.se