# IDENTIFYING AND RANKING THE WORLD'S LARGEST SCIENCE AND TECHNOLOGY CLUSTERS

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As in the previous two years, this Special Section presents the latest ranking of the world's largest science and technology (S&T) clusters. This spatial view of innovation performance is rooted in the recognition that innovation activities tend to be geographically concentrated. In other words, innovation performance often varies substantially within countries, and the cluster perspective highlights where such performance is strong—at least as far as the S&T dimension of innovation is concerned.

The methodological approach underlying this year's ranking is the same as last year. We identify clusters based on the locations of inventors listed in international patent applications and authors appearing in scientific journal articles. Our data sources continue to be patent filings under WIPO's Patent Cooperation Treaty (PCT) and scientific publications contained in the Web of Science's SCI Expanded, published by Clarivate. Our data for this year's ranking spans 2013-2017, compared to the 2012-2016 time frame used last year.

For a more detailed description of the cluster ranking methodology, we refer the interested reader to last year's Special Section (Bergquist et al., 2018).

## The top 100 S&T clusters

Table S-1.1 summarizes our geocoding results, and Table S-1.2 presents our top 100 cluster rankings. There are relatively few changes from last year, partly reflecting the overlap in time frames but arguably also the persistence of local innovation performance. The composition of the top 10 clusters remains unchanged, with Tokyo–Yokohama at the top of the list, followed by Shenzhen–Hong Kong (2) and Seoul (3). Beijing (4) and San Jose–San Francisco, CA (5) swapped rank compared to last year.

In both 2018 and 2019, the same 27 countries comprise the top 100 clusters. The United States of America (U.S.) continues to host the largest number of clusters (26), followed by China (18)—which is two more than China hosted in 2018. Germany (10), France (5), the United Kingdom (U.K.) (4), Canada (4), and Japan (3) follow next, all unchanged from the previous year.[1]

Compared to last year, almost all of the Chinese clusters moved up the ranks. Guangzhou, the 21st ranked cluster in 2019, moved up 11 places as compared to its 2018 ranking (21, +11). Likewise, Hangzhou (30, +11), Qingdao (80, +22), Suzhou (81, +19), Chongqing (88, +15) and Jinan (89, +10) also registered double-digit rank increases. This reflects faster overall growth in international patent applications and scientific publications by Chinese entities compared to most other countries (Figure S-1.1).

Two factors may explain rank changes from one year to the next. First, rank changes may be due to changes in the volume of patent applications and scientific publications during the two time frames. The declines in the rankings of Heidelberg–Mannheim, 53 in 2019 as compared to 46 in 2018 (53, -7), and Stuttgart (26, -5) mostly reflect declining S&T output while the climb in rankings by Phoenix (76, +10) and Portland (44, +4) reflect increases in S&T output. Second, rank changes may be due to a growing or shrinking cluster geography. For example, the rank increases of Brussels (40, +11) and Istanbul (69, +15) mostly reflect growing cluster areas.[2] It is important to note that such geographical shifts may be sensitive to the threshold

The views expressed here are those of the authors and do not necessarily reflect those of WIPO or its member states.

TABLE S-1.1

## Summary of geocoding results

| | Scientific publications | | PCT applications | | | | |
|---|---|---|---|---|---|---|---|
| Country | Number of addresses | City-level address accuracy (%) | Number of addresses | Block-level address accuracy (%) | Sub-City-level address accuracy (%) | City-level address accuracy (%) | Total address accuracy (%) |
| United States of America | 5,659,179 | 97.23 | 838,413 | 94.13 | 5.46 | 0.17 | 99.76 |
| China | 3,414,955 | 97.53 | 375,251 | 14.25 | 0.63 | 84.13 | 99.02 |
| Japan | 1,090,018 | 93.96 | 530,013 | 38.21 | 31.07 | 29.50 | 98.79 |
| Germany | 1,218,674 | 97.33 | 254,040 | 97.49 | 0.43 | 1.56 | 99.48 |
| Republic of Korea | 706,442 | 93.55 | 200,694 | 0.14 | 0.94 | 80.84 | 81.92 |
| United Kingdom | 1,219,072 | 96.55 | 77,764 | 77.87 | 8.28 | 11.48 | 97.63 |
| France | 1,028,646 | 92.81 | 105,291 | 85.29 | 1.51 | 7.19 | 93.99 |
| Italy | 948,100 | 95.47 | 40,238 | 86.57 | 5.00 | 7.02 | 98.59 |
| Canada | 775,947 | 98.23 | 41,799 | 96.71 | 2.37 | 0.55 | 99.63 |
| India | 587,078 | 92.25 | 36,651 | 32.63 | 43.42 | 19.41 | 95.46 |
| Spain | 716,434 | 96.63 | 26,598 | 69.98 | 9.54 | 19.11 | 98.64 |
| Netherlands | 458,825 | 97.32 | 50,294 | 88.96 | 0.53 | 10.00 | 99.49 |
| Australia | 712,786 | 81.55 | 20,032 | 92.29 | 5.30 | 1.28 | 98.87 |
| Brazil | 541,686 | 98.67 | 8,949 | 78.74 | 12.71 | 7.15 | 98.59 |
| Sweden | 263,589 | 97.60 | 39,949 | 94.59 | 0.88 | 3.93 | 99.40 |
| Switzerland | 284,132 | 90.65 | 35,052 | 88.15 | 5.29 | 4.74 | 98.17 |
| Russian Federation | 313,634 | 99.02 | 15,279 | 83.24 | 5.56 | 9.22 | 98.02 |
| Turkey | 360,651 | 96.56 | 11,173 | 31.17 | 50.54 | 14.63 | 96.35 |
| Iran (Islamic Republic of) | 326,572 | 97.00 | 317 | 0.63 | 1.58 | 86.44 | 88.64 |
| Israel | 140,961 | 89.81 | 27,369 | 50.39 | 8.51 | 30.09 | 88.98 |

Source: WIPO Statistics Database, March 2019.
Notes: This list includes the top 20 countries that account for the highest combined shares of patents and scientific articles. PCT inventor addresses were geocoded to the highest level of detail. Due to the much larger volume, scientific author addresses were geocoded to the city level only.

parameters of our clustering algorithm.[3] In particular, the addition of relatively few inventor and author locations may lead to sizeable shifts in the identified clusters. The rank changes associated with geographical shifts should therefore be treated with due caution.

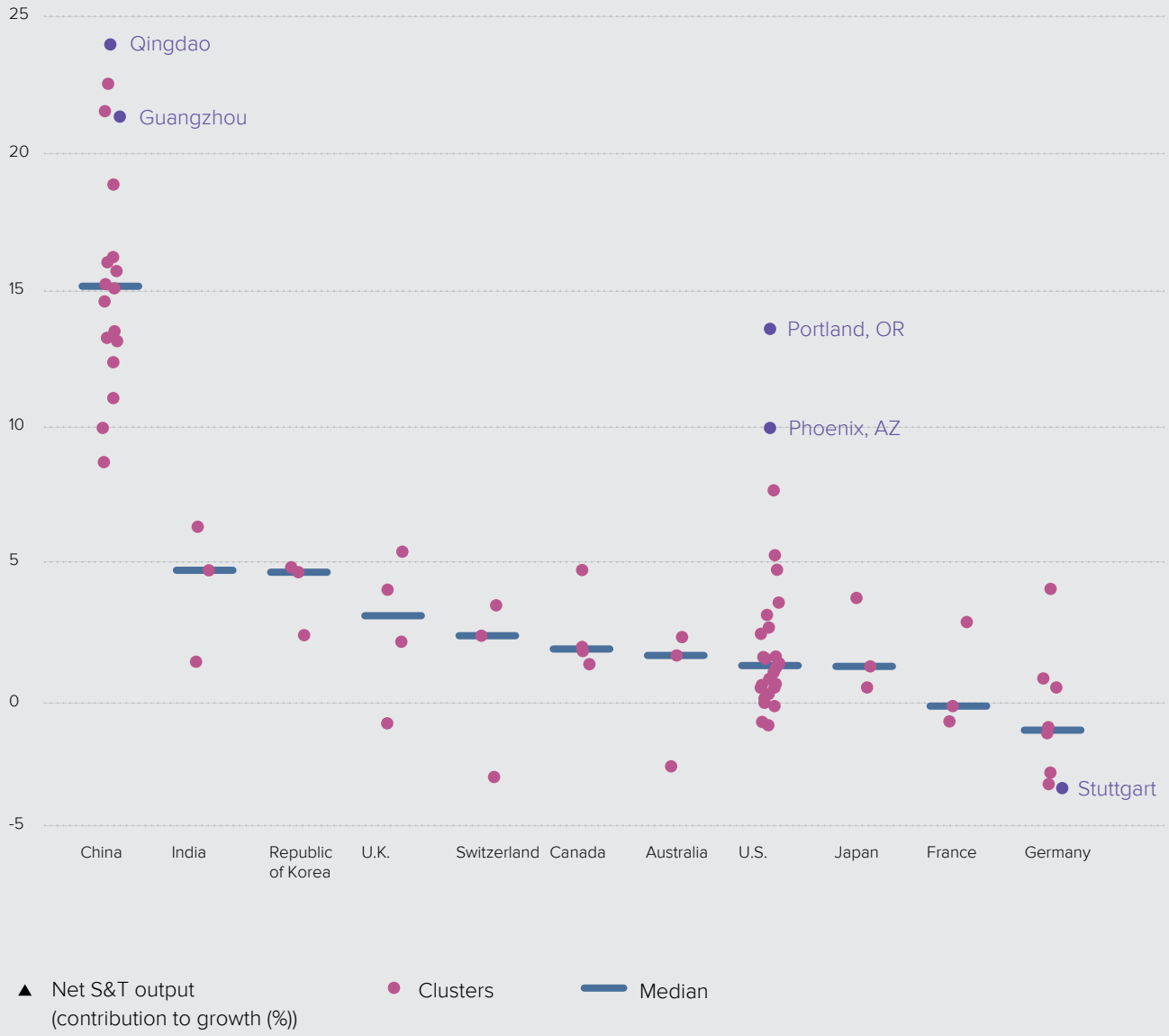
Figure S-1.1 depicts the percentage change in net S&T output by country. It highlights the fast growth of Chinese clusters and the declining S&T outputs for selected clusters—especially in Germany. US clusters show high variance in net S&T output, with two showing double-digit increases and several registering small declines.

Table S-1.3 shows the top field of scientific publishing, the top organizations with which scientific authors are affiliated, the top patenting field, and the top patent applicant. The data illustrates the diversity of clusters around the world in terms of the technology fields represented and the entities generating most S&T output. Compared to last year, there is a notable shift in the distribution of top patenting fields. Coinciding with this year's GII theme, medical technology is now the most frequent top field—appearing in 19 clusters, compared to 16 last year. Pharmaceuticals dropped to second place, with only 15 clusters featuring this field as the top field, compared to 22 clusters in 2018. Digital communications also saw a decline, with this field as the top field in 14 clusters, compared to 16 clusters in 2018. Within the top scientific fields, chemistry remained the most frequent one, though it declined from 36 clusters in 2018 to 32 clusters in 2019 (32, -4). Neurosciences & Neurology (17 clusters, +4) became more prominent, whereas Oncology (4 clusters, -6) turned out to be less prominent.

To provide insight into the national and global innovation networks in which the top 100 clusters operate, we list their top collaborating clusters in Table S-1.4. These collaborating clusters are identified by the volume of co-inventor relationships for patents and co-authorships for scientific publications. Table S-1.4 also lists the top collaborating entities within those top collaborating clusters. For many clusters, the top co-inventing and top co-authoring clusters are the same, partly reflecting the size and proximity of nearby clusters. However, there also many cases for which they do not coincide. For example, Beijing's strongest scientific links are with Shanghai, whereas the strongest patenting links are with San Jose–San Francisco, CA. Overall, Beijing is the top collaborating cluster for scientific co-authorships (18 cases), followed by Washington, DC–Baltimore, MD (8), New York City, NY (7), Boston-Cambridge, MA (6), and Cologne (6). San Jose–San Francisco, CA is the most frequent top co-inventing cluster (20 cases), followed by Beijing (8), Shenzhen–Hong Kong (6), and New York City, NY (5).

FIGURE S-1.1

## Net science and technology (S&T) output




Source: WIPO Statistics Database, March 2019.
Notes: Net S&T output refers to the difference of total patents and publications for each cluster, for all points that were located inside the same cluster as the previous year. For simplicity, Switzerland was assigned all three clusters it was associated with. Only economies with 3 or more clusters are presented here.

TABLE S-1.2

## Top 100 cluster rankings

| Rank | Cluster name | Economy | PCT applications | Scientific publications | Share of total PCT filings, % | Share of total pubs, % | Total | Rank 2012-16 | Rank change |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Tokyo-Yokohama | JP | 108,973 | 144,559 | 10.90 | 1.72 | 12.62 | 1 | - |
| 2 | Shenzhen-Hong Kong | CN/HK | 55,433 | 45,393 | 5.54 | 0.54 | 6.08 | 2 | - |
| 3 | Seoul | KR | 39,545 | 136,654 | 3.95 | 1.63 | 5.58 | 3 | - |
| 4 | Beijing | CN | 23,014 | 222,668 | 2.30 | 2.65 | 4.95 | 5 | 1 |
| 5 | San Jose-San Francisco, CA | US | 38,399 | 88,243 | 3.84 | 1.05 | 4.89 | 4 | -1 |
| 6 | Osaka-Kobe-Kyoto | JP | 28,027 | 67,127 | 2.80 | 0.80 | 3.60 | 6 | - |
| 7 | Boston-Cambridge, MA | US | 14,364 | 120,404 | 1.44 | 1.43 | 2.87 | 7 | - |
| 8 | New York City, NY | US | 12,329 | 133,195 | 1.23 | 1.59 | 2.82 | 8 | - |
| 9 | Paris | FR | 13,426 | 94,982 | 1.34 | 1.13 | 2.47 | 9 | - |
| 10 | San Diego, CA | US | 19,280 | 34,403 | 1.93 | 0.41 | 2.34 | 10 | - |
| 11 | Shanghai | CN | 8,736 | 114,395 | 0.87 | 1.36 | 2.24 | 12 | 1 |
| 12 | Nagoya | JP | 19,370 | 23,705 | 1.94 | 0.28 | 2.22 | 11 | -1 |
| 13 | Washington, DC-Baltimore, MD | US | 4,498 | 117,623 | 0.45 | 1.40 | 1.85 | 13 | - |
| 14 | Los Angeles, CA | US | 9,398 | 68,337 | 0.94 | 0.81 | 1.75 | 14 | - |
| 15 | London | GB | 4,070 | 107,131 | 0.41 | 1.28 | 1.68 | 15 | - |
| 16 | Houston, TX | US | 10,681 | 49,969 | 1.07 | 0.59 | 1.66 | 16 | - |
| 17 | Seattle, WA | US | 10,773 | 33,796 | 1.08 | 0.40 | 1.48 | 18 | 1 |
| 18 | Amsterdam-Rotterdam | NL | 4,491 | 78,994 | 0.45 | 0.94 | 1.39 | 17 | -1 |
| 19 | Chicago, IL | US | 6,455 | 55,718 | 0.65 | 0.66 | 1.31 | 19 | - |
| 20 | Cologne | DE | 7,374 | 43,621 | 0.74 | 0.52 | 1.26 | 20 | - |
| 21 | Guangzhou | CN | 4,029 | 59,762 | 0.40 | 0.71 | 1.11 | 32 | 11 |
| 22 | Daejeon | KR | 7,699 | 25,689 | 0.77 | 0.31 | 1.08 | 23 | 1 |
| 23 | Tel Aviv-Jerusalem | IL | 6,950 | 30,971 | 0.70 | 0.37 | 1.06 | 22 | -1 |
| 24 | Munich | DE | 6,833 | 30,764 | 0.68 | 0.37 | 1.05 | 24 | - |
| 25 | Nanjing | CN | 1,440 | 75,749 | 0.14 | 0.90 | 1.05 | 27 | 2 |
| 26 | Stuttgart | DE | 8,261 | 18,347 | 0.83 | 0.22 | 1.04 | 21 | -5 |
| 27 | Minneapolis, MN | US | 6,438 | 24,878 | 0.64 | 0.30 | 0.94 | 25 | -2 |
| 28 | Singapore | SG | 3,899 | 44,988 | 0.39 | 0.54 | 0.93 | 28 | - |
| 29 | Philadelphia, PA | US | 3,176 | 50,014 | 0.32 | 0.60 | 0.91 | 26 | -3 |
| 30 | Hangzhou | CN | 3,773 | 44,950 | 0.38 | 0.54 | 0.91 | 41 | 11 |
| 31 | Eindhoven | BE/NL | 8,175 | 6,198 | 0.82 | 0.07 | 0.89 | 29 | -2 |
| 32 | Stockholm | SE | 5,587 | 27,121 | 0.56 | 0.32 | 0.88 | 31 | -1 |
| 33 | Moscow | RU | 2,147 | 55,451 | 0.21 | 0.66 | 0.87 | 30 | -3 |
| 34 | Raleigh, NC | US | 3,006 | 46,797 | 0.30 | 0.56 | 0.86 | 34 | - |
| 35 | Melbourne | AU | 1,955 | 54,842 | 0.20 | 0.65 | 0.85 | 33 | -2 |
| 36 | Frankfurt Am Main | DE | 5,226 | 25,235 | 0.52 | 0.30 | 0.82 | 35 | -1 |
| 37 | Sydney | AU | 2,454 | 47,979 | 0.25 | 0.57 | 0.82 | 36 | -1 |
| 38 | Wuhan | CN | 1,333 | 56,349 | 0.13 | 0.67 | 0.80 | 43 | 5 |
| 39 | Toronto, ON | CA | 2,298 | 47,218 | 0.23 | 0.56 | 0.79 | 37 | -2 |
| 40 | Brussels | BE | 3,149 | 39,340 | 0.31 | 0.47 | 0.78 | 51 | 11 |
| 41 | Berlin | DE | 3,393 | 35,542 | 0.34 | 0.42 | 0.76 | 39 | -2 |
| 42 | Madrid | ES | 1,605 | 49,980 | 0.16 | 0.59 | 0.76 | 38 | -4 |
| 43 | Taipei | TW | 1,428 | 51,144 | 0.14 | 0.61 | 0.75 | 40 | -3 |
| 44 | Barcelona | ES | 2,283 | 43,549 | 0.23 | 0.52 | 0.75 | 42 | -2 |
| 45 | Portland, OR | US | 5,813 | 12,041 | 0.58 | 0.14 | 0.72 | 49 | 4 |
| 46 | Tehran | IR | 99 | 59,717 | 0.01 | 0.71 | 0.72 | 44 | -2 |
| 47 | Xi'an | CN | 745 | 51,701 | 0.07 | 0.62 | 0.69 | 52 | 5 |
| 48 | Milan | IT | 2,177 | 37,953 | 0.22 | 0.45 | 0.67 | 45 | -3 |
| 49 | Denver, CO | US | 2,818 | 31,458 | 0.28 | 0.37 | 0.66 | 47 | -2 |
| 50 | Zürich | CH/DE | 3,007 | 29,651 | 0.30 | 0.35 | 0.65 | 48 | -2 |

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TABLE S-1.2

## Top 100 cluster rankings, continued

| Rank | Cluster name | Economy | PCT applications | Scientific publications | Share of total PCT filings, % | Share of total pubs, % | Total | Rank 2012-16 | Rank change |
|---|---|---|---|---|---|---|---|---|---|
| 51 | Montréal, QC | CA | 2,046 | 36,761 | 0.20 | 0.44 | 0.64 | 50 | -1 |
| 52 | Chengdu | CN | 1,364 | 42,467 | 0.14 | 0.51 | 0.64 | 56 | 4 |
| 53 | Heidelberg-Mannheim | DE | 3,903 | 20,938 | 0.39 | 0.25 | 0.64 | 46 | -7 |
| 54 | Istanbul | TR | 2,437 | 31,452 | 0.24 | 0.37 | 0.62 | 69 | 15 |
| 55 | Copenhagen | DK | 2,854 | 27,185 | 0.29 | 0.32 | 0.61 | 53 | -2 |
| 56 | Atlanta, GA | US | 1,591 | 36,308 | 0.16 | 0.43 | 0.59 | 54 | -2 |
| 57 | Rome | IT | 821 | 40,435 | 0.08 | 0.48 | 0.56 | 55 | -2 |
| 58 | Cambridge | GB | 2,431 | 26,164 | 0.24 | 0.31 | 0.55 | 59 | 1 |
| 59 | São Paulo | BR | 756 | 38,494 | 0.08 | 0.46 | 0.53 | 57 | -2 |
| 60 | Tianjin | CN | 807 | 37,572 | 0.08 | 0.45 | 0.53 | 67 | 7 |
| 61 | Cincinnati, OH | US | 3,616 | 13,736 | 0.36 | 0.16 | 0.53 | 62 | 1 |
| 62 | Nuremberg-Erlangen | DE | 3,699 | 12,357 | 0.37 | 0.15 | 0.52 | 58 | -4 |
| 63 | Pittsburgh, PA | US | 1,555 | 30,051 | 0.16 | 0.36 | 0.51 | 60 | -3 |
| 64 | Dallas, TX | US | 3,135 | 16,772 | 0.31 | 0.20 | 0.51 | 61 | -3 |
| 65 | Bengaluru | IN | 3,119 | 16,800 | 0.31 | 0.20 | 0.51 | 65 | - |
| 66 | Ann Arbor, MI | US | 1,413 | 30,555 | 0.14 | 0.36 | 0.51 | 63 | -3 |
| 67 | Changsha | CN | 984 | 33,067 | 0.10 | 0.39 | 0.49 | 68 | 1 |
| 68 | Helsinki | FI | 2,837 | 17,100 | 0.28 | 0.20 | 0.49 | 64 | -4 |
| 69 | Vienna | AT | 1,523 | 26,719 | 0.15 | 0.32 | 0.47 | 66 | -3 |
| 70 | Delhi | IN | 782 | 32,275 | 0.08 | 0.38 | 0.46 | 72 | 2 |
| 71 | Oxford | GB | 1,419 | 26,692 | 0.14 | 0.32 | 0.46 | 70 | -1 |
| 72 | Vancouver, BC | CA | 1,478 | 24,217 | 0.15 | 0.29 | 0.44 | 73 | 1 |
| 73 | Cleveland, OH | US | 1,460 | 23,982 | 0.15 | 0.29 | 0.43 | 71 | -2 |
| 74 | Lyon | FR | 2,270 | 16,950 | 0.23 | 0.20 | 0.43 | 74 | - |
| 75 | Busan | KR | 2,136 | 17,640 | 0.21 | 0.21 | 0.42 | 75 | - |
| 76 | Phoenix, AZ | US | 2,318 | 13,166 | 0.23 | 0.16 | 0.39 | 86 | 10 |
| 77 | Ankara | TR | 435 | 28,652 | 0.04 | 0.34 | 0.38 | 76 | -1 |
| 78 | Ottawa, ON | CA | 1,829 | 16,573 | 0.18 | 0.20 | 0.38 | 80 | 2 |
| 79 | Austin, TX | US | 2,151 | 13,516 | 0.22 | 0.16 | 0.38 | 77 | -2 |
| 80 | Qingdao | CN | 1,480 | 19,128 | 0.15 | 0.23 | 0.38 | 102 | 22 |
| 81 | Suzhou | CN | 2,119 | 13,692 | 0.21 | 0.16 | 0.37 | 100 | 19 |
| 82 | Bridgeport-New Haven, CT | US | 1,275 | 20,583 | 0.13 | 0.24 | 0.37 | 81 | -1 |
| 83 | Brisbane | AU | 1,098 | 21,591 | 0.11 | 0.26 | 0.37 | 83 | - |
| 84 | Hamburg | DE | 1,874 | 15,020 | 0.19 | 0.18 | 0.37 | 79 | -5 |
| 85 | Grenoble | FR | 2,045 | 13,286 | 0.20 | 0.16 | 0.36 | 78 | -7 |
| 86 | Lausanne | CH/FR | 1,859 | 14,605 | 0.19 | 0.17 | 0.36 | 85 | -1 |
| 87 | Harbin | CN | 168 | 28,773 | 0.02 | 0.34 | 0.36 | 93 | 6 |
| 88 | Chongqing | CN | 333 | 26,799 | 0.03 | 0.32 | 0.35 | 103 | 15 |
| 89 | Jinan | CN | 477 | 25,528 | 0.05 | 0.30 | 0.35 | 99 | 10 |
| 90 | Hefei | CN | 350 | 26,560 | 0.04 | 0.32 | 0.35 | 97 | 7 |
| 91 | Basel | CH/DE/FR | 2,064 | 11,889 | 0.21 | 0.14 | 0.35 | 82 | -9 |
| 92 | Manchester | GB | 965 | 21,028 | 0.10 | 0.25 | 0.35 | 84 | -8 |
| 93 | Changchun | CN | 191 | 27,372 | 0.02 | 0.33 | 0.34 | 95 | 2 |
| 94 | St. Louis, MO | US | 916 | 20,729 | 0.09 | 0.25 | 0.34 | 89 | -5 |
| 95 | Lund | SE | 1,925 | 12,124 | 0.19 | 0.14 | 0.34 | 90 | -5 |
| 96 | Columbus, OH | US | 991 | 19,902 | 0.10 | 0.24 | 0.34 | 88 | -8 |
| 97 | Mumbai | IN | 1,199 | 17,784 | 0.12 | 0.21 | 0.33 | 92 | -5 |
| 98 | Indianapolis, IN | US | 1,755 | 12,616 | 0.18 | 0.15 | 0.33 | 91 | -7 |
| 99 | Dublin | IE | 766 | 20,750 | 0.08 | 0.25 | 0.32 | 94 | -5 |
| 100 | Warsaw | PL | 429 | 23,419 | 0.04 | 0.28 | 0.32 | 98 | -2 |

Source: WIPO Statistics Database, March 2019.
Notes: Patent filing and scientific publication shares refer to the 2013–17 time frame and are based on fractional counts, as explained in the text. Codes refer to the ISO-2 codes. See page 17 for a full list, with the following addition: TW = Taiwan, Province of China.

The entities driving collaboration between two clusters remained constant for scientific publications but differed for patenting. The Chinese Academy of Sciences (18, Beijing) emerged as the most frequent top collaborating entity for all 18 times that Beijing is listed as collaborating cluster for scientific co-authorships. The same is true for Johns Hopkins University (8, Washington, DC–Baltimore, MD), Columbia University (7, New York City, NY), and Harvard University (6, Boston-Cambridge, MA). In contrast, a wider array of firms drive co-patenting relationships. For example, 14 different firms are listed as the top collaborating entities for the 20 times that San Jose–San Francisco, CA is listed as a top collaborating cluster. Beijing has 8 different entities as the primary driver for its patent collaborations. Shenzhen-Hong Kong, conversely, has only 2 entities for the 6 times it is listed as a top collaborating cluster for co-patenting—Huawei (5) and Shenzhen Guohua OptoElectronics (1).

## Concluding remarks

The 2019 S&T cluster ranking offers a window into the world's innovation hotspots. The microdata, on the basis of which we identify and measure S&T clusters, further provide insight into the nature and direction of innovative activity taking place within different clusters.

As in previous years, it is important to point out several caveats and limitations of our approach. First, the precise shape of the identified clusters depends critically on the threshold parameters of our clustering algorithm. Although the relative ranking does not change substantially within a plausible range of threshold parameters, especially for the top 25 clusters, the geographic coverage of each cluster does fluctuate depending on the parameters chosen.

Second, our approach places equal weight on patenting and scientific output. Different weights would imply different rank orders, though changes would only be significant for the lower half of the top 100 list. Finally, while S&T activity is central to innovation performance, it naturally focuses on the upstream segments of the innovation value chain. Our data do not capture how S&T activity translates to productivity gains as well as new products and services in the marketplace.

**Notes:**

1 Gothenburg (Sweden) and Tainan–Kaohsiung (Taiwan) dropped out of the top 100; Qingdao (China) and Chongqing (China) entered the top 100.

2 Both Guangzhou (#21, + 11) and Phoenix, AZ (#76, +10) also experienced non-trivial increases in cluster area, however their growth was still primarily driven by new S&T output.

3 See Bergquist et al. (2018) for a description of our clustering algorithm and the threshold parameters chosen.

**References:**


Bergquist, K., Fink, C., & Raffo, J. (2018). Special section: Identifying and ranking the world's largest science and technology clusters. In S. Dutta, B. Lanvin, & S. Wunsch-Vincent (Eds.), *Global Innovation Index 2018: Energizing the World with Innovation*. Ithaca, Fontainebleau, and Geneva: Cornell, INSEAD, and WIPO. 193–209.

Ester, M., Kriegel, H., Sander, J., & Xu, X. (1996). A density-based algorithm for discovering clusters in large spatial databases with noise. *Proceedings of 2nd International Conference on Knowledge Discovery and Data Mining*. 226–231.

Falagas, M.E., Pitsouni, E. I., Malietzis, G. A., & Pappas, G. (2007). Comparison of PubMed, Scopus, Web of Science, and Google Scholar: Strengths and Weaknesses. *The FASEB Journal*, 22(2), 338–42. Retrieved from https://doi.org/10.1096/fj.07-9492LSF.

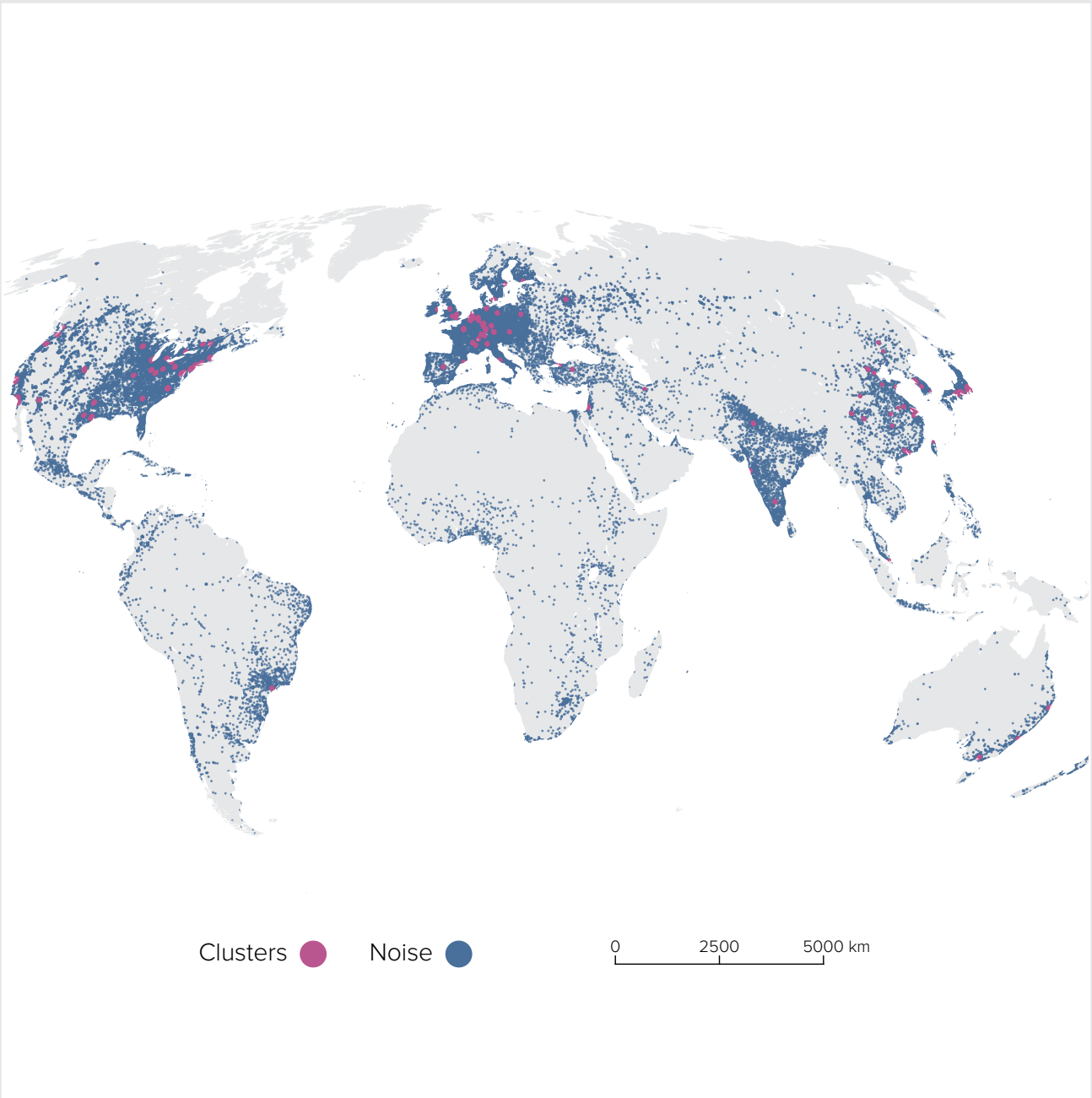
Garfield, E. (1970). Citation indexing for studying science. *Nature, 227*(5259), 669–671.

Garfield, E. (1972). Citation analysis as a tool in journal evaluation. *Science, 178*(4060), 471–79.

Harzing, A. W., Alakangas, S. (2016). Google Scholar, Scopus and the Web of Science: A longitudinal and cross-disciplinary comparison. *Scientometrics, 106*(2), 787–804. Retrieved from https://doi.org/10.1007/s11192-015-1798-9.

FIGURE S-1.2

## Top 100 clusters worldwide




Source: WIPO Statistics Database, March 2019.
Note: Noise refers to all inventor / author locations not classified in a cluster.

TABLE S-1.3

## Top 100 cluster rankings by publishing and patent performance

| | | | Scientific publishing performance | | |
|---|---|---|---|---|---|
| Rank | Cluster name | Economy(ies) | Top science field | Share, % | Top scientific organization |
| 1 | Tokyo-Yokohama | JP | Physics | 9.22 | University of Tokyo |
| 2 | Shenzhen-Hong Kong | CN/HK | Engineering | 10.81 | University of Hong Kong |
| 3 | Seoul | KR | Engineering | 7.53 | Seoul National University |
| 4 | Beijing | CN | Chemistry | 10.30 | Chinese Academy of Sciences |
| 5 | San Jose-San Francisco, CA | US | Chemistry | 6.14 | University of California |
| 6 | Osaka-Kobe-Kyoto | JP | Chemistry | 10.41 | Kyoto University |
| 7 | Boston-Cambridge, MA | US | Oncology | 5.63 | Harvard University |
| 8 | New York City, NY | US | Neurosciences & Neurology | 5.72 | Columbia University |
| 9 | Paris | FR | Physics | 7.48 | CNRS |
| 10 | San Diego, CA | US | Science & Technology-Other Topics | 6.21 | University of California |
| 11 | Shanghai | CN | Chemistry | 13.07 | Shanghai Jiao Tong University |
| 12 | Nagoya | JP | Chemistry | 9.24 | Nagoya University |
| 13 | Washington, DC-Baltimore, MD | US | Neurosciences & Neurology | 5.11 | Johns Hopkins University |
| 14 | Los Angeles, CA | US | Neurosciences & Neurology | 5.35 | University of California |
| 15 | London | GB | General & Internal Medicine | 6.90 | University of London |
| 16 | Houston, TX | US | Oncology | 11.86 | Baylor College of Medicine |
| 17 | Seattle, WA | US | General & Internal Medicine | 4.79 | University of Washington |
| 18 | Amsterdam-Rotterdam | NL | Cardiovascular System & Cardiology | 6.09 | University of Utrecht |
| 19 | Chicago, IL | US | Neurosciences & Neurology | 5.26 | Northwestern University |
| 20 | Cologne | DE | Chemistry | 6.77 | University of Bonn |
| 21 | Guangzhou | CN | Chemistry | 10.32 | Sun Yat Sen University |
| 22 | Daejeon | KR | Engineering | 13.45 | KAIST |
| 23 | Tel Aviv-Jerusalem | IL | Neurosciences & Neurology | 6.21 | Tel Aviv University |
| 24 | Munich | DE | Physics | 7.95 | University of Munich |
| 25 | Nanjing | CN | Chemistry | 12.35 | Nanjing University |
| 26 | Stuttgart | DE | Chemistry | 7.23 | Eberhard Karls University of Tubingen |
| 27 | Minneapolis, MN | US | Chemistry | 5.64 | University of Minnesota |
| 28 | Singapore | SG | Engineering | 10.56 | National University of Singapore |
| 29 | Philadelphia, PA | US | Neurosciences & Neurology | 5.84 | University of Pennsylvania |
| 30 | Hangzhou | CN | Chemistry | 12.43 | Zhejiang University |
| 31 | Eindhoven | BE/NL | Engineering | 14.72 | Eindhoven University of Tech. |
| 32 | Stockholm | SE | Science & Technology-Other Topics | 5.70 | Karolinska Institutet |
| 33 | Moscow | RU | Physics | 17.44 | Russian Academy of Sciences |
| 34 | Raleigh, NC | US | Science & Technology-Other Topics | 4.56 | University of North Carolina |
| 35 | Melbourne | AU | General & Internal Medicine | 5.42 | University of Melbourne |
| 36 | Frankfurt Am Main | DE | Physics | 9.05 | Goethe University Frankfurt |
| 37 | Sydney | AU | General & Internal Medicine | 5.43 | University of Sydney |
| 38 | Wuhan | CN | Chemistry | 10.43 | Huazhong University of Science & Tech. |
| 39 | Toronto, ON | CA | Neurosciences & Neurology | 7.07 | University of Toronto |
| 40 | Brussels | BE | Physics | 4.93 | KU Leuven |
| 41 | Berlin | DE | Chemistry | 7.28 | Free University Of Berlin |
| 42 | Madrid | ES | Chemistry | 5.77 | CSIC |
| 43 | Taipei | TW | Engineering | 8.22 | National Taiwan University |
| 44 | Barcelona | ES | Chemistry | 5.29 | University of Barcelona |
| 45 | Portland, OR | US | Neurosciences & Neurology | 6.54 | Oregon University System |
| 46 | Tehran | IR | Engineering | 15.92 | Tehran University of Medical Sciences |
| 47 | Xi'an | CN | Engineering | 13.97 | Xi'an Jiaotong University |
| 48 | Milan | IT | Neurosciences & Neurology | 7.96 | University of Milan |
| 49 | Denver, CO | US | Meteorology & Atmospheric Sciences | 5.00 | University of Colorado |
| 50 | Zürich | CH/DE | Chemistry | 7.87 | University of Zurich |

| | | Patent performance | | | |
|---|---|---|---|---|---|
| | Share, % | Top patenting field | Share, % | Top applicant | Share, % |
| | 13.85 | Electrical machinery, apparatus, energy | 9.86 | Mitsubishi Electric | 7.83 |
| | 17.23 | Digital communication | 38.39 | Huawei | 25.76 |
| | 16.10 | Digital communication | 16.63 | LG Electronics | 18.71 |
| | 22.69 | Digital communication | 23.60 | BOE Technology Group | 24.43 |
| | 38.59 | Computer technology | 23.18 | Google | 8.04 |
| | 22.53 | Electrical machinery, apparatus, energy | 13.27 | Murata Manufacturing | 10.61 |
| | 53.87 | Pharmaceuticals | 17.03 | M.I.T | 6.81 |
| | 13.26 | Pharmaceuticals | 14.52 | Honeywell | 5.49 |
| | 22.81 | Transport | 11.49 | L'Oréal | 7.60 |
| | 51.51 | Digital communication | 30.37 | Qualcomm | 58.45 |
| | 23.06 | Digital communication | 10.48 | Alcatel Lucent | 3.36 |
| | 37.49 | Electrical machinery, apparatus, energy | 17.99 | Toyota | 23.97 |
| | 24.62 | Pharmaceuticals | 17.74 | Johns Hopkins University | 13.52 |
| | 44.49 | Medical technology | 18.52 | University of California | 6.00 |
| | 49.28 | Digital communication | 11.71 | British Telecom | 8.06 |
| | 20.49 | Civil engineering | 34.74 | Halliburton | 18.55 |
| | 65.07 | Computer technology | 41.74 | Microsoft | 35.47 |
| | 13.01 | Civil engineering | 6.61 | Shell | 8.86 |
| | 28.12 | Digital communication | 8.22 | Illinois Tool Works | 14.76 |
| | 15.84 | Basic materials chemistry | 10.37 | Henkel | 9.55 |
| | 27.92 | Electrical machinery, apparatus, energy | 8.95 | South China University of Tech. | 5.26 |
| | 25.41 | Electrical machinery, apparatus, energy | 20.90 | LG Chem | 40.16 |
| | 34.05 | Computer technology | 17.76 | Intel | 5.30 |
| | 50.80 | Transport | 12.33 | BMW | 15.74 |
| | 17.55 | Electrical machinery, apparatus, energy | 10.35 | Southeast University | 9.36 |
| | 44.09 | Electrical machinery, apparatus, energy | 13.02 | Robert Bosch | 46.89 |
| | 70.89 | Medical technology | 30.22 | 3M Innovative Properties | 35.40 |
| | 37.35 | Computer technology | 7.64 | A*Star | 17.76 |
| | 50.32 | Pharmaceuticals | 20.85 | University of Pennsylvania | 10.85 |
| | 57.90 | Computer technology | 31.29 | Alibaba Group | 48.68 |
| | 61.43 | Medical technology | 26.00 | Philips Electronics | 77.26 |
| | 49.23 | Digital communication | 39.76 | LM Ericsson | 45.89 |
| | 37.50 | Computer technology | 11.24 | Yandex Europe | 3.91 |
| | 50.62 | Pharmaceuticals | 12.78 | Duke University | 8.44 |
| | 24.56 | Pharmaceuticals | 8.99 | Monash University | 5.56 |
| | 23.62 | Medical technology | 12.31 | Merck Patent | 9.04 |
| | 40.15 | Medical technology | 12.09 | Cochlear | 4.83 |
| | 29.81 | Optics | 15.27 | Wuhan China Star Optoelectronics Tech. | 16.88 |
| | 81.09 | Medical technology | 12.76 | Synaptive Medical | 5.10 |
| | 34.62 | Basic materials chemistry | 7.79 | Procter & Gamble Company | 5.23 |
| | 36.71 | Electrical machinery, apparatus, energy | 11.12 | Siemens | 12.67 |
| | 15.35 | Digital communication | 12.45 | CSIC | 9.16 |
| | 26.77 | Computer technology | 12.08 | Hewlett-Packard | 12.13 |
| | 29.52 | Pharmaceuticals | 9.93 | Hewlett-Packard | 19.87 |
| | 65.73 | Computer technology | 24.08 | Intel | 53.80 |
| | 10.85 | Medical technology | 12.43 | Gharooni, Milad | 3.04 |
| | 29.28 | Digital communication | 16.74 | Xi'an Jiaotong University | 11.90 |
| | 24.40 | Electrical machinery, apparatus, energy | 6.97 | Pirelli Tyre | 7.64 |
| | 56.07 | Medical technology | 13.77 | University of Colorado | 6.94 |
| | 36.18 | Medical technology | 8.39 | Sika Technology | 5.14 |

TABLE S-1.3

## Top 100 cluster rankings by publishing and patent performance, continued

| | | | Scientific publishing performance | | |
|---|---|---|---|---|---|
| Rank | Cluster name | Economy(ies) | Top science field | Share, % | Top scientific organization |
| 51 | Montréal, QC | CA | Engineering | 7.20 | McGill University |
| 52 | Chengdu | CN | Engineering | 11.14 | Sichuan University |
| 53 | Mannheim | DE | Oncology | 9.31 | Ruprecht Karl University Heidelberg |
| 54 | Istanbul | TR | Engineering | 6.99 | Istanbul University |
| 55 | Copenhagen | DK | Neurosciences & Neurology | 5.41 | University of Copenhagen |
| 56 | Atlanta, GA | US | Public, Environmental & Occupational Health | 6.76 | Emory University |
| 57 | Rome | IT | Neurosciences & Neurology | 6.62 | Sapienza University Rome |
| 58 | Cambridge | GB | Science & Technology-Other Topics | 7.50 | University of Cambridge |
| 59 | São Paulo | BR | Neurosciences & Neurology | 4.24 | Universidade de Sao Paulo |
| 60 | Tianjin | CN | Chemistry | 18.13 | Tianjin University |
| 61 | Cincinnati, OH | US | Pediatrics | 6.49 | University of Cincinnati |
| 62 | Nürnberg | DE | Chemistry | 7.95 | University of Erlangen Nuremberg |
| 63 | Pittsburgh, PA | US | Neurosciences & Neurology | 5.76 | PCSHE |
| 64 | Dallas, TX | US | Cardiovascular System & Cardiology | 6.50 | Univ. of Texas Southwestern Med. Center |
| 65 | Bengaluru | IN | Chemistry | 12.54 | IISC-Bengaluru |
| 66 | Ann Arbor, MI | US | Chemistry | 4.68 | University of Michigan |
| 67 | Changsha | CN | Engineering | 10.81 | Central South University |
| 68 | Helsinki | FI | Science & Technology-Other Topics | 4.81 | University of Helsinki |
| 69 | Vienna | AT | Physics | 4.89 | Medical University of Vienna |
| 70 | Delhi | IN | Chemistry | 7.83 | All India Institute of Medical Sciences |
| 71 | Oxford | GB | Physics | 7.19 | University of Oxford |
| 72 | Vancouver, BC | CA | Neurosciences & Neurology | 4.86 | University of British Columbia |
| 73 | Cleveland, OH | US | Cardiovascular System & Cardiology | 7.84 | Cleveland Clinic |
| 74 | Lyon | FR | Chemistry | 6.98 | CNRS |
| 75 | Busan | KR | Engineering | 9.69 | Pusan National University |
| 76 | Phoenix, AZ | US | Neurosciences & Neurology | 6.76 | Arizona State University |
| 77 | Ankara | TR | Cardiovascular System & Cardiology | 5.64 | Hacettepe University |
| 78 | Ottawa, ON | CA | Engineering | 6.12 | University of Ottawa |
| 79 | Austin, TX | US | Chemistry | 10.52 | University Of Texas Austin |
| 80 | Qingdao | CN | Chemistry | 13.52 | Ocean University of China |
| 81 | Suzhou | CN | Chemistry | 17.40 | Suzhou University |
| 82 | Bridgeport-New Haven, CT | US | Neurosciences & Neurology | 6.27 | Yale University |
| 83 | Brisbane | AU | Engineering | 5.32 | University of Queensland |
| 84 | Hamburg | DE | Physics | 7.89 | University of Hamburg |
| 85 | Grenoble | FR | Physics | 17.55 | CNRS |
| 86 | Lausanne | CH/FR | Chemistry | 7.95 | EPFL |
| 87 | Harbin | CN | Engineering | 12.15 | Harbin Institute of Technology |
| 88 | Chongqing | CN | Chemistry | 10.09 | Chongqing University |
| 89 | Jinan | CN | Chemistry | 14.24 | Shandong University |
| 90 | Hefei | CN | Physics | 14.69 | University of Science & Tech. of China |
| 91 | Basel | CH/DE/FR | Pharmacology & Pharmacy | 7.54 | University of Basel |
| 92 | Manchester | GB | Chemistry | 6.77 | University of Manchester |
| 93 | Changchun | CN | Chemistry | 23.62 | Jilin University |
| 94 | St. Louis, MO | US | Neurosciences & Neurology | 6.39 | Washington University (WUSTL) |
| 95 | Lund | SE | Science & Technology-Other Topics | 5.59 | Lund University |
| 96 | Columbus, OH | US | Oncology | 5.29 | Ohio State University |
| 97 | Mumbai | IN | Chemistry | 16.28 | Bhabha Atomic Research Center |
| 98 | Indianapolis, IN | US | Pharmacology & Pharmacy | 5.05 | Indiana University |
| 99 | Dublin | IE | General & Internal Medicine | 17.79 | Trinity College |
| 100 | Warsaw | PL | Chemistry | 9.32 | Polish Academy of Sciences |

Source: WIPO Statistics Database, March 2019.
Notes: Patent filing and scientific publication shares refer to the 2013–17 period and are based on fractional counts, as explained in the text. We use the location of inventors to associate patent applicants to clusters; note that addresses of applicants may well be outside the cluster(s) to which they are associated. The identification of technology fields relies on the WIPO technology concordance table linking International Patent Classification (IPC) symbols with 35 fields of technology (available at http://www.wipo.int/ipstats/en/).

| | | Patent performance | | | |
|---|---|---|---|---|---|
| | Share, % | Top patenting field | Share, % | Top applicant | Share, % |
| | 42.47 | Digital communication | 17.11 | LM Ericsson | 9.10 |
| | 42.54 | Pharmaceuticals | 11.70 | Sichuan Haisco Pharmaceutical | 4.32 |
| | 58.56 | Basic materials chemistry | 13.27 | BASF | 42.53 |
| | 18.58 | Other consumer goods | 18.74 | Arcelik | 46.21 |
| | 72.62 | Biotechnology | 15.25 | Novozymes | 11.02 |
| | 37.21 | Medical technology | 13.66 | Georgia Tech | 7.93 |
| | 31.67 | Medical technology | 10.87 | Bridgestone | 7.12 |
| | 73.38 | Computer technology | 15.46 | ARM | 9.09 |
| | 46.86 | Medical technology | 8.32 | Mahle Metal Leve | 3.23 |
| | 29.17 | Pharmaceuticals | 9.14 | Tianjin University | 11.93 |
| | 46.17 | Medical technology | 32.37 | Procter & Gamble Company | 43.19 |
| | 67.33 | Electrical machinery, apparatus, energy | 16.91 | Siemens | 37.99 |
| | 67.50 | Medical technology | 12.86 | University of Pittsburgh | 13.39 |
| | 39.25 | Civil engineering | 17.24 | Halliburton | 16.39 |
| | 30.39 | Computer technology | 22.79 | Hewlett-Packard | 11.26 |
| | 89.15 | Pharmaceuticals | 10.20 | University of Michigan | 27.71 |
| | 42.83 | Civil engineering | 15.63 | Zoomlion | 32.84 |
| | 56.72 | Digital communication | 31.13 | Nokia | 10.89 |
| | 28.13 | Pharmaceuticals | 9.29 | Siemens | 4.11 |
| | 14.08 | Pharmaceuticals | 13.98 | Ranbaxy Laboratories | 6.49 |
| | 78.10 | Biotechnology | 12.84 | Oxford University | 17.77 |
| | 70.21 | Medical technology | 9.60 | University of British Columbia | 7.07 |
| | 47.33 | Medical technology | 15.62 | Cleveland Clinic | 10.83 |
| | 31.25 | Basic materials chemistry | 10.63 | IFP Energies Nouvelles | 10.95 |
| | 35.02 | Electrical machinery, apparatus, energy | 7.61 | Pusan National University | 5.09 |
| | 50.97 | Semiconductors | 15.41 | Intel | 23.66 |
| | 17.32 | Medical technology | 13.63 | Aselsan | 21.65 |
| | 57.42 | Digital communication | 44.40 | Huawei | 35.66 |
| | 66.99 | Computer technology | 22.27 | University Of Texas | 12.58 |
| | 21.54 | Other consumer goods | 33.11 | Qingdao Haier Washing Machine | 14.66 |
| | 68.69 | Electrical machinery, apparatus, energy | 9.53 | Positec Power Tools | 4.68 |
| | 85.32 | Pharmaceuticals | 15.50 | Yale University | 11.13 |
| | 49.46 | Civil engineering | 12.68 | University of Queensland | 8.84 |
| | 57.59 | Organic fine chemistry | 16.14 | Henkel | 9.17 |
| | 42.01 | Electrical machinery, apparatus, energy | 13.97 | CEA | 40.01 |
| | 46.74 | Food chemistry | 8.87 | NESTEC | 26.77 |
| | 42.85 | Measurement | 12.51 | Harbin Institute of Technology | 38.65 |
| | 26.46 | Medical technology | 13.23 | Chongqing Runze Pharmaceutical | 10.51 |
| | 58.50 | Computer technology | 10.79 | Shandong University | 10.04 |
| | 41.28 | Other consumer goods | 12.12 | Anhui Jianghuai Automobile | 10.56 |
| | 60.83 | Pharmaceuticals | 19.04 | F. Hoffmann-La Roche | 13.38 |
| | 65.91 | Electrical machinery, apparatus, energy | 15.71 | Micromass | 13.76 |
| | 57.67 | Measurement | 14.00 | Changchun Institute Of Applied Chemistry | 15.69 |
| | 69.55 | Biotechnology | 16.63 | Monsanto Technology | 16.54 |
| | 86.72 | Digital communication | 22.79 | LM Ericsson | 21.81 |
| | 89.88 | Pharmaceuticals | 13.23 | Abbott Laboratories | 13.01 |
| | 22.72 | Organic fine chemistry | 18.23 | Piramal Enterprises | 5.26 |
| | 68.17 | Basic materials chemistry | 11.81 | Dow AgroSciences | 22.46 |
| | 30.49 | Computer technology | 11.08 | Alcatel Lucent | 8.07 |
| | 19.76 | Medical technology | 8.18 | General Electric | 4.00 |

The top scientific field is based on SCIE's Extended Ascatype subject field. An article can be assigned to more than one subject field. Fractional counting was used when more than one subject was assigned to an article. Codes refer to the ISO-2 codes. See page 17 for a full list, with the following addition: TW = Taiwan, Province of China. CNRS = Centre National de la Recherche Scientifique, CSIC = Consejo Superior de Investigaciones Cientificas, PCSHE = Pennsylvania Commonwealth System of Higher Education, IISC = Indian Institute of Science, EPFL = Ecole Polytechnique Federale de Lausanne, CEA = Commissariat a L'Energie Atomique et aux Energies Alternatives.

TABLE S-1.4

## Top collaborating entities by cluster

| | | | Scientific publishing collaboration | | |
|---|---|---|---|---|---|
| Rank | Cluster name | Economy(ies) | Top scientific collaborating cluster | Share, % | Top collaborating organization |
| 1 | Tokyo-Yokohama | JP | Osaka-Kobe-Kyoto | 8.15 | Kyoto University |
| 2 | Shenzhen-Hong Kong | CN/HK | Beijing | 9.66 | Chinese Academy of Sciences |
| 3 | Seoul | KR | Daejeon | 4.32 | KAIST |
| 4 | Beijing | CN | Shanghai | 3.15 | Chinese Academy of Sciences |
| 5 | San Jose-San Francisco, CA | US | Boston-Cambridge, MA | 5.28 | Harvard University |
| 6 | Osaka-Kobe-Kyoto | JP | Tokyo-Yokohama | 20.16 | University of Tokyo |
| 7 | Boston-Cambridge, MA | US | New York City, NY | 4.95 | Columbia University |
| 8 | New York City, NY | US | Boston-Cambridge, MA | 4.88 | Harvard University |
| 9 | Paris | FR | Lyon | 2.53 | CNRS |
| 10 | San Diego, CA | US | San Jose-San Francisco, CA | 5.36 | University of California |
| 11 | Shanghai | CN | Beijing | 6.00 | Chinese Academy of Sciences |
| 12 | Nagoya | JP | Tokyo-Yokohama | 24.42 | University of Tokyo |
| 13 | Washington, DC-Baltimore, MD | US | Boston-Cambridge, MA | 4.62 | Harvard University |
| 14 | Los Angeles, CA | US | San Jose-San Francisco, CA | 4.77 | University of California |
| 15 | London | GB | Oxford | 2.62 | University of Oxford |
| 16 | Houston, TX | US | San Jose-San Francisco, CA | 6.49 | Stanford University |
| 17 | Seattle, WA | US | Boston-Cambridge, MA | 5.30 | Harvard University |
| 18 | Amsterdam-Rotterdam | NL | Nijmegen | 4.70 | Radboud University Nijmegen |
| 19 | Chicago, IL | US | New York City, NY | 4.35 | Columbia University |
| 20 | Cologne | DE | Berlin | 3.97 | Free University of Berlin |
| 21 | Guangzhou | CN | Beijing | 7.06 | Chinese Academy of Sciences |
| 22 | Daejeon | KR | Seoul | 29.76 | Seoul National University |
| 23 | Tel Aviv-Jerusalem | IL | Haifa | 4.11 | Technion Israel Institute of Tech. |
| 24 | Munich | DE | Cologne | 5.12 | University of Bonn |
| 25 | Nanjing | CN | Beijing | 6.55 | Chinese Academy of Sciences |
| 26 | Stuttgart | DE | Cologne | 4.42 | University of Bonn |
| 27 | Minneapolis, MN | US | Washington, DC-Baltimore, MD | 4.14 | Johns Hopkins University |
| 28 | Singapore | SG | Beijing | 2.39 | Chinese Academy of Sciences |
| 29 | Philadelphia, PA | US | New York City, NY | 6.27 | Columbia University |
| 30 | Hangzhou | CN | Beijing | 5.58 | Chinese Academy of Sciences |
| 31 | Eindhoven | BE/NL | Amsterdam-Rotterdam | 24.27 | Delft University of Technology |
| 32 | Stockholm | SE | Uppsala | 6.31 | Uppsala University |
| 33 | Moscow | RU | Saint Petersburg | 2.02 | Russian Academy of Sciences |
| 34 | Raleigh, NC | US | Washington, DC-Baltimore, MD | 4.85 | Johns Hopkins University |
| 35 | Melbourne | AU | Sydney | 6.37 | University of Sydney |
| 36 | Frankfurt Am Main | DE | Cologne | 5.74 | University of Bonn |
| 37 | Sydney | AU | Melbourne | 7.47 | University of Melbourne |
| 38 | Wuhan | CN | Beijing | 7.48 | Chinese Academy of Sciences |
| 39 | Toronto, ON | CA | Mississauga, ON | 2.97 | McMaster University |
| 40 | Brussels | BE | Gent | 5.43 | Ghent University |
| 41 | Berlin | DE | Cologne | 4.95 | University of Cologne |
| 42 | Madrid | ES | Barcelona | 8.82 | University of Barcelona |
| 43 | Taipei | TW | Taichung | 7.15 | China Medical University Taiwan |
| 44 | Barcelona | ES | Madrid | 8.24 | CSIC |
| 45 | Portland, OR | US | San Jose-San Francisco, CA | 6.12 | University of California |
| 46 | Tehran | IR | Kuala Lumpur | 0.34 | Universiti Malaya |
| 47 | Xi'an | CN | Beijing | 6.89 | Chinese Academy of Sciences |
| 48 | Milan | IT | Rome | 6.10 | Sapienza University Rome |
| 49 | Denver, CO | US | Washington, DC-Baltimore, MD | 5.05 | Johns Hopkins University |
| 50 | Zürich | CH/DE | Bern | 3.38 | University of Bern |

| | | Patent collaboration | | | |
|---|---|---|---|---|---|
| | Share, % | Top patent collaborating cluster | Share, % | Top collaborating applicant | Share, % |
| | 24.89 | Osaka-Kobe-Kyoto | 1.30 | Hitachi | 4.15 |
| | 20.15 | Beijing | 0.21 | Huawei | 70.34 |
| | 16.93 | Daejeon | 2.82 | LG Chem | 9.80 |
| | 32.13 | San Jose-San Francisco, CA | 1.19 | Intel | 58.38 |
| | 55.82 | Portland, OR | 1.71 | Intel | 83.05 |
| | 13.44 | Tokyo-Yokohama | 5.16 | Hitachi | 3.20 |
| | 15.52 | San Jose-San Francisco, CA | 2.65 | Robert Bosch | 4.78 |
| | 56.89 | Boston-Cambridge, MA | 3.18 | Merck Sharp & Dohme Corp. | 7.76 |
| | 25.27 | Lyon | 1.39 | IFP Energies Nouvelles | 26.68 |
| | 35.93 | San Jose-San Francisco, CA | 2.04 | Qualcomm | 10.11 |
| | 38.80 | New York City, NY | 1.72 | Merck Sharp & Dohme Corp. | 63.36 |
| | 12.98 | Tokyo-Yokohama | 3.35 | Toyota | 6.70 |
| | 56.85 | San Jose-San Francisco, CA | 3.13 | Robert Bosch | 6.33 |
| | 37.56 | San Jose-San Francisco, CA | 4.22 | University of California | 4.07 |
| | 76.75 | Cambridge | 1.73 | British American Tobacco | 7.08 |
| | 51.03 | New York City, NY | 0.89 | Exxonmobil | 16.76 |
| | 61.10 | San Jose-San Francisco, CA | 2.28 | Elwha LLC | 10.62 |
| | 54.38 | Houston, TX | 1.70 | Shell | 53.50 |
| | 16.34 | San Jose-San Francisco, CA | 1.69 | Motorola Mobility | 10.53 |
| | 39.63 | Aachen | 2.61 | Grüenthal | 15.95 |
| | 38.12 | Shenzhen-Hong Kong | 0.83 | Shenzhen Guohua Optoelectronics | 18.10 |
| | 16.14 | Seoul | 12.69 | Lg Hausys | 6.30 |
| | 46.91 | Haifa | 5.72 | Intel | 18.77 |
| | 15.48 | Nürnberg | 1.95 | Siemens | 56.89 |
| | 36.02 | Beijing | 1.78 | LM Ericsson | 15.08 |
| | 14.55 | Mannheim | 1.25 | BASF | 26.75 |
| | 28.14 | San Jose-San Francisco, CA | 1.18 | Pure Storage | 8.08 |
| | 23.94 | San Jose-San Francisco, CA | 1.72 | Hewlett-Packard | 17.96 |
| | 14.00 | New York City, NY | 14.37 | Merck Sharp & Dohme Corp. | 19.73 |
| | 20.88 | Shanghai | 0.73 | Shenzhen Luoshuhe Tech. Development | 17.31 |
| | 14.23 | Amsterdam-Rotterdam | 0.67 | ASML | 8.99 |
| | 80.32 | Uppsala | 2.88 | LM Ericsson | 61.77 |
| | 29.89 | Saint Petersburg | 2.45 | Rawllin International | 11.87 |
| | 26.58 | San Jose-San Francisco, CA | 3.19 | Carbon3D | 12.51 |
| | 38.37 | Sydney | 1.92 | Onesteel Wire | 5.33 |
| | 15.29 | Mannheim | 10.18 | BASF | 44.98 |
| | 23.95 | San Jose-San Francisco, CA | 1.73 | Dolby Laboratories | 48.55 |
| | 38.69 | Shenzhen-Hong Kong | 2.08 | Huawei | 79.45 |
| | 85.53 | Mississauga, ON | 4.05 | Flextronics AP | 7.51 |
| | 85.67 | Gent | 2.70 | Universiteit Gent | 8.91 |
| | 13.95 | Cologne | 5.50 | Bayer | 36.76 |
| | 29.91 | Barcelona | 2.19 | Laboratorios del Dr. Esteve S.A. | 14.83 |
| | 32.62 | Hsinchu | 7.86 | MediaTek | 55.61 |
| | 8.11 | Madrid | 1.25 | CSIC | 11.30 |
| | 37.69 | San Jose-San Francisco, CA | 9.93 | Intel | 76.00 |
| | 79.81 | Houston, TX | 2.10 | Rice University | 100.00 |
| | 25.90 | Shenzhen-Hong Kong | 3.60 | Huawei | 91.60 |
| | 22.38 | Turin | 1.13 | Pirelli Tyre | 30.35 |
| | 20.28 | San Jose-San Francisco, CA | 3.99 | Intel | 7.59 |
| | 78.28 | Basel | 2.30 | F. Hoffmann-La Roche | 13.27 |

CONTINUED

TABLE S-1.4

## Top collaborating entities by cluster, continued

| | | | Scientific publishing collaboration | | |
|---|---|---|---|---|---|
| Rank | Cluster name | Economy(ies) | Top scientific collaborating cluster | Share, % | Top collaborating organization |
| 51 | Montréal, QC | CA | Toronto, ON | 3.94 | University of Toronto |
| 52 | Chengdu | CN | Beijing | 7.46 | Chinese Academy of Sciences |
| 53 | Mannheim | DE | Cologne | 5.91 | University of Cologne |
| 54 | Istanbul | TR | Ankara | 5.06 | Hacettepe University |
| 55 | Copenhagen | DK | Århus | 4.79 | Aarhus University |
| 56 | Atlanta, GA | US | Washington, DC-Baltimore, MD | 4.99 | Johns Hopkins University |
| 57 | Rome | IT | Milan | 5.60 | University of Milan |
| 58 | Cambridge | GB | London | 10.73 | University of London |
| 59 | São Paulo | BR | Rio De Janeiro | 2.99 | Universidade Federal do Rio de Janeiro |
| 60 | Tianjin | CN | Beijing | 9.34 | Chinese Academy of Sciences |
| 61 | Cincinnati, OH | US | Washington, DC-Baltimore, MD | 4.07 | Johns Hopkins University |
| 62 | Nürnberg | DE | Munich | 9.44 | University of Munich |
| 63 | Pittsburgh, PA | US | Washington, DC-Baltimore, MD | 4.30 | Johns Hopkins University |
| 64 | Dallas, TX | US | New York City, NY | 4.61 | Columbia University |
| 65 | Bengaluru | IN | Delhi | 2.40 | CSIR |
| 66 | Ann Arbor, MI | US | Boston-Cambridge, MA | 4.41 | Harvard University |
| 67 | Changsha | CN | Beijing | 5.61 | Chinese Academy of Sciences |
| 68 | Helsinki | FI | Stockholm | 3.32 | Karolinska Institutet |
| 69 | Vienna | AT | Graz | 2.37 | Medical University of Graz |
| 70 | Delhi | IN | Pune | 1.31 | CSIR |
| 71 | Oxford | GB | London | 12.14 | University of London |
| 72 | Vancouver, BC | CA | Toronto, ON | 5.55 | University of Toronto |
| 73 | Cleveland, OH | US | New York City, NY | 3.93 | Columbia University |
| 74 | Lyon | FR | Paris | 19.11 | APHP |
| 75 | Busan | KR | Seoul | 26.06 | Seoul National University |
| 76 | Phoenix, AZ | US | Washington, DC-Baltimore, MD | 3.79 | Johns Hopkins University |
| 77 | Ankara | TR | Istanbul | 5.04 | Istanbul University |
| 78 | Ottawa, ON | CA | Toronto, ON | 8.78 | University of Toronto |
| 79 | Austin, TX | US | Houston, TX | 3.81 | UTMD Anderson Cancer Center |
| 80 | Qingdao | CN | Beijing | 12.97 | Chinese Academy of Sciences |
| 81 | Suzhou | CN | Beijing | 8.30 | Chinese Academy of Sciences |
| 82 | Bridgeport-New Haven, CT | US | New York City, NY | 7.29 | Columbia University |
| 83 | Brisbane | AU | Melbourne | 8.32 | University of Melbourne |
| 84 | Hamburg | DE | Cologne | 6.12 | University of Bonn |
| 85 | Grenoble | FR | Paris | 15.85 | CNRS |
| 86 | Lausanne | CH/FR | Zürich | 5.93 | University of Zurich |
| 87 | Harbin | CN | Beijing | 6.73 | Chinese Academy of Sciences |
| 88 | Chongqing | CN | Beijing | 5.73 | Chinese Academy of Sciences |
| 89 | Jinan | CN | Beijing | 7.03 | Chinese Academy of Sciences |
| 90 | Hefei | CN | Beijing | 8.33 | Chinese Academy of Sciences |
| 91 | Basel | CH/DE/FR | Zürich | 7.78 | University of Zurich |
| 92 | Manchester | GB | London | 8.03 | University of London |
| 93 | Changchun | CN | Beijing | 11.07 | Chinese Academy of Sciences |
| 94 | St. Louis, MO | US | Boston-Cambridge, MA | 4.13 | Harvard University |
| 95 | Lund | SE | Stockholm | 7.38 | Karolinska Institutet |
| 96 | Columbus, OH | US | Washington, DC-Baltimore, MD | 3.58 | Johns Hopkins University |
| 97 | Mumbai | IN | Pune | 2.11 | University of Pune |
| 98 | Indianapolis, IN | US | New York City, NY | 4.21 | Columbia University |
| 99 | Dublin | IE | London | 2.49 | University of London |
| 100 | Warsaw | PL | Kraków | 3.37 | Jagiellonian University |

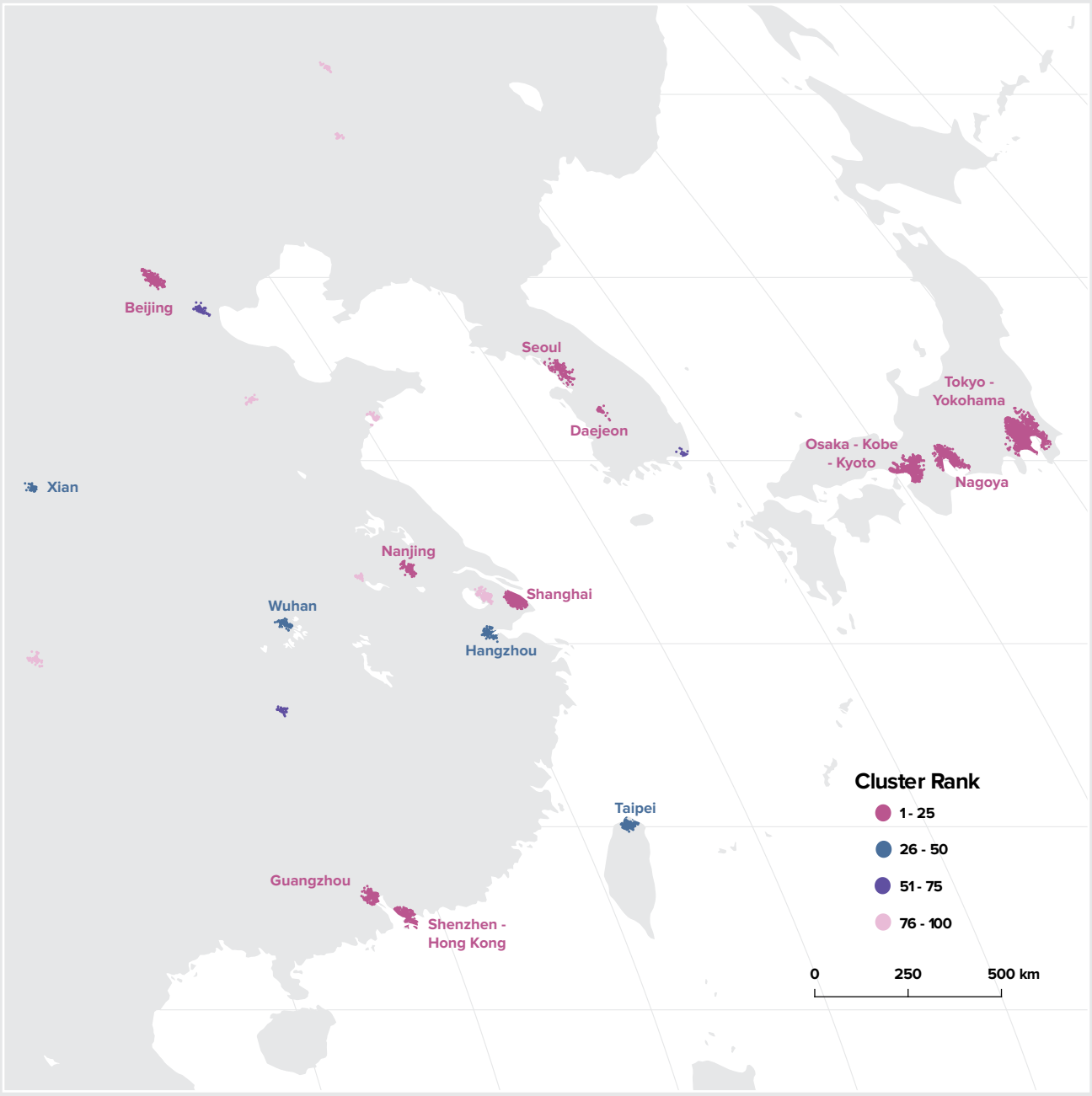
Source: WIPO Statistics Database, March 2019.
Notes: Patent filing and scientific publication shares refer to the 2013–17 period and are based on fractional counts, as explained in the text. Collaboration is based on the locations of authors/inventors listed on the same article/patent. Codes refer to the ISO-2 codes. See page 17 for a full list, with the following addition: TW = Taiwan, Province of China. CNRS = Centre National de la Recherche Scientifique, CSIC = Consejo Superior de Investigaciones Cientificas, CSIR = Council of

| | | Patent collaboration | | | |
|---|---|---|---|---|---|
| | Share, % | Top patent collaborating cluster | Share, % | Top collaborating applicant | Share, % |
| | 80.05 | New York City, NY | 2.80 | Interdigital Patent Holdings | 41.02 |
| | 32.60 | Shenzhen-Hong Kong | 1.24 | Huawei | 73.47 |
| | 16.50 | Frankfurt Am Main | 10.81 | BASF | 25.02 |
| | 16.01 | Ankara | 0.41 | Arcelik | 21.92 |
| | 89.74 | Lund | 1.37 | Danmarks Tekniske Universitet | 12.22 |
| | 21.76 | San Jose-San Francisco, CA | 2.85 | Stanford University | 6.43 |
| | 20.88 | Cologne | 2.45 | Bayer | 96.21 |
| | 55.30 | London | 2.83 | British American Tobacco | 9.31 |
| | 30.80 | Rio De Janeiro | 1.31 | Petrobras | 20.65 |
| | 25.00 | Beijing | 1.28 | China Electric Power Research Institute | 16.67 |
| | 22.88 | Frankfurt Am Main | 2.57 | Procter & Gamble Company | 82.39 |
| | 50.66 | Munich | 3.54 | Siemens | 58.26 |
| | 30.78 | Boston-Cambridge, MA | 2.51 | Berkshire Grey | 17.44 |
| | 15.18 | San Jose-San Francisco, CA | 3.73 | Hewlett-Packard | 17.20 |
| | 10.25 | San Jose-San Francisco, CA | 5.33 | Applied Materials | 28.00 |
| | 63.27 | Detroit, MI | 4.72 | BASF | 11.23 |
| | 25.37 | Basel | 0.42 | Novartis | 100.00 |
| | 57.86 | Beijing | 2.75 | Broadcom | 32.12 |
| | 46.22 | Graz | 2.00 | AVL List | 21.15 |
| | 40.65 | Bengaluru | 3.84 | Mcafee | 13.62 |
| | 54.67 | London | 2.73 | Sony | 12.24 |
| | 80.16 | San Jose-San Francisco, CA | 3.37 | Genentech | 6.45 |
| | 12.65 | San Jose-San Francisco, CA | 1.08 | Cisco Technology | 23.30 |
| | 26.28 | Paris | 8.28 | IFP Energies Nouvelles | 22.25 |
| | 15.30 | Seoul | 21.29 | Samsung Electronics | 8.84 |
| | 24.62 | Portland, OR | 6.03 | Intel | 94.14 |
| | 11.74 | Istanbul | 3.16 | Santa Farma Ilac | 30.02 |
| | 76.62 | Dallas, TX | 2.74 | Blackberry | 51.43 |
| | 15.98 | San Jose-San Francisco, CA | 7.32 | Applied Materials | 9.51 |
| | 45.07 | Shanghai | 0.52 | Dow Global Technologies | 74.23 |
| | 42.80 | Beijing | 1.74 | Jiangsu Huadong Inst. of Li-Ion Battery | 74.93 |
| | 14.93 | New York City, NY | 5.71 | Bristol-Myers Squibb | 25.73 |
| | 24.30 | Melbourne | 1.70 | University of Queensland | 10.59 |
| | 15.45 | Cologne | 2.40 | Henkel | 35.93 |
| | 30.03 | Paris | 5.99 | CEA | 39.14 |
| | 32.16 | Genève | 5.00 | NESTEC | 18.14 |
| | 17.84 | Beijing | 3.61 | MediaTek | 50.84 |
| | 24.88 | Shenzhen-Hong Kong | 1.30 | Huawei | 83.08 |
| | 22.11 | Beijing | 1.13 | Nokia | 23.13 |
| | 36.97 | Shenzhen-Hong Kong | 3.27 | Huawei | 76.16 |
| | 44.58 | Zürich | 3.71 | Abb Technology Ag | 8.13 |
| | 51.13 | Cambridge | 2.46 | AstraZeneca | 28.01 |
| | 58.97 | Beijing | 3.75 | Peking University | 22.07 |
| | 67.33 | Seattle, WA | 2.62 | Elwha LLC | 75.48 |
| | 64.40 | Stockholm | 9.26 | LM Ericsson | 81.90 |
| | 27.09 | Cincinnati, OH | 2.48 | Procter & Gamble Company | 36.43 |
| | 23.22 | Bengaluru | 3.95 | Unilever | 25.91 |
| | 12.66 | Boston-Cambridge, MA | 1.17 | Constellation Pharmaceuticals | 13.32 |
| | 50.08 | San Jose-San Francisco, CA | 1.62 | Hewlett-Packard | 25.04 |
| | 42.84 | Kraków | 1.91 | ABB Technology | 20.10 |

Scientific & Industrial Research – India, APHP = Assistance Publique Hopitaux Paris (APHP), KAIST = Korea Advanced Institute of Science & Technology, CEA = Commissariat a L'Energie Atomique et aux Energies Alternatives.

FIGURE S-1.3

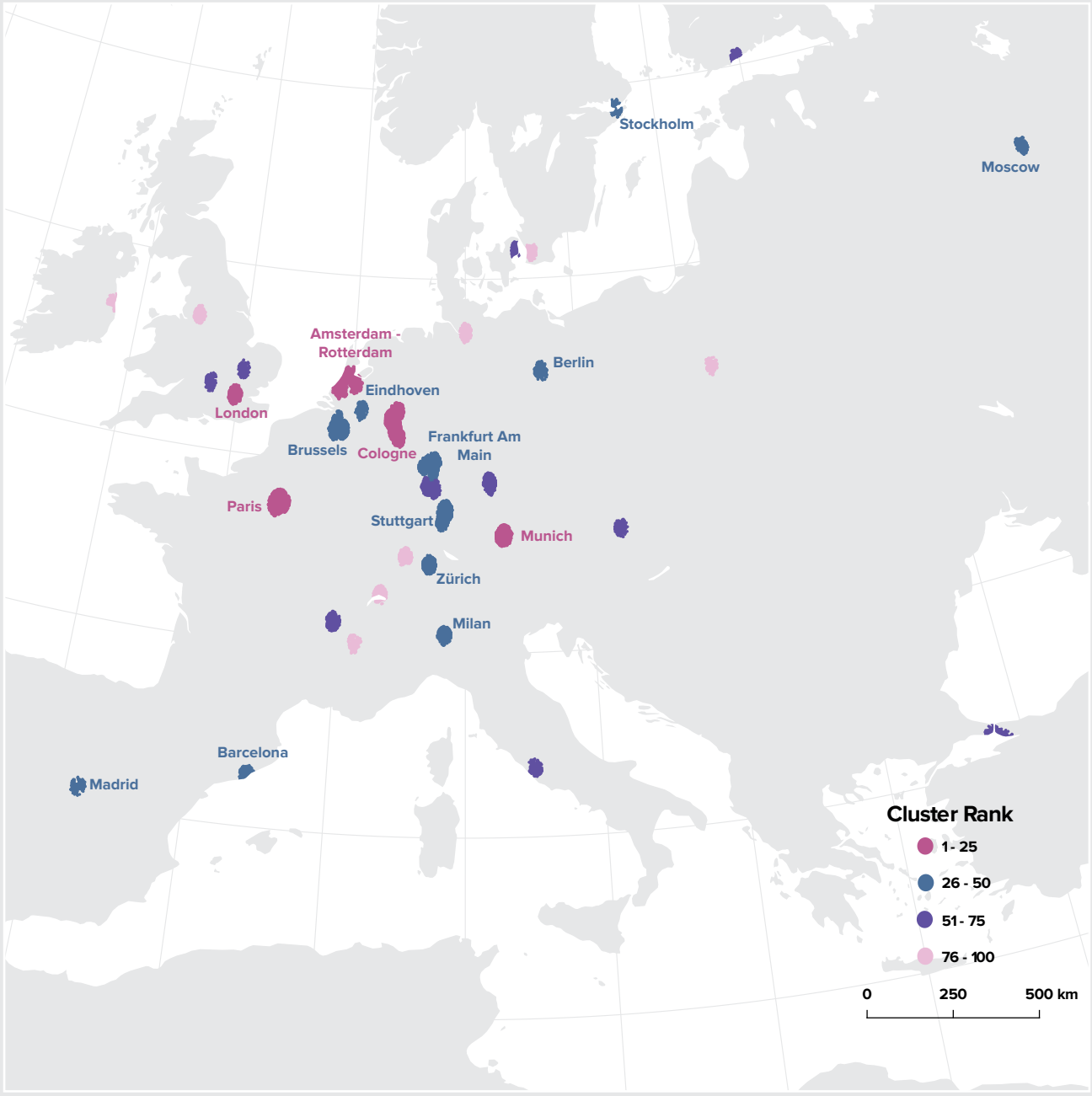
## Regional clusters: Asia




Source: WIPO Statistics Database, March 2019.
Note: Cluster rank is based on total share in patent filing and scientific publication using fractional counting and the publication period of 2013-2017, as explained in the text.

FIGURE S-1.4

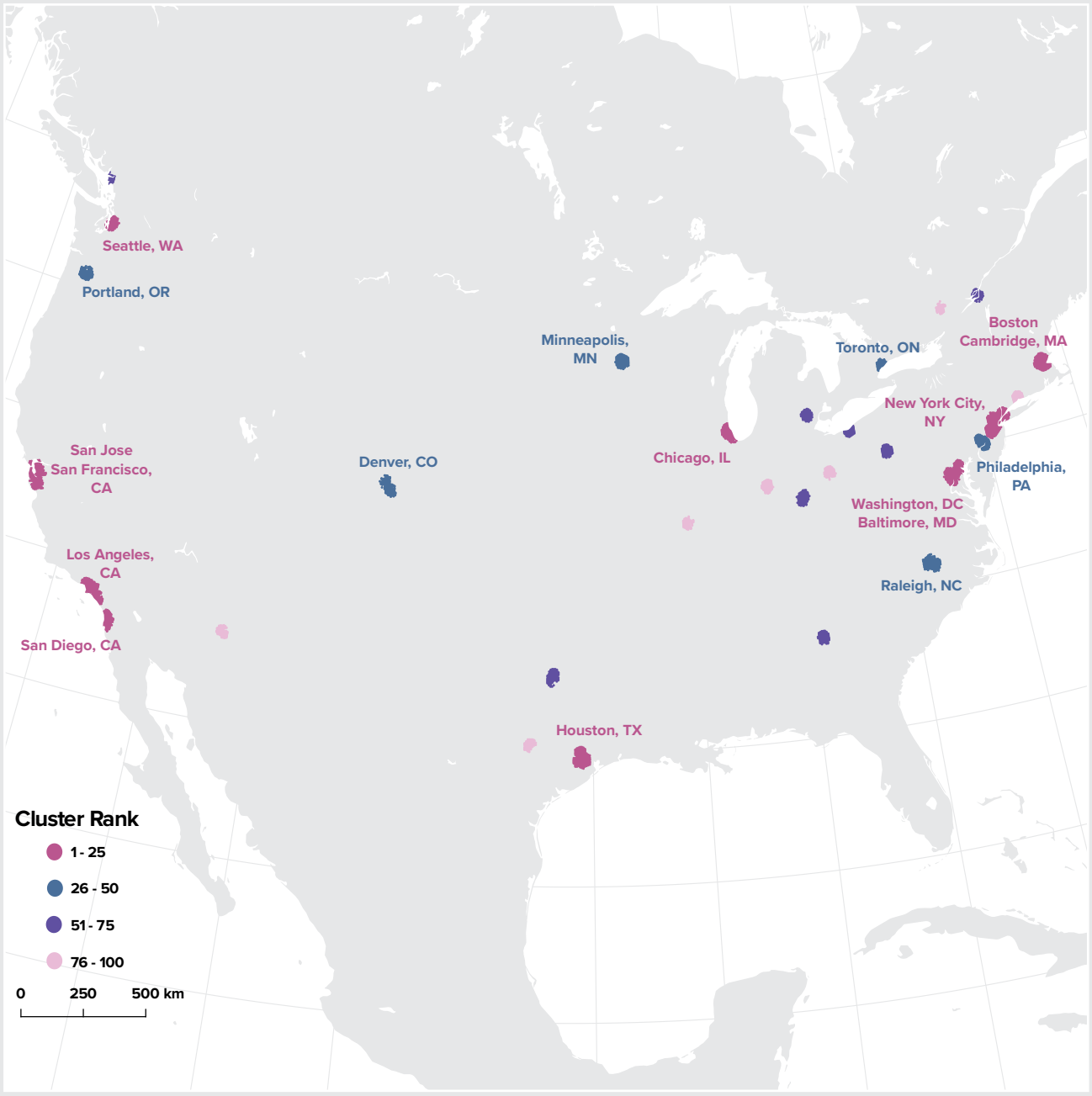
## Regional clusters: Europe




Source: WIPO Statistics Database, March 2019.
Note: Cluster rank is based on total share in patent filing and scientific publication using fractional counting and the publication period of 2013-2017, as explained in the text.

FIGURE S-1.5

## Regional clusters: Northern America




Source: WIPO Statistics Database, March 2019.
Note: Cluster rank is based on total share in patent filing and scientific publication using fractional counting and the publication period of 2013-2017, as explained in the text.