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Supplementary information

Life science ecosystems in Asia: biomedical innovation trends over the past decade

In the format provided by the authors and unedited

Data and analysis
The analysis used databases and analyst reports for Asia, Europe and the United States from multiple sources outlined below. Given the broad, disparate sets of data from multiple sources, including information from local sources for certain Asian countries such as China, India, Japan and South Korea, the analyses triangulated and cross-referenced various data estimates. The goal is to ensure robust directional guidance and comparison on each of the parameters measured for the three geographies, rather than a precise measure of each parameter. Further, to normalize and account for the variations across datasets for any applicable parameter, the average of the various data points for such parameter was used.

Public funding
The annual public biomedical R&D funding from 2014-2023 for Asia, Europe and the United States was collected from government agencies and public funding reports for various markets. Data includes spending at public research institutes, higher education and government sectors in the field of health and medical sciences. All data are nominal figures, and the local currency data was converted to US dollars, where applicable, using the mean daily exchange rate for the respective year. For missing data for any year for a particular country, estimated values were calculated by extrapolation from the previous or subsequent years using average growth rates for the funding period. For a particular country or year, where data from multiple sources showed significant variation, the average of such data points was used.

Data sources for each geography and key countries are listed below:

- **Asia**: Besides data from Organization for Economic Co-operation and Development (OECD) Health R&D Expenditure (USD, purchasing power parity, PPP, at current prices) which was used as primary data source, country-specific data sources were used to supplement OECD data
    - Australia: Australian Bureau of Statistics; Government Science Research and Innovation Budget reports; Strategic Review of Health and Medical Research reports
    - China/Hong Kong/Taiwan: China Ministry of Health, Science and Technology; National Natural Science Foundation of China; Taiwan Biomedical Industry Innovation Program (BIIP); Hong Kong Health and Medical Research Fund (HMRF)
    - India: Indian Department of Biotechnology (IDB); Indian Council of Medical Research (ICMR); Department of Health Research
    - Japan: Science and Technology Agency; Agency for Medical Research and Development (AMED); Ministry of Health and Welfare
    - Singapore: Agency for Science and Technology Research (A*STAR); Department of Statistics Singapore (SingStat); Research Innovation and Enterprise (RIE) Surveys
    - South Korea: Department of Health and Welfare; Korea Health Industry Development Institute (KHIDI); Korea Drug Development Fund (KDDF)

- **Europe**: OECD Health R&D Expenditure data; government agencies/statistics bureaus; Horizon Europe (Horizon Health Cluster; EU4Health; Innovative Health Initiative); UK Research and Innovation reports

- **United States**: National Institute of Health (NIH); National Health Expenditure Accounts

Although the United States accounts for the highest public biomedical funding of ~$48 billion in 2023, as percentage of nominal GDP, Australia and Singapore had the highest public biomedical R&D funding (~0.3% of GDP), with Japan and the United States at ~0.2% of GDP, and rest of the countries at <0.1% of GDP. South Korea and Singapore had the highest growth of ~9% and ~7% respectively over the study period, with China growing at ~5.5%, while the public funding in Australia and Japan was largely flat over the study period (Table 1). In contrast, public research funding was broadly flat/declining across major European countries (France, Germany, United Kingdom).

Table 1 | Public biomedical R&D funding data, by country and region in US$ billions

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
US	30.1	30.2	32.3	34.2	36.6	39.4	41.5	42.7	45.3	48.3
Europe	23.0	23.2	24.2	25.3	27.0	28.5	31.1	34.3	34.9	35.3
Asia	19.4	19.3	19.7	21.2	22.6	23.9	24.3	25.4	27.5	29.2
Australia	3.8	3.5	3.5	3.6	3.8	4.2	4.5	4.2	4.4	4.8
China	4.5	4.7	4.8	5.4	6.5	6.9	6.3	6.2	7.3	7.6
India	0.2	0.2	0.3	0.4	0.5	0.7	0.8	0.9	0.9	1.0
Japan	7.9	7.6	7.5	8.0	8.0	8.2	8.4	9.1	9.4	9.7
Singapore	1.2	1.2	1.3	1.3	1.3	1.4	1.6	1.8	2.0	2.2
S Korea	1.6	1.8	2.0	2.1	2.3	2.4	2.7	3.2	3.5	3.9

Publications

High impact articles provide an indication of the leading scientific ideas shaping innovation and the ecosystems around such academic institutions. For this study, data for publications over 2014-2023 period — for number of overall, high impact and top 1% highly cited articles — were collected from multiple sources such as Nature Publication Index (NPI), National Center for Science and Engineering Statistics/Science and Engineering Indicators and World Bank top 1% cited publications, amongst others. Only the publications covering biological and biomedical sciences, chemistry and health sciences were included in the datasets. NPI data (fractional count, share data to ensure allocation for multi-author/multi-country contributions) was used as the primary indicator (Table 2), and top 1% highly cited publications (Table 3) for most recent years were used to supplement the NPI data.

Asia is by far the leading producer of high-impact publications, with China alone ahead of both US and Europe over the 2014-2023 period for the combined score across the three disciplines. Both Japan and South Korea are also ahead of all European countries, except for Germany and the United Kingdom. However, the United States leads in health sciences as well as biological and biomedical sciences disciplines, with China the second largest contributor. In chemistry, Asia is significantly ahead of both Europe and the United States, with China the leading contributor. Additionally, Asia — and in particular China, India and South Korea — have seen a significant increase in top-cited publications over the past decade, while the United States and Europe have been declining/flat during the study period. Similar analysis using NPI data also showed that the United States and Europe publications declined ~15–20% across the three disciplines, while Asia grew ~35–60% across the three disciplines during 2018–2023.

Table 2 | NPI fractional count, share data for 2023 across the three disciplines of biological sciences, chemistry and health Sciences, by country and region

	Biological Sciences	Chemistry	Health Sciences	Total
US	7255	4498	5019	16772
Europe	4800	4667	3375	12842
Asia	4138	14824	2332	21294
Australia	345	304	332	981
China	2740	11553	1400	15693
India	98	868	55	1021
Japan	649	1216	286	2151
Singapore	100	242	54	396
South Korea	206	641	205	1052

Source: Nature Publication Index

Table 3 | Top 1% cited biomedical publications for 2018 and 2023, by country and region

	2018	2023	*2018-2023 growth*
US	6325	5670	*-10.4%*
Europe	12925	14175	*9.7%*
Asia	4950	6930	*40.0%*
Australia	1188	1224	*3.0%*
China	1782	3096	*73.7%*
India	248	576	*132.7%*
Japan	644	720	*11.9%*
Singapore	495	504	*1.8%*
S Korea	198	288	*45.5%*

Source: World Bank

Patents

Triadic patent families, whereby a set of patents are registered in the European Union (European Patent Office, EPO), Japan (Japan Patent Office, JPO) and the United States (US Patent and Trademark Office, USPTO) simultaneously, are often viewed as a good measure to compare innovative performance across regions since triadic patents reduce potential country-specific bias of innovators. Triadic patent families attributed to country of residence for inventors from Asia, Europe and the United States over the 2014–2021 period were identified as per OECD classification from the OECD Patent Statistics and OECD Science and Technology database (latest available data from 2021). The data was further triangulated with the World Intellectual Property Organization (WIPO) database for biotechnology patents originating from each country and geography.

For triadic patent families, Asia's share has steadily increased from ~37% of global share in 2014 to ~50% in 2021, with US and Europe accounting for ~24% each (Table 4). China has witnessed the largest growth, increasing >10x from <1% share in 2014 to ~11% in 2021, with South Korea increasing its share to ~6% in 2021 while Japan has remained broadly flat at ~30% during 2014–2021.

Specifically for biotech patent families, filings have grown ~12.8% in Asia over 2014–2021, as compared to ~6% growth for the United States and broadly flat/declining for Europe. China patents grew >25%, with South Korea biotech patents growing at >14% during 2014-2021. In contrast, most European countries are seeing a flat/declining trend of biotech patents (Table 5). In absolute number of biotech patents, China, Japan and South Korea are well ahead of all major European countries (France, Germany, United Kingdom).

Table 4 | Percentage share of global triadic patents (all figures in %)

	2014	2015	2016	2017	2018	2019	2020
US	28.0	25.2	24.9	24.4	23.5	22.8	22.6
Europe	30.3	26.1	25.7	24.9	24.9	24.5	23.9
Asia	37.1	43.4	44.1	45.1	45.6	46.6	47.5

Source: OECD Patents

Table 5 | Triadic patent families, by country

	2016	2017	2018	2019	2020	2021	CAGR
US	5,733	6,049	6,504	6,662	7,592	7,510	*6.1%*
France	517	530	475	465	560	477	*-1.8%*
Germany	624	675	638	670	778	731	*1.6%*
UK	496	509	578	601	670	581	*1.7%*
Australia	164	175	184	187	193	217	*4.4%*
China	1,123	1,536	1,893	2,099	2,896	3,192	*25.3%*
Japan	1,649	1,583	1,744	1,668	1,563	1,637	*2.8%*
Singapore	107	105	89	127	137	122	*2.8%*
S Korea	883	939	1,027	1,082	1,432	1,558	*14.1%*

CAGR, compounded annual growth rate 2016–2021

Venture funding

The biotech venture/private equity investments from 2014–2023 for each of the markets were collected from DealForma and BioCentury (BCIQ) databases. The data was further triangulated with data from PitchBook and Venture Intelligence, as well as discussions with local sources in Asian countries such as China, India, Japan and South Korea, including analyst reports from Deloitte, HSBC, iQVIA, McKinsey, amongst others. The investment data is only for biopharma companies, and excludes hospitals, medical devices, diagnostics and healthcare services companies. The annual investment figures are shown in Table 6 and Table 7 below; all numbers are in US$ billions (converted at exchange rate, as applicable). For missing data for any year for a particular country, the value from the previous or subsequent year for such country was used. For a particular country or year, where data from multiple sources showed significant variation, the average of such data points was used.

Table 6 | Private biotech funding for China, Europe and the United States in US$ billions

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
China	0.1	0.2	0.9	1.2	3.1	2.4	5.5	5.8	2.5	2.3
Europe	1.4	2.2	1.9	2.5	2.1	2.8	3.4	5.2	2.6	3.1
US	4.8	9.0	6.6	8.0	12.2	14.1	18.5	28.6	19.4	14.3

Table 7 | Private biotech funding for Asian countries in $US billions, cumulative for 2018–2023

	2018-2023
Autralia	1.0
China	21.6
India	0.2
Japan	0.6
Singapore	1.0
S Korea	0.8

Clinical-stage assets

Data for clinical-stage assets was collected from Citeline Pharmaprojects/Trialtrove and IQVIA 2024 R&D reports, with company headquarters in a particular country used for allocation of clinical assets across Asia, Europe and the United States (Table 8). The data was further triangulated with information from local regulatory authorities' databases (US FDA; Japan PMDA; China CFDA, amongst others).

Asia has seen a dramatic increase in global share of clinical assets, from ~25% in 2018 to ~37% in 2023, while clinical assets originating from Europe have declined significantly from a ~30% share in 2018 to ~22% in 2023. It broadly mirrors the data for distribution of R&D companies with headquarters across Asia, Europe and the United States (Table 9).

China has delivered the strongest growth, with its share of clinical assets at ~28% in 2023, second only to the United States at ~33%, and significantly ahead of Europe at ~22%. In contrast, Japan has seen a significant decline from 14% in 2018 to ~5% in 2023.

Additionally, Asia is seeing an increasing number of new molecular entities (NMEs) approved by US FDA, with 24 approvals from Japan, 7 from China and 3 from South Korea during 2014–2023. In contrast, there were no NME approvals from China or South Korea prior to 2014. India and Singapore still lag in this metric with no NME approvals by US FDA during the 2014–2023 period.

Table 8 | Percentage share of global clinical assets by region

	2018	2023
Asia	26%	37%
Europe	29%	22%
US	38%	33%
Japan	14%	5%
China	8%	28%
S Korea	4%	4%

Source: IQVIA 2024 R&D report

Table 9 | Distribution of R&D companies by headquarters

	2023
US	39%
Europe	25%
UK	5%
Germany	2%
France	3%
Asia	32%
China	16%
Japan	3%
S Korea/Aust/Sin	13%

Source: Citeline 2024 R&D Report

Initial public offerings (IPOs)
Data for companies listed on various stock exchanges globally was collected from multiple sources including Capital IQ, Nasdaq, LSE, HKEX, ASX, as well as analyst reports from Deloitte, Goldman Sachs, HSBC, JP Morgan, McKinsey, amongst others. Company headquarters in a particular country was used to allocate listing originating from Asia, Europe and the United States. Only biopharma firms were included in the analysis, and medical devices, diagnostics and healthcare services companies were excluded.

Although the IPO activity has moderated over the past couple of years, biotechs from Asia — especially China and South Korea —have actively tapped the public markets, with the total number of IPOs from Asia ~2x higher than those from Europe during 2018–2023. However, India, Japan and Singapore are lagging significantly behind on this parameter, with minimal biotech IPO activity.

Data limitations
Given the multi-factorial analysis, and triangulation from multiple data sources, the aim was to provide a robust, directional guidance and comparison between the geographies for each of the measured parameters, rather than precise measure for each of the parameters and countries.

Public biomedical research funding data for certain countries in Asia (such as China or India) and Europe is not readily available from one central source (as is the case for the NIH for the United States) and was collected from various sources with missing data for certain countries and certain years. Although not as robust as the data for the United States, estimates from triangulation of OECD data and local sources provides good directional guidance as well as comparison between various countries and geographies.

Similarly, venture funding data for certain markets may not include all investments across biopharma in these geographies, especially in Asia. Additionally, given recent geopolitical considerations, there is potential dual counting for venture funding and/or IPOs, especially for China companies that have used United States / Europe-domiciled subsidiaries to raise capital from overseas investors. Discussions and inputs from local sources were used to supplement global databases.

Finally, the clinical assets are all programs across various stages of the clinical pipeline, including me-too/me-better molecules. A better innovation metric would be to include only the first-in-class/best-in-class assets; however, given the large pipeline globally (>21,000 drugs), the total number of clinical assets was used. A broad measure of first-in-class/best-in-class assets from analyst reports available for certain markets, which demonstrated similar trends as the overall clinical pipeline, was used to supplement the overall data.