CHAPTER

Factors that promote the development of nanoscience

4

Key findings

132,220 awards were related to nanoscience, accounting for approximately 3.6% of all awards, with a compound annual growth rate (CAGR) of 3% (2009–18).

Material science, chemistry, and physics and astronomy had the highest ratio of awards related to nanoscience (29%, 17.9%, and 14.8% respectively). The number of nano-related awards also ranked first in materials science (2009–18).

A higher CAGR for nano-related awards in eight subjects: The CAGR for nano-related awards in eight analyzed subjects[1] in

Pharmacology, Toxicology and Pharmaceutics, and Energy Nano-related awards in pharmacology, toxicology, and

[1] Only pharmacology, toxicology, and pharmaceutics is an exception. That is because the CAGR of all awards in the subject pharmacology, toxicology, and pharmaceutics is high (14% in the book). However, the CAGR of nano-related awards in pharmacology, toxicology, and pharmaceutics is the highest among all subjects (4.9%).

Big Data Analysis of Nanoscience Bibliometrics, Patent, and Funding Data (2000–2019)
https://doi.org/10.1016/B978-0-323-91311-9.00004-9

this chapter is higher than the respective subject's average CAGR, including biochemistry, genetics, and molecular biology; chemical engineering; chemistry; energy; engineering; environmental science; materials science; medicine; and physics and astronomy.

The National Natural science Foundation of China (NSFC) funded the largest number of nano-related awards. Between 2009 and 18, the NSFC funded 27,387 nano-related awards, accounting for 8.7% of all of their awards.

28%
In 2019%, 28% of global nano-publications were international collaboration efforts. The percentage had increased 8 points since 2000 and was currently higher than the global average.

pharmaceutics and in energy had the fastest growth (the highest CAGR) among all the subjects; their CAGR was 4.9% (2009–18).

The National Science Foundation (NSF) funded the highest amount of nano-related awards. Between 2009 and 18, the NSF funded around US $6.9 billion for 12,942 nano-related awards, ranking number one among all funders.

2.5
China's international collaboration effort in nanoscience continued to grow. Its internationally collaborated nano-publications had the highest academic influence of all comparator countries, with a field-weighted citation impact of 2.5 (2010–19).

4.1 Funding analysis for nanoscience

Research funding has become a crucial means and channel for society to invest in science and technology, and it is also a crucial step for scientific advancement. This section focuses on the funding for nanoscience-related projects in all granted awards, to explore the driving forces behind scientific research development.

Elsevier's funding data platform, Funding Institutional, provides funding information about more than three million projects, covering 3500 government and private fundraising organizations worldwide. See Appendix C for further details about the platform. This book provides an assessment of nano-related projects worldwide based on information from Funding Institutional.

Funding information collected by the platform covered multiple global funding agencies, including information about more than 2000 funding agencies in the United States, such as the National Science Foundation (NSF), National Institutes of Health (NIH), NASA, Department of Energy, and Department of Defense; projects from the National Natural Science Foundation of China (NSFC); projects funded by the German Science Foundation (Deutsche Forschungsgemeinschaft [DFG]), the Federal Ministry for Food and Agriculture (Bundesministerium für Ernährung und Landwirtschaft), Volkswagen Foundation, and the German Environment Agency; projects funded by 729 foundations in the UK (including UK Research and Innovation, Wellcome Trust, etc.); and projects from the Japan Society for the Promotion of Science (JSPS). Funding agencies from South Korea have not yet been included in this platform.

Number and value of nano-related awards

Between 2009 and 2018, a total of 132,220 awards[2] were related to nanoscience, accounting for approximately 3.6% of global awards, according to Funding Institutional. The total rose from 3% in 2009 to 4% in 2018, resulting in a compound annual growth rate (CAGR)

[2] Nano-related awards: With "Nano" in the title or abstract of the award. Search date: Mar. 2020. The 2019 data were not fully updated. Thus, 2009−18 was selected for funding analysis.

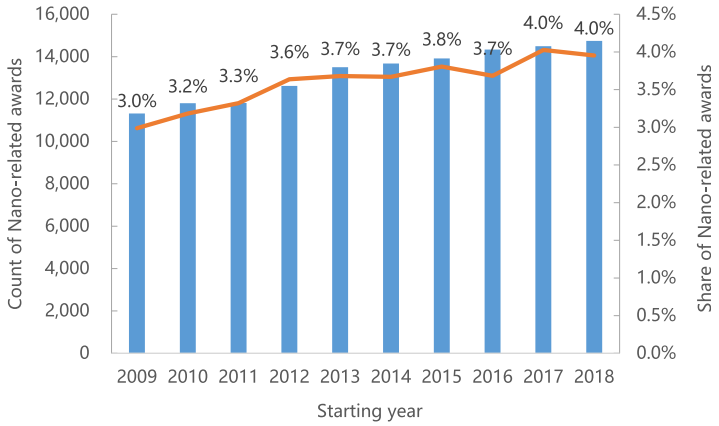

FIGURE 4.1

Trends for the share and number of nano-related awards in the world (2009–18).

Source: Funding Institutional.

of 3% (Fig. 4.1). In that period, the number of awards worldwide remained mostly unchanged. Based on available data, the total amount of funding for nano-related projects reached US $42.3 billion[3] between 2009 and 2018.

Nano-related awards in each subject

Fig. 4.2 illustrates the number and growth of nano-related awards in key subjects with the highest number of nano-related awards, including biochemistry, genetics, and molecular biology; chemical engineering; chemistry; energy; engineering; environmental science; materials science; medicine; pharmacology, toxicology, and pharmaceutics; and physics and astronomy. Among them, nano-related awards in materials science, physics and astronomy, and chemistry had the highest percentages. The results aligned with subjects' ranking by share of nano-publications, indicating a positive correlation between funding and academic output (Fig. 4.3).

[3] A small amount of budget information was unavailable in Funding Institutional.

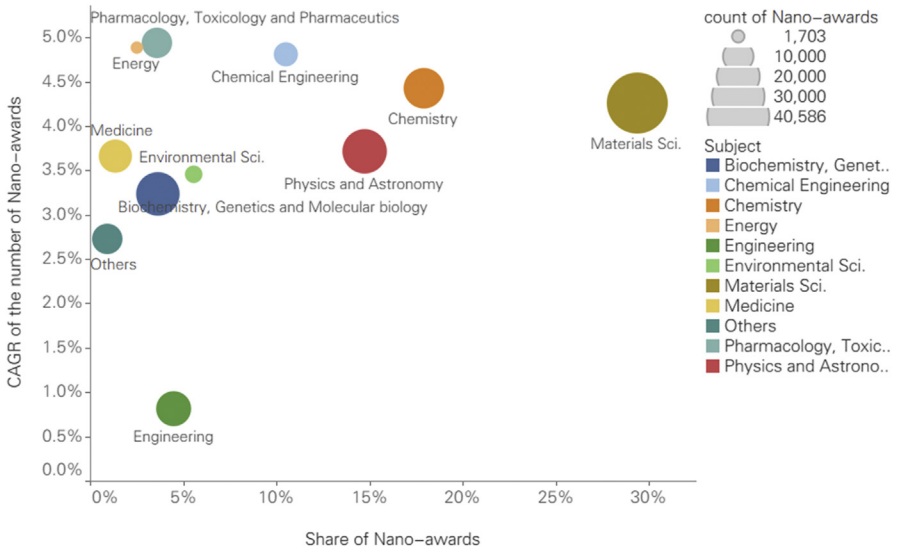

FIGURE 4.2

Number, share, and compound annual growth rate (CAGR) of nano-related awards in each discipline in the world (2009–18).

Source: Funding Institutional.

Materials science has the largest number and share of nano-related awards. Between 2009 and 18, a total of 40,586 funded projects in materials science were nanoscience related, accounting for 29% of awards in the field with a CAGR of 4.3%. The average CAGR for all awards in materials science was 2.5%. Most nano-related funded projects were in the subject of chemistry (17,903 projects, at 17.9% and a CAGR of 4.4%), followed by physics and astronomy (21,543 projects with a share of 14.8% and a CAGR of 3.7%).

Nano-related awards in energy and in pharmacology, toxicology, and pharmaceutics had the fastest growth with the highest CAGR. The exponential growth of awards in pharmacology, toxicology, and pharmaceutics as a whole drove the surge in numbers of nano-related awards. The CAGR of nano-related awards in pharmacology, toxicology, and pharmaceutics was 4.9%, whereas this subject's overall CAGR in awards was 14%. Except for those in pharmacology, toxicology, and pharmaceutics, the growth rates of nano-related awards in each subject, as measured by CAGR, were higher than the subjects' overall averages.

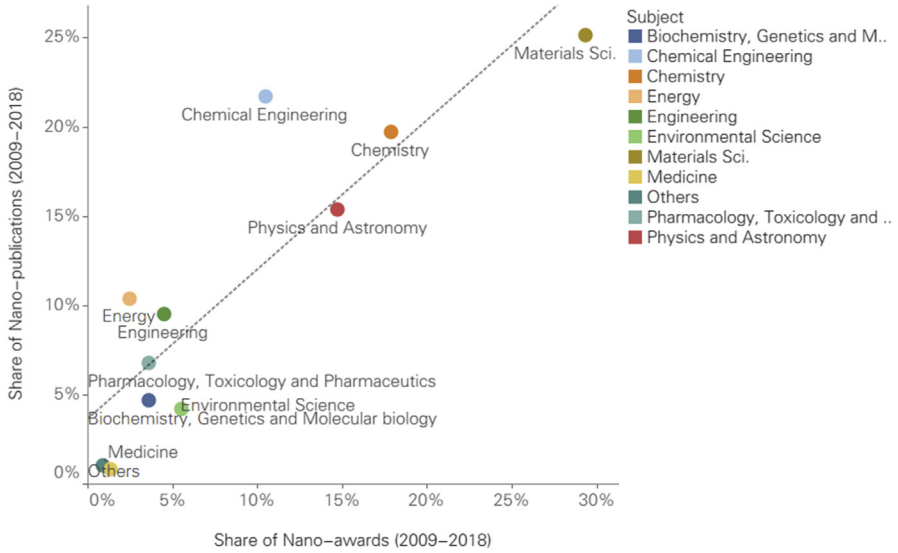

FIGURE 4.3

The share of nano-related awards (x-axis) versus the share of nano-publications (y-axis) in each subject (2009–18).

Source: Funding Institutional, Scopus.

Energy placed second among the key subjects discussed subsequently, which are ranked by the CAGR of their nano-related awards. The growth of nano-related awards in energy was faster than its average of all awards. The CAGR of nano-related awards in energy was 4.9%, whereas the CAGR of all awards in the subject was −3.3%.

Top 10 funders by count of nano-related awards

Fig. 4.4 lists the top 10 institutions that funded the most nano-awards from 2009 to 2018. These institutions funded 64% of global nano-related awards in that period. Among them, the NSFC funded the most nano-related awards, with a total of 27,387, accounting for 8.7% of all NSFC-funded awards. The number of nano-related awards funded by the NSFC also continued to grow, and its growth rate (a CAGR of 17.8%) was the fastest among the top 10 institutions.

The funding trends in nano-related awards differed across major funders in the United States. With 10.1% of its awards relevant to nanoscience, the NSF had the highest share of nano-related awards.

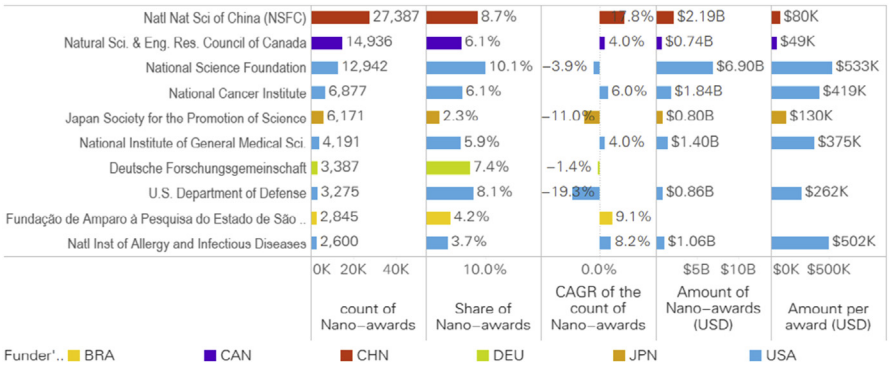

FIGURE 4.4

Top 10 funders[4] that funded the most nano-related awards in the world (2009–18). *BRA*, Brazil; *CAN*, Canada; *CHN*, China; *DEU*, Germany; *JPN*, Japan; *USA*, United States.

Source: Funding Institutional.

The number of nano-related awards from the US Department of Defense declined the fastest, with a CAGR of −19.3%. However, funding continued to grow for nano-related awards sponsored by the three funders affiliated with the NIH: the National Cancer Institute, the National Institute of General Medical Science, and the National Institute of Allergy and Infectious Diseases.

A comparison of the number of nano-related awards (Fig. 4.4) and academic output (Fig. 4.5) per leading funders showed that many funding agencies overlapped in both lists, including the NSFC, NSF, Foundation for the NIH, German Science Foundation, and JSPS. This indicated a positive correlation between the investment of funding agencies and academic outputs. The comparison excluded funders whose data were unavailable in Funding Institutional, which did not cover funding information other than the NSFC for Chinese funders and does not yet include funding data from South Korea.

[4] The project amount information for DFG and the Brazil Foundation is unavailable, and the funding agency data from South Korea are not yet included on this platform.

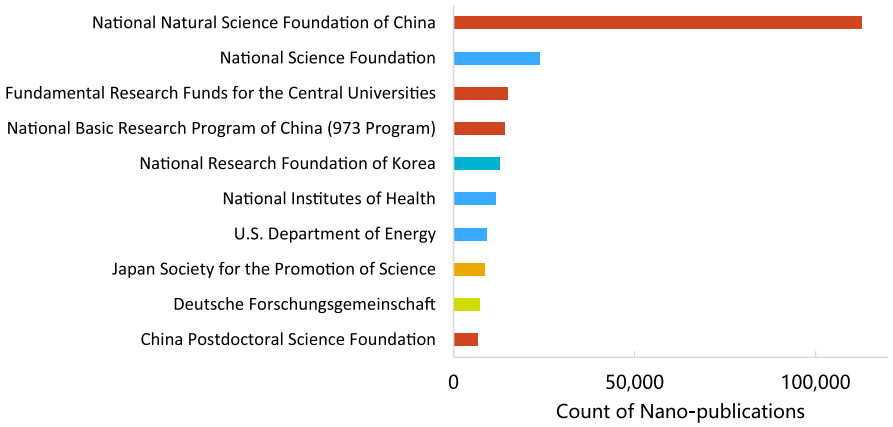

FIGURE 4.5

Top 10 funders by nano-publication count (2009–18).

Source: Scopus.

4.2 International collaboration in nanoscience

As globalization increases, international collaborations in the scientific research community have become more frequent. Cooperation across institutions, regions, continents, and time zones has brought about the exchange and sharing of knowledge, which has increased academic impact. For example, internationally collaborated publications from 2010 to 2019 that are indexed in the Scopus database have an average count of citations per publication 1.68 times the overall average.

International collaboration rate in nanoscience compared with all research fields combined

As one of the key areas in modern science, nano-related research showed a higher degree of global cooperation. Between 2010 and 2019, 21% of the world's publications across all research fields were published under international collaboration efforts, but this number was 25% in nano-related research (Fig. 4.6). In all comparator countries, the international collaboration rate of nano-publications was higher than the nation's average and the world, indicating that global cooperation became more frequent in nano-related research activities.

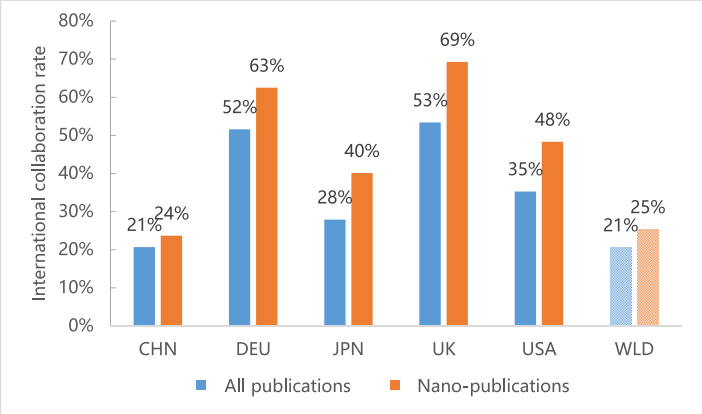

FIGURE 4.6

International collaboration rates in nanoscience and all fields for comparator countries and the world (2010–19). *CHN*, China; *DEU*, Germany; *JPN*, Japan; *UK*, United Kingdom; *USA*, United States; *WLD*, world.

Source: Scopus.

China's international collaboration effort still lags behind that of other developed countries. Between 2010 and 2019, 24% of nano-publications were produced with global cooperation, slightly lower than the global average of 25% and lower than the comparator countries. There are two possible reasons for this. First, China contributed to 39% of worldwide nano-publications in 2019, becoming the country with the highest nano-related academic output. Having many Chinese academic institutions that led the world in nano-related research created a path for a more robust domestic collaboration than global cooperation. As shown in Fig. 4.8, China's domestic collaboration rate continued to outperform its international collaboration rate. Second, compared with developed countries in Europe and the United States, China had a relatively low global collaboration rate in overall scientific research, affecting nanoscience's international collaboration.

Academic impact of China's internationally collaborated nano-publications

International collaboration has improved the overall academic impact of nano-publications. Between 2010 and 2019, the field-weighted citation impact (FWCI) of internationally collaborated nano-publications in the world was 1.9, which was 26% higher than the FWCI for all nano-publications (Fig. 4.7). The same observation was found in all key countries, indicating that international collaboration is beneficial for improving academic impact.

In addition, internationally collaborated nano-publications with China as a partner had a higher academic impact compared with other countries. Between 2010 and 2019, the FWCI of internationally collaborated nano-publications in which China participated was the highest among all comparators (FWCI = 2.5), which was higher than publications in which the United States participated (FWCI = 2.3). After China, the FWCI of internationally collaborated nano-publications

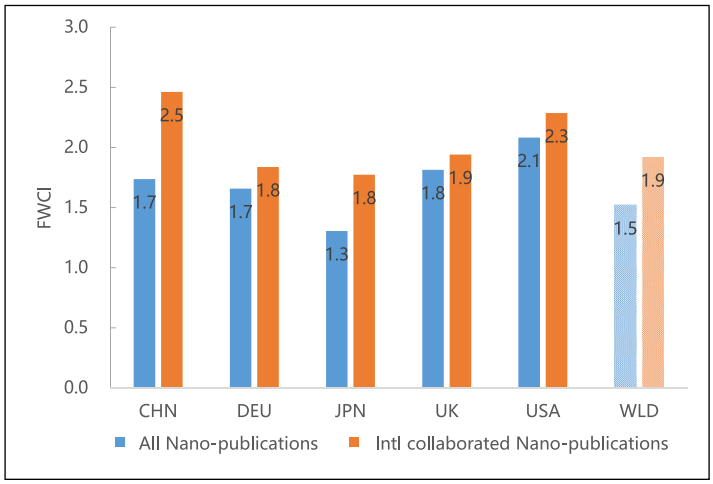

FIGURE 4.7

Comparison of the field-weighted citation impact (FWCI) of internationally collaborated nano-publications and of nano-publications in each comparator country and the world (2010–19). *CHN*, China; *DEU*, Germany; *JPN*, Japan; *UK*, United Kingdom; *USA*, United States; *WLD*, world.

Source: Scopus.

with Japan as a partner was 1.8, which was 36% higher than the overall average of the nation's nano-publications (FWCI = 1.3).

Upward trend in international collaborations in nanoscience

The international collaboration rate in nanoscience increased significantly in key countries and the world in the past few decades (Fig. 4.8). Globally, the international collaboration rate of nano-publications in the world increased from 18% in 2000 to 26% in 2019. Only the institutional collaboration share showed a downward trend, indicating that the geographical footprint of cooperation in nano-related research was expanding.

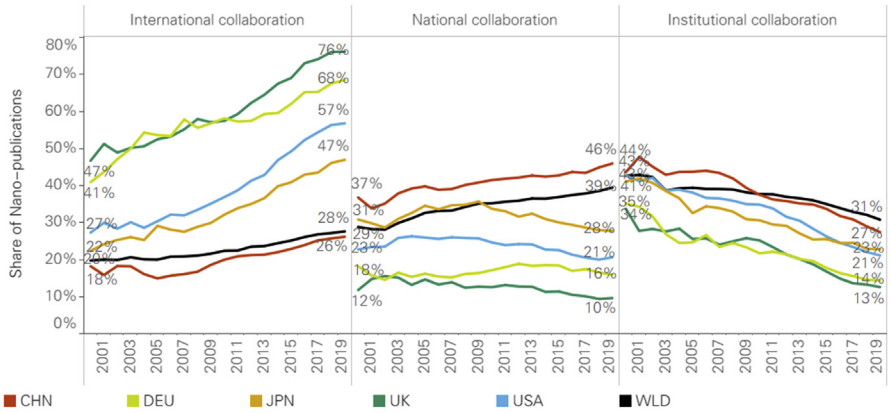

FIGURE 4.8

Trend in nano-publications' share with different types of collaborations in each comparator country and the world (2000–19). *CHN*, China; *DEU*, Germany; *JPN*, Japan; *UK*, United Kingdom; *USA*, United States; *WLD*, world.

Source: Scopus.