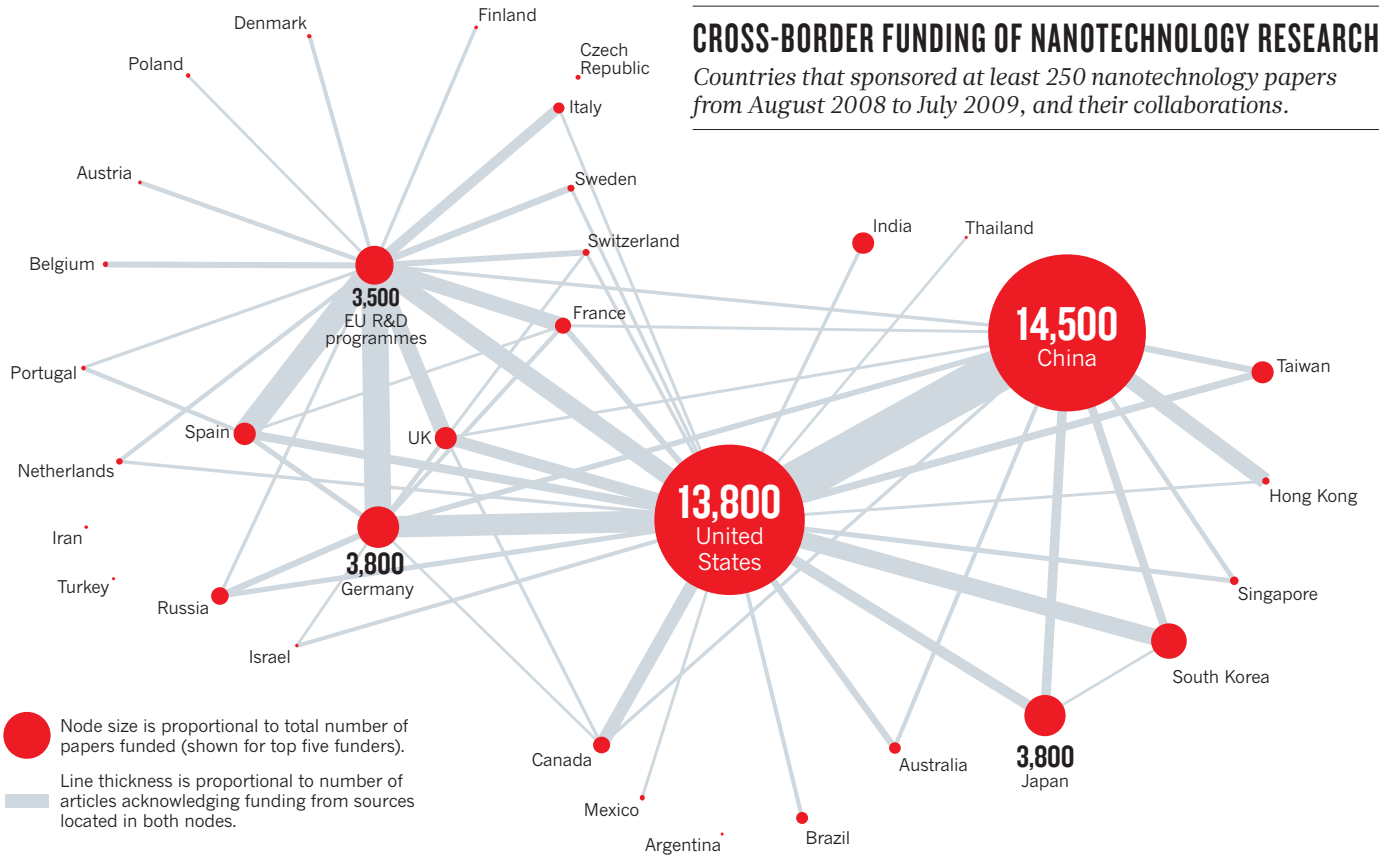
COMMENT

CROSS-BORDER FUNDING OF NANOTECHNOLOGY RESEARCH

Countries that sponsored at least 250 nanotechnology papers from August 2008 to July 2009, and their collaborations.



Follow the money

What was the impact of the nanotechnology funding boom of the past ten years? **Philip Shapira** and **Jue Wang** have scrutinized the literature to find out.

Nanotechnology research spending worldwide expanded rapidly during the past decade. The US National Nanotechnology Initiative (NNI), announced in 2000, kicked off the funding boom: federal spending jumped from US$464 million in 2001 to nearly $1.8 billion in 2010[1]. China, Germany, Japan and Korea soon followed in setting up national nanotechnology programmes, and the European Union (EU) designated nanotechnology as a research priority in 2002. More than 60 countries now have national nanotechnology programmes[2]. Global public investment in research and development (R&D) in nanotechnology reached $8.4 billion in 2008, with a further $8.6 billion of corporate funding[3].

More spending naturally leads to more publications. But how do these funding outcomes vary in scale, productivity, disciplinary focus, collaboration patterns and impact? Using data-mining techniques, one can now make comparisons across countries for large numbers of organizations. We have analysed funding acknowledgments in nanotechnology papers to link research output to funders (P. Shapira and J. Wang, manuscript in preparation). We find that despite the initial focus on national initiatives, patterns of nanotechnology funding and collaboration transcend country boundaries (see 'Cross-border funding of nanotechnology research'). Importantly, the concentration of funds — whereby research sponsors support relatively fewer institutions — seems to yield lower-quality research.

Using a broad-based definition of nanotechnology[4], we identified more than 91,500 articles published worldwide between August 2008 and July 2009 (almost four times more publications than in 1998)[5]. Although the ▶

sample featured researchers in 152 countries, researchers in just 15 authored almost 90% of the papers. (An internationally co-authored paper is assigned to more than one country.) The top four countries by author affiliation are the United States (23%), China (22%), Germany (8%) and Japan (8%). The US share is not surprising given its dominance in funding. China's share has been rising rapidly, although it still spends less on nanotechnology R&D than the United States, particularly in the corporate sector. China's high output of publications reflects much lower personnel costs and national policies that have built up academic nanotechnology research[6].

Since 2008, the Thomson Reuters bibliographic and citation database has also included funding-acknowledgement data. About 67% of the 2008–09 nanotechnology publications include such acknowledgements, mostly to public research agencies, but also to foundations and corporations. We denote these 'grant-supported publications'. Although this category does not capture all the results of funding — public or otherwise — our data set of more than 61,300 grant-supported nanotechnology publications (some supported by multiple sponsors) tells us much about global funding patterns and their outcomes.

LITERATURE ANALYSIS

From this data set we identified a cluster of major research sponsors (see 'Nanotech's top ten funders'). The top ten by publication output fund 69% of all grant-supported publications, and are led by the National Natural Science Foundation of China, the US National Science Foundation (NSF), the Ministry of Science and Technology of China and the R&D programmes of the European Union (EU). Although the United States and China dominate, 13 other countries are represented among the top 25. Israel, the Netherlands and Switzerland are some of the small advanced economies with high-quality nanotechnology research.

China is close to the United States in number of publications, but still lags behind the United States and Europe in publication quality[5]. We looked at one quality measure — the number of early citations — for the top 25 research sponsors. Eight sponsors saw at least 10% of their grant-supported papers garner five or more citations within a year of publication. This group is led by four US agencies — the National Institutes of Health, the Department of Energy, the Department of Defense, and the NSF — followed by the UK Engineering and Physical Sciences Research Council (which ranks 16th in numbers of sponsored papers), the EU research programmes and the German Research Foundation. The Chinese Academy of Sciences takes the eighth slot, even though it is outside the top ten by volume. Other large Chinese sponsors have much lower early-citation figures.

NANOTECH'S TOP TEN FUNDERS

Funding data and early-impact data for more than 61,000 grant-supported nanotechnology research publications were analysed to identify key research sponsors.

Organization	Sponsored papers (and % of total)	Early-impact papers (% of sponsor's papers)
National Natural Science Foundation of China	10,200 (16.7)	4.7
US National Science Foundation	6,700 (10.8)	11.4
Ministry of Science and Technology of China	4,700 (7.7)	5.2
European Union (R&D programmes)	3,500 (5.8)	10.4
US Department of Health & Human Services (including National Institutes of Health)	3,100 (5.1)	15.0
Ministry of Education of China	3,100 (5.1)	4.6
US Department of Energy	3,000 (4.9)	12.5
US Department of Defense	2,600 (4.2)	12.3
German Research Foundation	2,600 (4.2)	10.2
Ministry of Education, Culture, Sports, Science and Technology of Japan	2,400 (3.9)	6.2

In general, we find that sponsors who concentrate funds in fewer institutions have lower research impact as measured by early-citation counts. It may well be that when groups from multiple institutions vie for funding, competition increases, review processes become less partial and more promising projects are selected.

Most nanotechnology funding is nationally oriented, but science crosses borders. In our data set, 23% of the papers have co-authors in more than one nation. Authors in China exhibit the lowest levels of international co-authorship (17% of all Chinese papers) and international funding acknowledgement (also 17%), whereas Germany, France and Britain report the highest levels of both. Some of this is mandated by the sponsor: EU R&D programmes typically require teamwork by researchers from different countries. In other cases, the multinational funding arises independently as researchers collaborate.

"China still lags behind the United States and Europe in publication quality."

The United States remains at the centre of the international nanotechnology map. US researchers partner most often with colleagues in China, although the actual number of collaborative articles is still low relative to national totals. China is the hub for co-funded nanotechnology research with other Asian countries (including Japan). Another cluster is evident in Europe, where there are major lines of co-funding between the EU and its member states. In these clusters, scientific capability, proximity, shared cultural norms, research policy and researcher mobility seem to facilitate the exchange of ideas.

Today, ten years after the launch of the NNI, a handful of countries and research agencies still sponsor much of the world's nanotechnology output. But despite all the international crosstalk, nanotechnology is not yet a truly global activity: most of the developing world is missing.

Nanotechnology has had a decade of growth. Flat public spending and competition from other emerging technologies suggest that nanotechnology funding, in the United States and Europe at least, is unlikely to rise at the same pace in the next few years. So how should stakeholders continue to increase the quality and industrial applications of nanotechnology research? One way would be to foster more high-quality international collaborations, perhaps by opening funding competitions to international researchers and by offering travel and mobility awards for domestic researchers to increase alliances with colleagues in other countries. ■

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