National Network
For Critical
Technology Assessment

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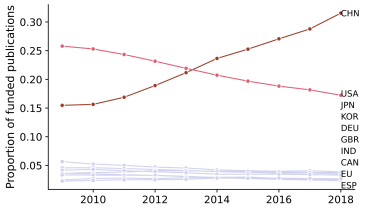
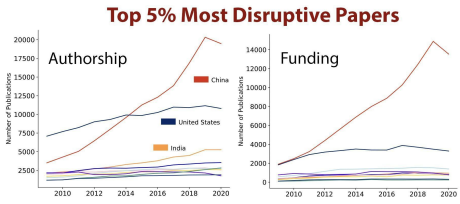
By quantitatively characterizing how countries produce and fund their science, we show that China has become the largest funder of both impactful and disruptive science while the US remains as the key research partner for most countries. We showcase an interactive visualization tool that can reveal the global scientific landscape, with a case study of post-CMOS technology.

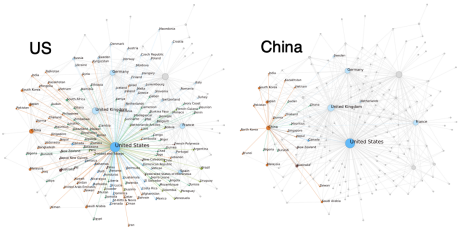
Research Issue As part of the Global Awareness team, our focus centers around the investigation of "How can we effectively track worldwide *investment and production* in crucial scientific technologies?" This is founded on the understanding that maintaining national security and economic prosperity requires prompt and equitable investment in emerging, critical technologies. Evaluating current investments necessitates a comprehensive understanding of international science investment and production. Our research, therefore, aims (i) to elucidate the global landscape of national funding and scientific publications through a thorough bibliometric data analysis, (ii) to develop an interactive analysis platform that displays each nation's comparative advantage across research fields, and (iii) to analyze the post-CMOS research landscape.

Methods and Data Our research tracks publications, funding, and impact using data from bibliometric databases, including Microsoft Academic Graph, Web of Science, OpenAlex, and PatentsView. We use a combination of manual and automatic curation methods to clean and connect datasets. Our analysis incorporates representation learning techniques such as SPECTER and UMAP and leverages the disruptiveness index.



Results and Insights *Global funding landscape*: Our analysis reveals China's emerging dominance in global science funding, primarily attributed to its robust domestic funding; a large fraction of publications produced by Chinese researchers acknowledges domestic funding from Chinese institutions, while the same fraction in other countries is much smaller. China not only leads in the production and funding of overall publications, but also in *the most disruptive research*. In 2010, the top 5% most disruptive papers were equally likely to be funded by the US and China. However, in 2020, the top 5% most disruptive papers were four times more likely to acknowledge funding from China compared to the US. Robust domestic funding also allows China, along with other Asian nations, to have the least dependency on international funding in terms of both quantity and composition. Meanwhile, The US remains the most influential research partner globally. Without international funding from the US, many countries' research might stagnate. By contrast, China's sphere of influence predominantly consists of Asian nations (and notably the US).





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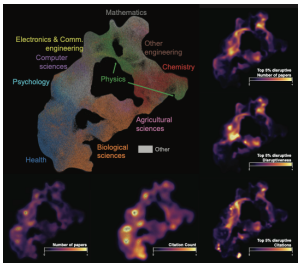
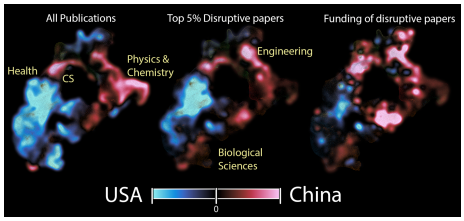
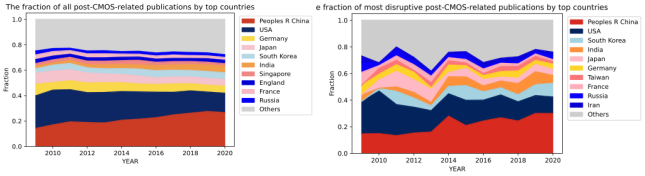
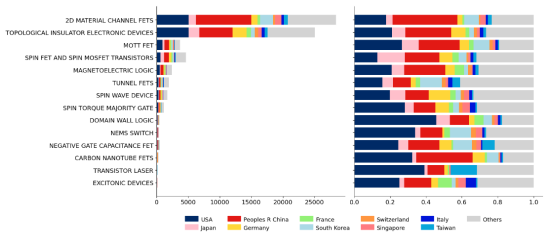


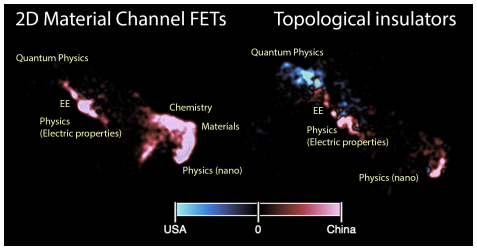
High-resolution comparative advantage and interactive visualization tool[1]: We created an interactive visualization tool that leverages representation learning methods to map scientific publications and patents into the same space. It computes and visualizes comparative advantages at the level of individual publications. It facilitates the exploration of the production and funding landscape, offering the ability to superimpose various metadata, such as country, location, and disruptiveness. It reveals that while the US exhibits an advantage in health sciences, China dominates in the basic sciences and engineering. Moreover, China's presence is stronger in the *most disruptive papers*, with this dominance becoming even more pronounced in the *funding of such transformative research*.

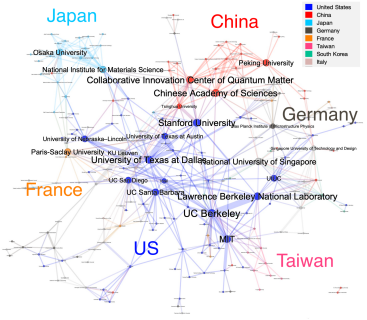




The status of the post-CMOS technology development: In our analysis of the 2022 International Roadmap for Devices and Systems (IRDS) report, which documents key references in the *post-CMOS technologies*, we find a *profound shift in dominance from the US to China* the publications that are emerging in the post-CMOS technologies (those that cite the key IRDS references). This pattern also holds for the most disruptive publications. The two technology areas that have experienced the largest surge in the last ten years are 2D material channel FETs (e.g., those based on graphene) and Topological insulators. Both fields present comparable trends where the US and China have traded the places, with China currently leading the way. Our visualization provides additional insights into the topical distribution of each post-CMOS technology in the knowledge space. While the US retains a comparative advantage around quantum physics within the realm of Topological Insulators, China demonstrates clear dominance across all subfields of 2D Material Channel FETs and Topological Insulators. From an institutional perspective, when examining the key papers cited in the IRDS, the US occupies the central position in the collaboration network.







Summary We document a significant shift in the global scientific landscape marked by *China's rapid ascent and the US's swift decline*. This goes beyond just the number of publications, but extends to other aspects, especially in the *production & funding of the most cited and disruptive papers*. China is markedly investing more in both domestic and international research by Chinese institutions than the US does for its own, and robustly funds basic physical sciences as well as engineering. Our analysis of

[1] A working demo available at: https://sg.iu.edu/visualization/sciencemaps/

post-CMOS technologies reveals a major reversal in the positions of the US and China over the decade, with China now leading in most post-CMOS technologies, especially those that are most active. Despite the US still being the most critical research partner for most and holding a central position in the international collaboration network, it seems to be lagging in funding and producing the most disruptive and impactful scientific research. This is particularly pronounced in basic physical sciences and engineering. Although private investment in the US may be offsetting this shortfall, the severe underperformance in driving disruptive science could hinder its advancement in critical technologies, such as next-generation semiconductor device research.