National Network
for Critical
Technology Assessment

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Chinese science is driving disruptive advance in both emerging and unexpected growth areas of critical science and technology, with scientists best positioned to catalyze future advances in and around these areas.

Research Issue

How can we monitor and anticipate global scientific engagement and production in and around critical technologies? How do national innovation systems strategically engage in science and technological advance; developing established areas, or catalyzing and incubating new ones? How can we predict which scientists are positioned to take advantage of emerging opportunities? And what are new technologies on the horizon? Our approach to answering these questions identifies the value of training and research investment in each techno-scientific area relative to the goal of sustained global leadership. The answer to these questions allows us to strategically assess the situation of the U.S. current and future position relative to the advancing frontier of critical technologies.

Methods and Data

In order to identify robust estimates of country activities, positions and commitments, we take three distinct but complementary approaches to evaluating national research productivity and their resulting roles in unfolding scientific and technological advance across all areas and within critical strategic areas–artificial intelligence, energy, biotechnology, and semiconductors. Our first approach builds a model that embeds research pathways through a hypergraph of scholars and topics in order to identify the leadership of scientists to **emerging** areas of science and technology. These can be understood as research possibilities that are currently or are likely to receive attention in the near future as an extrapolation of current trends. Our second approach builds a model that embeds all papers in an evolving hypergraph of topics to represent the research frontier and capture the **prescience** of each combination of technologies and concepts—the extent to which it is ahead of its time. These can be understood as pivots or changes in the direction of current trends and attention. Our final approach calculates **disruption** indices across the entire citation graph and for strategic areas to identify the degree to which each country is engaged in work that becomes recognized as having catalyzed new directions of research (disruptive) that eclipse the work from which they depart.

Insights

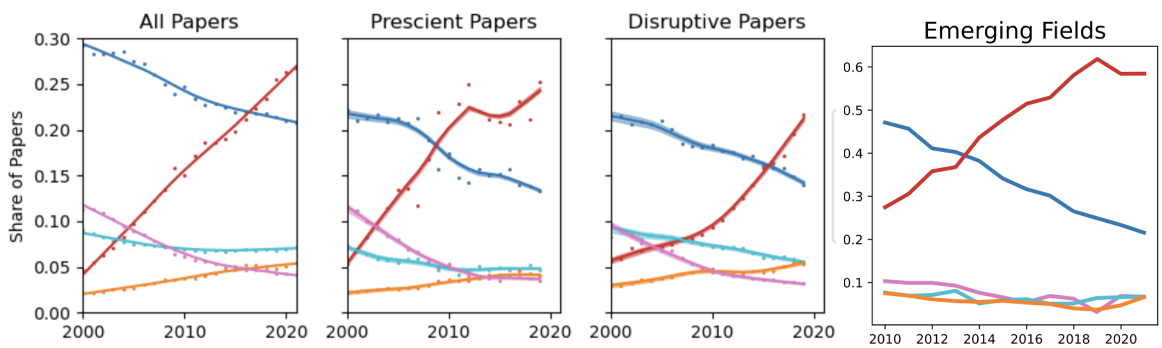
1. China has become increasingly dominant in terms of the production of leading scientific research, and in terms of the scientists engaged in undertaking it.
2. China's rising prominence is not solely a result of increases in the absolute number of researchers and papers. Chinese research is more likely to have very high (and low) placement in all three models (Fig 1).
3. China has massively accelerated its disruptive science in the past two decades, with a higher than average and growing proportion of papers ahead of their time, and in the catalysis of emerging techno-scientific areas, recognised by global scientists as disruptive citation patterns (Fig 1d).
4. China has been slower in their dominance of development across established areas, where the U.S. has maintained greater, but decreasing strength.
5. The U.S. continues to maintain global leads in interstitial areas that link other regions of critical techno-scientific research (e.g., social science linking AI and biotech).
6. The U.S. is markedly less focused on emerging areas, prescient and disruptive research, which will

shape technological leadership in the long-term (Fig 1c).

Options and Trade-offs

Our research highlights two critical trade-offs in the cultivation of national science and technology. **First**, should the U.S. cultivate, staff and sponsor research in targeted areas of nationally perceived critical technology importance (the current Chinese strategy), or do we continue to enable research across the landscape, including critical areas, but also many others that stitch them together, like the social and behavioral strategies (the current U.S. strategy)? The first leads to near-term advance; the second creates a reservoir of connection and distinction that may fuel long-term advance. **Second**, do we sponsor research in areas of established leadership, or do we cultivate research on emerging areas positioned to destabilize areas of dominance and drive the future? Our research suggests that while these are complementary, the mature U.S. research eco-system is associated with a systematic lower likelihood of focusing on emergent areas positioned to become important for the next generation of critical technologies (see Fig. 1c). Some but not all of China's dominance may be accounted for by the relative youth of its scientific workforce, second only to India's, alongside its rapid growth in scientific productivity. These patterns promise to shape the structure of technological leadership for decades.

Figure 1. U.S. (blue) vs. Chinese (red) shares of (a) all, (b) prescient, (c) disruptive, and (d) emerging fields.



Early wins

Our research suggests that to retain historical leadership in areas of critical science and technology advance, the U.S. could beneficially consider increased appropriations and sponsorship of high-risk, high-return science (e.g., ARPA-E/H; integrated high-risk institute investments) to complement its mature scientific portfolio in order to compete for leadership in emergent areas of scientific leadership.

Next Steps: Upcoming work and plans for integration

Among our own team, we will develop a precise landscape of scientific talent for each country with respect to current and future advances in order to understand ongoing and changing scientific leadership. We will also articulate and register areas of future advance and by whom. With other members of the Global Situational Awareness Team, we will predictively model funding with respect to techno-scientific advance (e.g., investment of size X in area Y will produce advances Z, conditional on the population of scientists situated in that area.) With the Domestic Situated Awareness Team, we will expand our work from publications to global patents and their relevance to products. With the four Deep Dive teams, we will examine high-resolution comparative advantages in specific critical technology areas to trace the linkages through country-scientist collaborations, from research to technologies to industrial dominance and explore the health of the "knowledge supply chain." With the Equity team, we will examine the relationship between equity across areas as well as of diversity of participation on advance within areas and across the techno-scientific system.