

Disruptive Discoveries More Likely between Scientists Who Meet Face to Face

Collaborations between scientists at far-off institutions are less likely to produce breakthrough discoveries than those between scientists who can meet face to face on a regular basis.

By **Katherine Wright**

With the ability to voice chat or video conference with just about anyone, anywhere, anytime, humanity has never been more connected. For scientists, that connectivity has allowed research collaborations that span the globe, revolutionizing how science is conducted. But, according to a new study led by Lingfei Wu of the University of Pittsburgh, those remote collaborations are not fulfilling their full potential [1]. Specifically, the team finds that remote collaborations are less likely to produce breakthrough discoveries than those

between scientists who can meet face to face on a regular basis. The reason? Wu says it's because publications from collaborations that include members at far-off institutions normally report follow-up work that builds on earlier studies rather than conceptual work that presents new ideas. He also says that the finding has implications for how researchers conduct collaborations and how organizations fund them.

The past six decades have seen the advent of satellite-communication technologies, the internet, web cameras, and smartphones. Each of these advances has fostered closer collaboration between geographically dispersed researchers. In theory, this progression should have led to more and more “optimized” groups in which each person has complementary, highly specialized knowledge, with the outcome that each research generation should have innovated and problem solved at a higher level than the previous one, Wu says. But that expectation is not borne out in the data. “We have more scientists with more connections but not more big ideas,” Wu says.

To understand why, Wu and his colleagues analyzed data from 20 million research papers published between 1960 and 2020 and from 4 million patent applications published between 1976 and 2020. They collected information on where each paper's or patent's researchers were located, its citation network, and, for the roughly 90,000 papers for which the information was available, what roles each of those researchers took on during the project.



Over the past six decades, remote collaborations have become significantly more common, with the average distance between researchers in a collaboration increasing tenfold.

Credit: YURII Seleznov/stock.adobe.com

The team found that both the number of remote collaborations and the average distance between members of a collaboration have steadily increased over the past six decades. For example, in 1960, a paper's authors were at institutions separated by, on average, less than 100 km, a distance traversable by car or by train in a couple of hours. In 2020, that gap had increased to nearly 1000 km, a distance typically covered by international air travel. In tandem, Wu and his colleagues found a 12% increase over this time period in the fraction of extremely long-distance research collaborations, which they define as collaborations between researchers at institutions over 2500 km apart. That distance corresponds to the separation between the University of Lisbon in Portugal and Leipzig University in Germany, for example.

Using the citation networks of the papers and patents, Wu and his colleagues next assigned to each document a “disruption score”—a measure of how groundbreaking the ideas presented in the work were. A paper or patent that subsequent articles cited alongside many of its references was classed as “developing.” Conversely, a work that was cited without its references being cited at the same time was considered “disruptive.” “We use the citations like votes,” Wu says. “When a future work ignores the forebears of a paper, it’s a vote for novelty.”

Wu and his colleagues found that the disruption score dropped as the distances between the institutions of a publication's team members increased. They found a 6% drop in the disruption score for papers and a 12% drop for patents when the collaborators were over 600 km apart, which corresponds to the distance between Paris and Frankfurt. This drop was consistent across fields and continents. “The remote work penalty happens across the board,” Wu says.

Delving next into the roles of researchers, the team found that the division of responsibilities within a given project was also affected by distance. Scientists at institutions far from the core research group were less likely to take on conceptual tasks, such as coming up with the idea for the project or writing the paper. This trend held across research fields, time periods, and collaboration sizes. It also held when two scientists switched from working at the same institution to working at different ones, as often happens when a PhD student graduates, for example. “When someone moves away, they switch from being

the brains of the project to being the muscle,” Wu says. “That was a very consistent pattern in our data.”

Combining all the pieces, Wu and his colleagues conclude from their data that widely dispersed collaborations typically work on codifying knowledge, not creating it. Despite all the technological changes the world has seen, “collaboration at a distance continues to center on late-stage, technical projects rather than conceptual ones,” Wu says. “Remote teams may have more specialized knowledge, but that knowledge is leveraged to test someone's already published idea and not to come up with new ones.”

Roberta Sinatra, a computational social scientist at the University of Copenhagen, Denmark, thinks that the result answers an important question: Given the ease with which researchers can share ideas and combine their knowledge, why haven't scientific breakthroughs become more common today than in the past? “From a data perspective, explaining why this hasn't happened was not an easy endeavor,” Sinatra says. “We think that very diverse collaborations, involving scientists from all around the globe, have the potential to produce more breakthroughs, which is why, for example, funding agencies encourage collaborations across institution and countries. This study shows that this encouragement is not necessarily a good idea.”

As well as potentially influencing how funders support research teams, Wu thinks that these new results have implications for immigration policies. Increasingly, he says, talented future researchers who move countries to study are finding it harder to stay in their chosen countries once they graduate. Wu says that the enforced return of early-career scientists from developed to developing countries is often marketed by governments as a good thing for their home countries. But he thinks otherwise. “It is a disservice to a very talented group of individuals,” Wu says. Even if they can maintain online collaborations, this work shows that those scientists will more often than not end up contributing to technical advances in a field rather than to disruptive changes. “We have to decide what is the product of science,” Wu says. “Is it producing papers or is it training the next generation of intellectual leaders?” If the latter, “then we need more open immigration policies,” he says. “Young talent needs to be able to move freely between countries to have regular in-person interactions. If researchers in academia or

industry want to carry out fundamentally innovative work, they can't rely on digital technologies to connect with others."

Katherine Wright is the Deputy Editor of *Physics Magazine*.

REFERENCES

1. Y. Lin *et al.*, "Remote collaboration fuses fewer breakthrough ideas," *Nature* **623** (2023).