1 – Traduza para o português o trecho em destaque. 2 – Leia todo o texto e escreva um resumo de suas principais ideias.

Is science getting less disruptive — and does it matter?

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A finding that papers and patents that change the course of science are becoming less dominant is prompting soul-searching on the nature of the modern scientific enterprise.

The influential twentieth-century physicist and philosopher Thomas Kuhn was instrumental in formulating the term 'paradigm shift' to characterize how unexpected evidence can set research fields off in new directions. A paper published in *Nature* last month by the social scientists Michael Park, Erin Leahey and Russell Funk has prompted lively debate by suggesting that the proportion of disruptive papers and patents has been decreasing over time[1].

By analysing more than 60 years of data from bibliometric and patent databases, the authors conclude that it is less likely now than in the mid-twentieth century that any one paper or patent will be 'highly disruptive' — that is, that it will change the course of an entire scientific field. Although the number of new papers and patents the researchers classified as disruptive stayed broadly the same over the period they studied — from 1945 to 2010 — the explosion in research articles, patents and funding in that time means that disruptive science's share of publishing and patenting has been dropping.

Much of the reaction has involved soul-searching about the implications for science if innovation is slowing down, as well as questions about the nature of the modern scientific enterprise itself. This, in turn, is prompting more questions that could become the subject of further analysis.

The study uses a number of measures of disruptiveness. The one that has attracted perhaps the most attention is called the CD index, which is based on citations. As the authors write, "if a paper or patent is disruptive, the subsequent work that cites it is less likely to also cite its predecessors", whereas "if a paper or patent is consolidating, subsequent work that cites it is also more likely to cite its predecessors". In other words, with more consolidation, the same previously disruptive papers continue to be cited.

Single papers do have the potential to disrupt or create fields. One of the best-known examples is James Watson and Francis Crick's model of DNA from 1953, created with the help of Rosalind Franklin's groundbreaking X-ray crystallography work[2,3]. Another is the 1995 discovery by Michel Mayor and Didier Queloz of a planet orbiting a Sun-like star[4] that launched the field of searching for exoplanets.

But new directions also arise from many studies reporting long-running research efforts. Gravitational waves are one example. Much as the paper from the LIGO collaboration reporting the first direct detection of a gravitational wave[5] is itself highly cited, subsequent work has continued to cite work that led up to it. Researchers cite studies for different reasons, and not only to acknowledge previously important work that is being built on. Park and his colleagues do control for some of these things, to better compare disruptiveness today with that several decades ago.

For this Editorial, *Nature* spoke to a number of scholars who study science and innovation. The paper by Park and his colleagues[1], they say, builds on a pattern identified elsewhere in the specialist literature[6,7], and some are worried by the findings' implications. Science and innovation are drivers of both growth and productivity, and declining disruptiveness could be linked to the sluggish productivity and economic growth being seen in many parts of the world.

Others argue that a decline in the fraction of disruptive science shouldn't cause concern if the absolute number of disruptive studies has remained relatively constant over time. If a greater proportion of publications are consolidating, that could just reflect the current situation: in many disciplines, the fundamentals are agreed on, so most further advances will be incremental, rather than disruptive. No doubt scholars will analyse the importance of these findings using qualitative approaches, such as interviews and observations that capture researchers' own experiences in individual fields, as the sociologist Harry Collins has done from within the LIGO team.

Another reason that the study by Park and his colleagues has created such resonance is that it plays into wider concerns about how science is organized. One of these is whether the division of science into ever-narrower units of knowledge is detrimental to the discovery of new paths. Critics also point to publication incentives and metrics-driven research evaluations, which steer scientific study away from risk-taking as funders, researchers and institutions take the safe option to keep the grant–publication–citation wheel turning. This periodically leads to calls to incentivize more high-risk, high-reward research, and initiatives such as the United Kingdom's Advanced Research and Invention Agency. This is modelled on the US Defense Advanced Research Projects Agency (founded in 1958), so the search for disruptive innovation is not new.

But it is also possible that science's knowledge and publication overload is not specifically a research problem. The lack of space to think in the face of an information deluge is apparent across many sectors of society. Some in innovation studies think that artificial intelligence could help, by sifting and sorting information in meaningful and beneficial ways, aiding researchers in summarizing cutting-edge knowledge in a discipline[8], for example, or identifying which research projects have the potential for breakthroughs[9]. If used appropriately, such technological disruption has the potential to free up more time for scientists to progress their fields — disruptively or otherwise.

Asking questions about the nature of science and reflecting on the answers can only be a good thing. The work by Park and his colleagues must continue to be built on, using both quantitative and qualitative methods, down to the level of individual fields. This will help us to understand in more detail how and why science is changing, and where we want it to lead. The end result could be disruption or consolidation — or even a paradigm shift.

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