# Review of: "Science desperately needs disruptive innovation"

Nazeem Mustapha

Potential competing interests: No potential competing interests to declare.

The contributions of this paper are as follows:

1. The development of a Disruption Index (DI) that enables cross-analyses between hi-tech and science for the first time (according to the authors).
2. The identification of similar disruption patterns between hi-tech and science, but with science lagging in both identifying and harnessing innovation advancements and being affected by exogenous shifts

The basic premise of the paper is that the fundamental scientific methodology is Incremental Progression (InP), which guides scientists to evolve step by step and ensures gradual progress. InP is highly effective within a defined context or paradigm, but it also narrows scientists' scope of thinking by tunneling them into niches where they become experts. The authors go on to argue: “Decision makers in universities, funding agencies, and research institutes should adopt a venture capital approach to boosting new disciplines, and allowing research pivots (i.e., unexpected turns), based on the understanding of disruption activity and patterns, as manifested in the DI and DP measures. They need to encourage endogenous disruption by promoting a “startup mindset”; ” etc.

The results are obtained from data from hi-tech and science to analyze disruption patterns. The hi-tech dataset is based on the number of investments in 15 startup categories between 1991-2020, including Cloud Storage, Mobile Apps, Quantum, and Generative AI. Results show that hi-tech and science have similar disruption patterns, but science lags in identifying and harnessing innovation advancements compared to hi-tech. The authors suggest that decision-makers can use the Disruption Index (DI) framework proposed in the paper to assimilate the hi-tech disruption mindset in science. However, the paper does not provide any specific quantitative results or statistical analyses. This is a shortcoming and a missed opportunity. This paper could add value if the authors used their index and framework to suggest future areas of disruption (ironically, in a self-similar fashion).

There are a number of other issues that arise. Firstly, the relevance of the work require an assessment of the 2 contributions.

1. The paper does not provide a detailed literature survey. However, it does mention that previous studies seeking a methodological framework for disrupting science have focused on scientific conduct without integrating the vast hi-tech disruption methodologies and experience. The authors suggest that their new Disruption Index (DI) can bridge this gap and enable cross-analyses between hi-tech and science

2. By construction, this contributes to knowledge. But there are no surprises here, because the two areas (science and hi-tech) follow similar knowledge construction pathways.

The latter point also brings up a critical epistemological point. The work done here rests on what is meant by “science” and “hi-tech”. There are vast amounts of literature on each of these concepts, and the authors need to clearly define each and explain the scope of their study with respect to these. Otherwise, this paper is just a diversion from mainstream research, and not worthy of publication.

Another concept that needs to be defined and located within the literature is “innovation”, which has grown over the last 30 years into a well-explored research field. Again, there are many competing concepts that all still vie for attention.

The paper makes the argument for creating more disruptive mindsets in science, (a “startup mindset” at universities and the like). Again, this hinges on what is meant by “science”, first of all. Secondly, the paper needs to motivate why a startup mindset is required at universities. In order so to do, it needs to discuss what the purpose of the university as an institution is. There is a reason, after all, why the entrepreneurial aspect is called the university third mission (not first or even second). Furthermore, university third mission has gone beyond just the entrepreneurial/economic bent to reach to broader community purpose.

Finally, some general comments on the area of research itself. The authors make the common mistake to assume that innovation (including disruptive innovation) is largely science based. This is demonstrably false as evidenced by surveys done on innovation from all corners of the globe. First observed by Adam Smith in the Wealth of Nations, who identified two modes of learning: One – “A great part of the machines made use of in those manufactures in which labour is most subdivided, were originally the invention of common workmen, who, being each of them employed in some very simple operation, naturally turned their thoughts towards finding out easier and readier methods of performing it.” and, two, the science mode of learning – "All the improvements in machinery, however, have by no means been the inventions of those who had occasion to use the machines. Many improvements have been made by the ingenuity of the makers of the machines, when to make them became the business of a peculiar trade; and some by that of those who are called philosophers, or men of speculation, whose trade it is not to do anything, but to observe everything, and who, upon that account, are often capable of combining together the powers of the most distant and dissimilar objects"

The other critique of the thinking elucidated in this paper relates to the distinction between incremental innovation and disruptive innovation. The authors treat these as if they are distinct processes. But it is often the case that incremental innovations lead to disruptive innovations. Indeed one of the examples they mention, the classical one of the internet, clearly illustrates this. The development of the internet can be traced back to several key milestones and the collaborative efforts of numerous individuals and organizations over several decades. Here is a simplified overview

- The precursor to the internet was the Advanced Research Projects Agency Network (ARPANET), which was funded by the U.S. Department of Defense's Advanced Research Projects Agency (ARPA) in the late 60s.
- Packet Switching: The concept of packet switching, developed by Paul Baran in the early 1960s, was crucial for the efficient transmission of data over a network.

- TCP/IP: The Transmission Control Protocol (TCP) and Internet Protocol (IP) were developed by Vinton Cerf and Robert Kahn in the 1970s.
- Ethernet and Local Area Networks (LANs): Ethernet, developed by Robert Metcalfe and others at Xerox PARC in the 1970s, allowed computers to connect and share data within a local area network (LAN).
- Domain Name System (DNS): The DNS was introduced in the 1980s to translate human-readable domain names into IP addresses.
- World Wide Web: Tim Berners-Lee, working at CERN in the late 1980s, developed the concept of the World Wide Web. It combined hypertext (linking documents through hyperlinks) with the internet.
- Commercialization and expansion: in the 1990s as described in the paper.
- Broadband and mobile technology

Another problem with the thinking here is that it is very linear. And dealing with complex systems, this can be a failing. My opinion is that linear thinking is not good enough here. Another example the paper quotes as disruptive is digital technology in cameras. This is not something their approach would have picked up, because the crucial breakthrough in this hi-tech area was the introduction of CCDs (charged coupled devices). This technology stemmed from astronomy research, but found application virtually everywhere in the modern world. Which brings me to my final point. The one defining attribute (if there is such a thing) of a disruptive innovation, is its application in areas elsewhere. The methodology and data of this paper does not account for this. It is good that the paper restricts itself to “hi-tech” (seemingly digital) disruptions only, because of this fundamental limiting conception. The authors need to acknowledge that not all disruptive innovations occur in tech areas. And I daresay the future areas of greatest disruption will not be digital.