SIDEBAR

Measuring Cross-Disciplinarity Using Publication Output

This sidebar uses cross-disciplinarity as an envelope term that includes convergent, multidisciplinary, and interdisciplinary research because the measurement techniques for examining publication output are similar. Cross-disciplinary research includes the following:

- Convergent research that is driven by a specific and compelling problem requiring deep integration across disciplines (NSF 2019). Convergent science is a team-based approach to problem solving cutting across fields of inquiry and institutional frontiers to integrate areas of knowledge from multiple fields to address specific scientific and societal challenges.
- Multidisciplinary research (MDR) that "juxtaposes two or more disciplines focused on a question … [where] the existing structure of knowledge is not questioned" (NRC 2014:44).
- Interdisciplinary research (IDR) that "integrates information, data, methods, tools, concepts, and/or theories from two or more disciplines focused on a complex question, problem, topic, or theme" (NRC 2014:44).

Efforts using publication output to measure cross-disciplinary research yields results that are not suitable for comparing at the country level (Wagner et al. 2011; Wang and Schneider 2020). This finding is similar to sidebars in previous *Indicators* reports (NSB 2010; NSB 2016; Wagner et al. 2009). This sidebar explains the ongoing methodological issues with measuring convergence, MDR, and IDR at the country level and provides potential directions for future research.

For measurement at the country level, researchers have analyzed cross-disciplinary research using various bibliometric measures. Some have used article citations (Campbell et al. 2015; Porter and Chubin 1985), coauthor fields of specialization (Porter et al. 2007), text mining of abstracts or keywords listed on each article (Del Rio et al. 2001), or network analysis (Leydesdorff and Rafols 2011). An analysis of various approaches for measuring interdisciplinarity revealed a lack of consistent measurement outcomes across scientific fields, over time, and for countries or economies (Digital Science 2016).

Measuring cross-disciplinarity is challenging because indicators that are valid by one measure (e.g., citation counts), are not stable in another scientific area. For example, looking within the broad field of health sciences, health economics uses fewer citations, while biomedicine uses many more. When attempting to measure cross-disciplinarity for health sciences, the differences between health economics and biomedicine are, at least in part, related to different citation habits and not necessarily to differences in the cross-disciplinarity of the research.

Although research has not uncovered robust cross-disciplinary measures for countries, there are insights into the growth and influence of convergence, IDR, and MDR. Measured broadly, researchers find growth in cross-disciplinarity: "from about the mid-1980s, both natural sciences and engineering (NSE) and medical fields (MED) raised their level of interdisciplinarity at the expense of a focus on specialties" (Larivière and Gingras 2014:197). The team also found that the social sciences, as well as the arts and humanities, were the most open to collaborating with other disciplines. While cross-disciplinarity has grown, citation lags are associated with cross-disciplinary research papers. Specifically, they garner fewer than the normal number of citations for the first 3 years but pick up more citations than normal over 13 years (Wang, Thijs, and Glänzel 2015).

Recently, Digital Science prepared a report for the Research Councils of the United Kingdom (RCUK) that scanned the current literature and measurement approaches (Digital Science 2016). RCUK concluded that "no single indicator of interdisciplinarity (either MDR or IDR) analysed here should, used alone, satisfy any stakeholder. They show diverse inconsistency—in terms of change over time, difference between disciplines and trajectory for countries—that raises

doubts as to their specific relevance" (Digital Science 2016:8). The RCUK report suggested that combining bibliometric IDR measures with other data, such as award information, could create a framework for expert analysis of IDR. Among the recommendations were continued exploration of text analysis and the inclusion of departmental affiliations in award information.

Similarly, the 2021 National Academies of Sciences, Engineering, and Medicine workshop on Measuring Convergence in Science and Engineering found that "using a single or even a few atomistic indicators to measure complex research activities capable of addressing societal problems is misguided" (NASEM 2021:49). Workshop participant Ismael Rafols suggested shifting from an atomistic to a portfolio approach, investigating the entire landscape that makes convergence possible.