Measuring Interdisciplinarity at the National Science Foundation

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Fostering interdisciplinary research is a priority at the National Science Foundation (NSF). To this end, the NSF has undertaken several foundation-wide initiatives and encouraged the development of multi-directorate programs. As these new initiatives and programs grow, so does interest in assessing the success of such experiments in fostering interdisciplinary research (IDR). A primary challenge in measuring IDR is identifying and bounding the discrete disciplines that comprise interdisciplinary work (Wagner et al. 2011). A newly constructed topic model of the textual content of the NSF's award proposals offers a new approach for quantifying IDR. This paper compares the use of institutional structure (via co-funding) and scientific content (via the topic model) for measuring IDR at the NSF.

Much of the literature on measuring IDR focuses on examining the outputs of science and relies on bibliometric analyses of publication data (see, for example, Porter & Rafols, 2009 or Wagner et al. 2011). The NSF award database provides a unique opportunity for measuring IDR for two reasons. First, research proposals contain a broader scope of data on the people, inputs and processes of science than is typically contained in publication data and better encompass the "messiness" of interdisciplinary scientific inquiry. Second, the NSF is the only science funding agency that supports research across all scientific disciplines. It is organized into directorates that align with the broadest of scientific disciplines, which can be used as proxies to identify the disciplinary components within IDR.

Methods

This comparative methodological assessment used the Directorate for Social, Behavioral, and Economic Sciences (SBE) as a case study. All 14,225 awards issued by SBE between 2000 and 2011 were examined using the following two approaches:

Co-funding Analysis: When an award spans the scientific focus of more than one program or directorate at the NSF, each program can contribute a portion of its total funding. Interdisciplinarity can be inferred when more than one directorate funds a single award. IDR was measured by identifying the co-funded awards and capturing the precise percentage of the full award amount contributed from each directorate.

Topic Model Analysis: Using LDA, a text-mining technique that extracts latent topical categories (Newman, et al. 2009), the NSF recently developed a topic model of all NSF awards issued between 2000 and 2011 (available at http://readidata.nitrd.gov/star). Each award in the NSF portfolio is now tagged with up to 4 different topics from the set of 1000 topics in the model. For this study, each topic was categorized into the discipline associated with the NSF directorate in which the topic occurred most

frequently – normalized to account for the disparate sizes of the directorates' portfolios. Interdisciplinary awards were identified based on the number of disciplines associated with the topic tags assigned to each award. Each award's degree of interdisciplinarity was calculated by weighting the disciplines by their placement in the topic tag list.

In addition to calculating the percent of SBE's portfolio comprised of interdisciplinary awards and quantifying the distribution of disciplines in the SBE portfolio, the discipline co-occurrence network graphs of SBE's full portfolio were also constructed for each analysis (using the Sci2 Tool, http://sci2.cns.iu.edu).

Results

These two analyses revealed vastly different degrees of interdisciplinarity in the SBE Portfolio – with the co-funding analysis ascribing less interdisciplinarity (15% by count; 55% by dollar amount) than the topic model analysis (55% by award count; 61% by dollar amount). A closer look at the specific interdisciplinary awards in each analysis revealed that the co-funding analysis substantially underestimated interdisciplinarity in SBE's small and medium sized awards. A temporal analysis of the data revealed remarkable constancy in the degree of interdisciplinarity and disciplinary make up of SBE's portfolio over time by each of the compared methods. In the discipline co-occurrence networks, the disciplines in the co-funding analysis were only slightly less connected than in the topic model analysis. However, the average edge weight and node strength was much higher in the topic model analysis.

Conclusions

Until now the NSF has used co-funding arrangements as the primary indicator of IDR. However, in addition to overlooking interdisciplinarity in small and medium sized awards, the total dollar amount included in the co-funded SBE portfolio from 2000 to 2011($4.2 billion) is nearly double SBE's actual expenditures ($2.3 billion). The picture that emerges from the co-funding analysis suggests that SBE should fund more of the largest awards in order to meet its goal of increased interdisciplinarity. However, the topic model analysis' more nuanced approach asserts just the opposite. Increasing interdisciplinarity can be achieved by developing policies that encourage and support interdisciplinary activity across the full spectrum of research supported by SBE.

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