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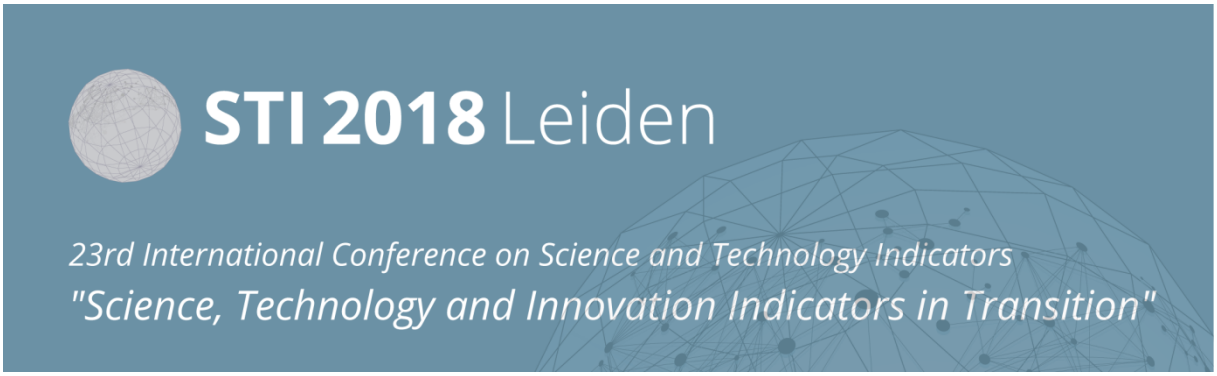

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From theory to practice: Operationalization of the GTEC framework[1]

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Introduction

This paper presents a first attempt to operationalize the Global Scientific Workforce (GTEC) Framework proposed by Welch et al. (2018). The purpose of the framework is to address the many conceptual gaps that currently exist in analyzing the globalization of the scientific landscape. Moving beyond a simple binary classification of global research, this theoretical framework suggests four dimensions to characterize and contextualize the scientific workforce based on their: 1) traits and experience, 2) cognitions, 3) community, and 4) institutional context. Further, it emphasizes the importance of the application of different lenses reflecting variations in national priorities and contextual settings relevant to STI. This paper aims at three specific goals. First, it shows the many current complexities and limitations on data collection and retrieval related to the global scientific workforce. Second, it illustrates through the lenses of the GTEC Framework the distinctions in how global-ness is operationalized. Finally, we demonstrate how these different approaches affect results and conclusions derived, which will ultimately affect interpretations and have policy implications.

The GTEC Framework

The GTEC Framework presents an opportunity for the conceptual improvement of the study of globalized science. Consistent with studies of foreign-born populations, the framework includes two dimensions relevant to the individual: global traits and experiences and global cognitions. These traits move beyond a dichotomous viewpoint of "foreignness" of faculty and scientists and encompasses a broader set of measures including their place of birth, but also the location of their education, where they have worked as well as their gender and ethnicity. More broadly, it recognizes that it is possible to measure globalness, as opposed to foreignness, for each of these aspects for any scientist, regardless of location.

Cognitions describe how scientists observe and understand their local, international context. They are formed over time and result from norms and incentives, opportunities and experiences, perceived bias or treatment by other scientists, and observed global behaviour of others. They include expectations, attitudes, beliefs and preferences relevant to career and personal life.

[1] This work was supported by a National Science Foundation Grant 1661206: Connecting nuances of foreign status, professional networks, and higher education.

Two additional dimensions of the GTEC framework encompass the context in which a scientist exists: global community and global institutional context. The community dimension emphasizes the measurement of a scientist within their social context and captures aspects of both their local and global diaspora as well as their cultural distance from their present location. Global institutional context refers to the cultural climate of their workplace and professional communities regarding factors such as acceptance and satisfaction, expectations, incentives, immigration laws, and the university structure. The GTEC framework presents important data challenges in the sense that it analyses scientists' global characteristics from different perspectives and hence, requires an exploration of current available datasets to ensure the viability of its operationalization

Data challenges

Research on the globalization of science is characterized by limited as well as fragmented data sources, resulting in a severely limited understanding of the global scientific workforce. In the United States, where foreign-born faculty comprise a significant portion of the academic STEM workforce, outdated or significantly limited national-level data has hampered the advance of research on this population For instance, the Department of Education National Study of Post-Secondary Faculty (NSOPF) data collected a decade ago are still used to estimate the size and ethnic composition of foreign-born faculty population in the United States (Mamiseishvili, 2011). Until recently, mobility studies have typically used national and regional survey data which limited capacity to perform large-scale analyses or even to ensure data interoperability (Akerblom, 2000). Bibliometric data have often been used to analyse international collaboration structures, production, knowledge flows and impact (Wagner & Jonkers, 2017), and more recently, have been used to track scientific mobility (Robinson-Garcia et al., 2018; Sugimoto et al., 2017), but still lack other important contextual data.

Data and methods

To evaluate the potential value and contribution of the GTEC framework, it is important to evaluate how the dimensions above align with existing data, and what current data limitations exist. To do this, we use data on scientists located in the United States from several overlapping sources. We begin with data from two National Science Foundation surveys that were designed to investigate the professional networks of women and underrepresented minorities in STEM fields, as compared to their male and white counterparts.[2] Data were collected based on a nationwide survey of 10,076 and 9,925 tenured and tenure-track academic scientists in eight STEM disciplines: biology, biochemistry, chemistry, civil engineering, computer science, electrical engineering, earth and atmospheric sciences, and mathematics. The sample frame includes faculty in a broad set of academic institution types, ranging from highly competitive research intensive universities to teaching focused institutions.

From the survey, we gather scientists' race, gender, citizenship status, country of origin, parents' origin, scientific field, institution and institutional type. These data were further supplemented with life-time publications from 1980 through 2015 indexed in Web of Science

[2] NSF Grant # REC-0529642. NETWISE I "Women in Science and Engineering: Network Access, Participation and Career Outcomes" (CO-PIs: Julia Melkers, Eric Welch)
NSF 0910191. NETWISE II "Women in Science and Engineering II: Breaking Through The Reputational Ceiling: Professional Networks As A Determinant of Advancement, Mobility, And Career Outcomes For Women And Minorities In Stem" (CO-PIs: Julia Melkers, Eric Welch, Monica Gaughan)

(WoS).[3] From bibliometric data we were able to capture the productivity of scientists with regard to the number of publications and citations generated, and their international collaborations. Furthermore, mobility data was matched from the bibliometric records (Robinson-Garcia et al., 2018), which defines scientists' mobility types for the 2008-2015 period. Finally, ethnicity of co-authors was extracted based on the algorithm developed by William Kerr (Kerr, 2008; Kerr & Lincoln, 2010). Our final set is formed by a total of 4,063 respondents spread over these two national surveys.

Analyses and discussion

This paper empirically illustrates the potential contribution the GTEC framework can make to our understanding of the global scientific workforce. As well as describing issues and limitations when merging data from sources of different nature, we will illustrate the heterogeneity of researchers 'globalness' depending on how this is defined and operationalized. Furthermore, we discuss how choices on indicators and variables employed will influence results obtained. For this we re-produce selected studies performed on foreign-born US scientists' contribution to the US scientific system using different indicators of foreign-ness.

The GTEC framework presents this phenomenon from a multidimensional perspective which considers these conditions as some of many factors that affect the globalization of the scientific workforce. It encompasses previous literature while fostering more insightful and critical analyses. While the dataset described here moves us past a dichotomous understanding of foreign-born or mobile, it still leaves room for improvement to fully understand the global scientist.

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[3] Web of Science data was matched to the survey by using the author name disambiguation algorithm developed by Caron & van Eck (2014).

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