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## Contest: Measuring Tech Emergence<sup>1</sup>

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### Introduction

Extensive ways to measure R&D activity exist, but there is a gap in measuring *frontier* research topics. We seek to develop new emergence indicators to support researchers, research managers, businesses, and others in identifying topics at the frontiers of science and technology (S&T). Distinguishing cutting edge R&D activities can inform strategy development, reveal new opportunities, and sharpen research program assessment. Combined with regional mapping, R&D emergence indicators could contribute to smart specialization [<http://s3platform.jrc.ec.europa.eu>].

This is a “micro” approach – to identify topics of accelerating research attention *within* specified technical domains (e.g., within solar cells, or, more narrowly even, within Dye-Sensitized Solar Cells) – to complement “macro” identification of which technical domains are emerging (c.f., Small, Boyack & Klavans, 2014). Indicators of which countries, organizations, or individuals are contributing most to specialized advances in a given domain provide vital competitive technical intelligence. “R&D emergence indicators” focus on measuring frontier contributions to complement general S&T indicators.

We formulate a suite of indicators, develop software routines to calculate them, and devise reports and visualizations to communicate to different audiences, including researchers, managers, and policy makers, as described elsewhere (Carley et al., 2018; Porter et al., to appear).

Technological emergence draws on roots in philosophy of science, systems science, and evolutionary economics, offering a framework to understand R&D advance (Alexander et al., 2012; Serhat and Porter, 2018). Our project implements a model of what constitutes technological emergence, deriving mainly from two sources. The U.S. Intelligence Advanced Research Projects Activity (IARPA) Program on Foresight and Understanding from Scientific Exposition (FUSE) [<http://www.iarpa.gov/index.php/research-programs/fuse>] focused

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attention on developing ways to identify emergence, and to anticipate emerging topics over the coming three years. Rotolo et al. (2015) reviewed literature and identified emergence criteria. We adapt those criteria to seek evidence for four emergence factors: term novelty, persistence, and accelerating growth, plus formation of a research community.

Our approach extracts abstract records on a given S&T topic from global research publication or patent databases (e.g., Web of Science, MEDLINE, PATSTAT). We experiment with ways to clean and consolidate those records' topical content, then score topics' degree of emergence. The computational algorithm then scores "players" (countries, organizations, individuals) in the focal research area, based on the extent to which they contribute on the highly emerging topics. The makeup of the scores and how they behave is then studied through nine diversified S&T case studies. Testing seeks to validate the emergence indicators by analyzing how well they predict R&D activity in a subsequent two-year period.

Our process to calculate R&D emergence indicators is explained in recent articles (Carley et al., 2018; Porter et al., to appear). We seek to improve these in terms of:

- Consolidating topical terms more effectively
- Comparing alternative formulations of emergence scoring routines
- Exploring steps to filter emergent terms (e.g., application of TFIDF variants) and clustering to form compelling topics.
- Consolidating procedures to make them easy to apply using *VantagePoint* software [[www.theVantagePoint.com](http://www.theVantagePoint.com)], and also accessible via open source means.

We are conducting multiple case studies to test procedures and seek useful applications, including:

- Complementing established S&T metrics to help assess R&D capabilities and opportunities.
- Gauging how government funding advances cutting edge research activity.
- Tracking topical diffusion from research to patents to commercialization arenas.
- Illuminating regional or national differences in specialized frontier R&D within a target domain.

### **The Contest to Measure Tech Emergence: A "Challenge"**

Our approach to generating R&D emergence indicators is offered as a base model. Diverse approaches to measure and predict emerging S&T topics are possible. Our "Challenge" seeks better approaches to devise indicators of emerging topics within target research domains. The "topic extraction challenge" of 2017 offers a model challenge – see <http://www.topic-challenge.info> for this initiative by Kevin Boyack, Wolfgang Glänzel, and colleagues.

This poster sketches the parameters of our "Measuring Tech Emergence" Contest, seeking to elicit interest and participation. It illustrates by showing our version of emergence indicators, itself currently under active revision. The gist is to analyse ten years of abstract research publication records to predict which topics will be especially prominent in the following two years. We are finalizing ground-rules for the Contest, including access to practice datasets (~Jan. 1, 2019). Participants can experiment with those data to develop their analytical approach, in preparation for the contest dataset to be provided ~April. Competitors will have ~10 days to offer their results for our assessment. Winners will be announced and awarded at the 2019 Global Tech Mining (GTM) conference in Atlanta. Participation is open to all, with special encouragement to student groups to participate.

This presentation seeks feedback and ideas to help structure a productive, fulfilling Contest experience for participants. We hope you elect to participate! For further information, visit: [www.vpinstitute.org/wordpress/academic-portal/tech-emergence-contest/](http://www.vpinstitute.org/wordpress/academic-portal/tech-emergence-contest/). To receive updates, send your email address to: [stephen.carley@searchtech.com](mailto:stephen.carley@searchtech.com).

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