Webinar June 18, 2019 – Gretchen Jordan
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The Research Profiles Framework: How Theory Guides Evaluation of Research Portfolios

The Need for More Theory:

In October 2018 at a gathering sponsored by the Gordon and Betty Moore Foundation, a group of experts grappling with how to improve the evaluation of basic science concluded that we need more "theory" of how basic science advances and how to make those advances more likely. I wonder what we mean by that. Are we on the same page?

A **theory** is a set of interrelated concepts, definitions, and propositions that explains or predicts events or situations by specifying relations among variables. The situation is very complex, and study to date quite limited. Specifically, what would we include in that "theory"? What parts of the theory are known already? How do we build new theory? What would be next steps?

Use an Example Framework to Aid Discussion

Colleagues and I developed the Research Profiles Framework in a 12 year study funded by the Office of Basic Energy Sciences in the U.S. Department of Energy (DOE) between 1995 and 2007[1]. The project was to learn how to assess the research environment. That is easy compared to the accompanying question of how to improve it, which requires linking specific environments with improved outcomes. There we ran into the same lack of theory and evaluation capabilities mentioned above. We made some progress in characterization and theory, building on theories from organizational development. Perhaps exposure to the progress we made can inform discussion of what theory we need to improve evaluation of basic science, and where we might start.

High Level Logic of How Science Advances

Let us start examining the outcomes of science at a high level of abstraction. The end goal of publicly funded science is to provide economic or social value to the public. That could be a myriad of things, from contributing to the U.S. being a leader in a particular area of science, to improvements in consumer products or the attitudes toward behaviors that increase the risk of disease, or improvements in the healthcare system or health generally. As these examples and Figure 1 show, we suggest that there are three general categories of outcomes of science: effects on the science community, effects on the economy or society, and effects in between these two where the knowledge is being considered or applied by policy makers or businesses or public groups but has not yet translated to social or economic outcomes.

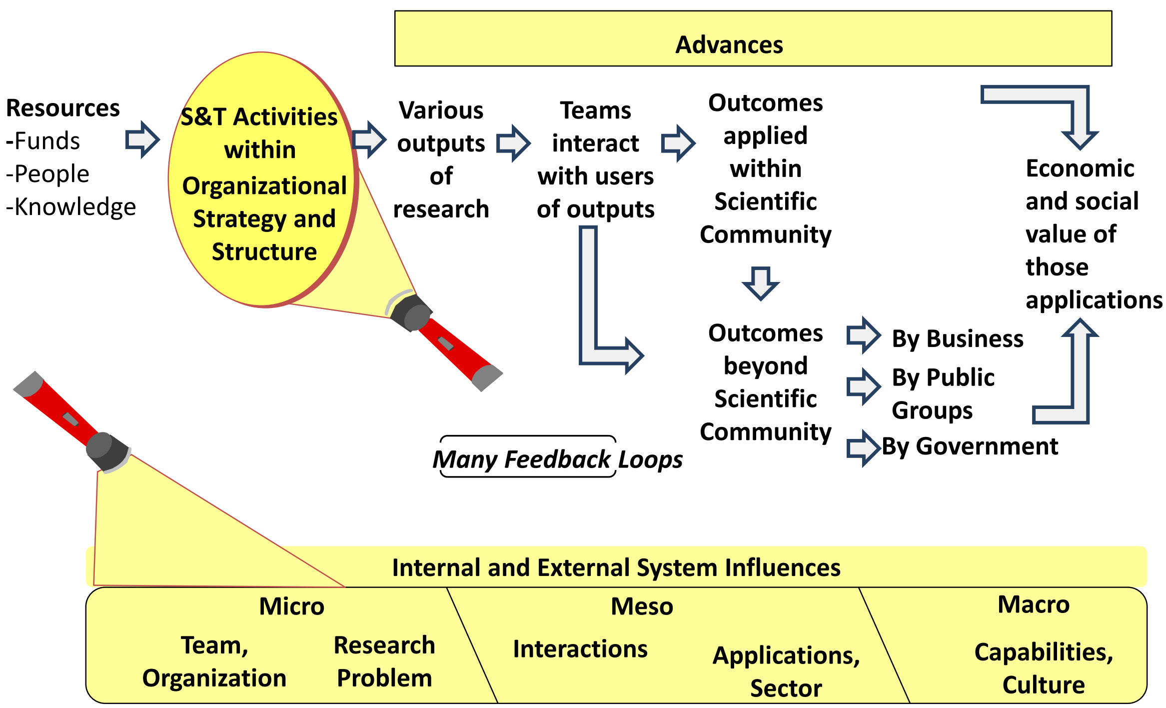
The logic model also calls out the precursors of the outcomes, the building and managing of research strategies and teams (research profiles), activities and outputs, and interactions with the users of those outputs. Notice that these interactions could be either with users within the scientific

[1] See References. This short paper also draws from a 2013 white paper I wrote for the National Academy of Sciences to inform a study on the Science of Team Science on how to evaluate the outcomes of team science.

community or in other cases, including policy research and translational research, with an application community. These interactions might occur during planning, during the research, after the research report or publication, or combinations of these. Importantly, although not shown, there are many possible feedback loops between any science project or program and the outcomes (the non-linear model).

This logical framework for evaluating a sequence of outcomes for basic science considers the characteristics of the research teams and organizations and its translation into outcomes, building on related research in the science of science and related literature and practice in research evaluation. The framework also considers the contextual factors that influence the inputs, activities, outputs, interactions, and near-term, mid-term, and long-term outcomes of science, at the micro, meso (sector), and macro levels of the system. Such factors include the nature of scientific problem, how quickly a solution to the problem is needed, and the readiness of potential users to adopt the translational outcomes of the research (e.g., new technologies or medical treatments).

Figure 1. High Level Logical Framework of How Science and Technology Advance



Research Profiles Captures Competing Values and Contingent Organizational Effectiveness

Our DOE study used multiple, diverse focus groups and literature review to identify "What researchers need to do excellent science". The inherent tensions between autonomy and control were evident, as were differences by types of work and research objectives. To organize the complexity of what we had learned, we followed the lead of Altschuld and Zheng (1995) who proposed using the Competing Values theory to assess research organizations. They argued that research organizations whose outputs were intellectual rather than tangible products needed a framework for evaluating effectiveness that made value judgments explicit rather than explicit. Since the Competing Values theory captures four different models of organizational effectiveness, it provides guidance for recognizing value biases.

Cameron and Quinn (1999) developed the Competing Values Theory because organizational culture is a complex, interrelated, comprehensive, and ambiguous set of factors, and it is impossible to include every relevant factor in diagnosing and assessing organizational culture. They argued that their Competing Values framework

- Was based on empirical evidence,
- Captured accurately the reality being described,
- Integrated and organized most of the dimensions that stakeholders value, and
- Was congruent with well-known and well-accepted categorical schemes that organize the way people think, their values and assumptions about what makes a good organization, and the ways they process information.

We modified the Competing Values framework to reflect the specifics of research and research organizational culture. The knowledge production system consists of a range of research organizations that produce various kinds of research results. Research objectives and research scope differ. Thus expectations for performance should differ. Figure 2 shows the four types of research profiles associated with two primary dimensions, or strategic choices: the relative degree of risk or desired discontinuity and the relative scope of the research problem or its systemic character. These profiles suggest different management strategies depending on context, a contingency theory of effectiveness.

We define the research objectives dimension as *Degree of Radicalness* in the scientific or technological advance, on a continuum from incremental (or normal or straightforward) to radical. This can be operationalized looking at the degree of change in the state of the art, centrality of the problem, and the discovery of a pattern that upsets existing theory or a technology that creates a new field or market niche. For example, Stokols, Hall and Vogel (2013) have distinguished between interdisciplinary and transdisciplinary team science in terms of the degree of novelty and innovation reflected in the conceptual frameworks, methodological approaches, and translational advances produced by particular research teams and programs.

The second dimension of research objectives is the *Scope of Focus*, a continuum from narrow to broad, further defined by the number of variables or processes or components or the number of levels or of systems involved, or the extremeness of the environments of the work. The question of the amount of the scientific advance can involve multiple outcomes, that is, the number of variables or processes that are being researched at the same time. Some fields have a systemic quality, that is, a large number of variables have to be considered at the same time. An example would be research to support cessation of smoking cigarettes, a health risk that required research to support and integrate multiple levels of government policies, change clinical practice, and inform and persuade the media and the public.

The two dimensions define four research profiles or strategies. All profiles are present and valuable, depending on the circumstances.

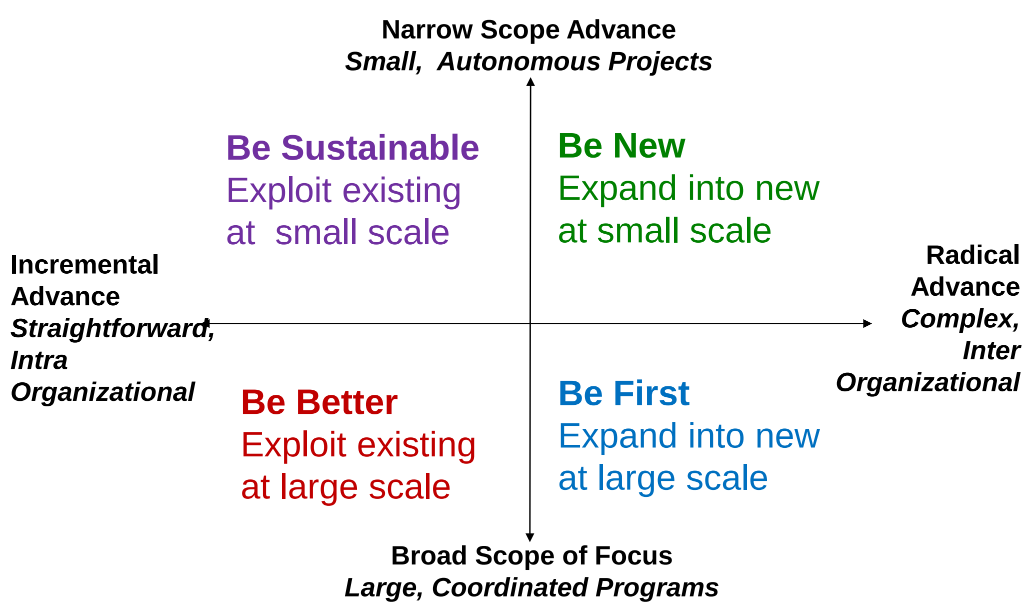
Be New: Expand into new at a small scale - narrow scope of focus aiming at a radical advance

Be First: Expand into new at a large scale - broad scope of focus aiming at a radical advance

Be Better. Exploit existing at a large scale - broad scope of focus aiming at an incremental advance

Be Sustainable: Exploit existing at a small scale - narrow scope of focus aiming at an incremental advance

Figure 2. Research Profiles: Two dimensions form four profiles with different objectives



Most research organizations will have more than one, if not all, of the profiles in their portfolio. For example, the Office of Science in DOE funds both radical research from individual principal investigators and large projects in fusion energy. The Office also funds many graduate students in physics and large user facilities. It isn't difficult to think of examples where pursuit of a scientific question moves from profile to profile over time, starting out with one person with a novel discovery, to that person having larger projects and teams working with them continuing to build and lead in research in that area. Eventually the objective becomes improving incrementally on what was discovered, and getting this into textbooks for a new generation to build upon or challenge.

Our main hypothesis with the Research Profiles Framework is an application of the Contingency Theory of Organizational Effectiveness.
There will be more and better science and technology advances when an organization (funder, institute, research team) matches its structure to strategy and strategy to the given set of circumstances.

In matching structure to strategy, there are tensions because the nature of the science and science objectives can be at odds with aspects of structure. Managing a science portfolio can require an “ambidextrous” management structure. Here are a few examples.

- More radical research needs autonomy but larger, more complex tasks also need coordination.
- Broad scale research requires sustained commitment of large resources, while remaining open to change.
- More radical and broad scope requires complex tasks and teams, multiple organizations, making integration more difficult (many parameters, knowledge sets).
- More radical research requires more time for outcomes, thus sustained commitment.
- More normal research may be essential, but is not always valued by funders.

Research Profiles argues that the objectives of the science will differ depending on the context and that decisions on research strategy ought to recognize competing values. What is the nature of the question, the scientific field, the researchers’ approach, the existing knowledge base and tools? What are the objectives and time frame of the funder? Which profile of research (strategy) is best to respond to a need or opportunity or the role the funder takes in the larger research community?

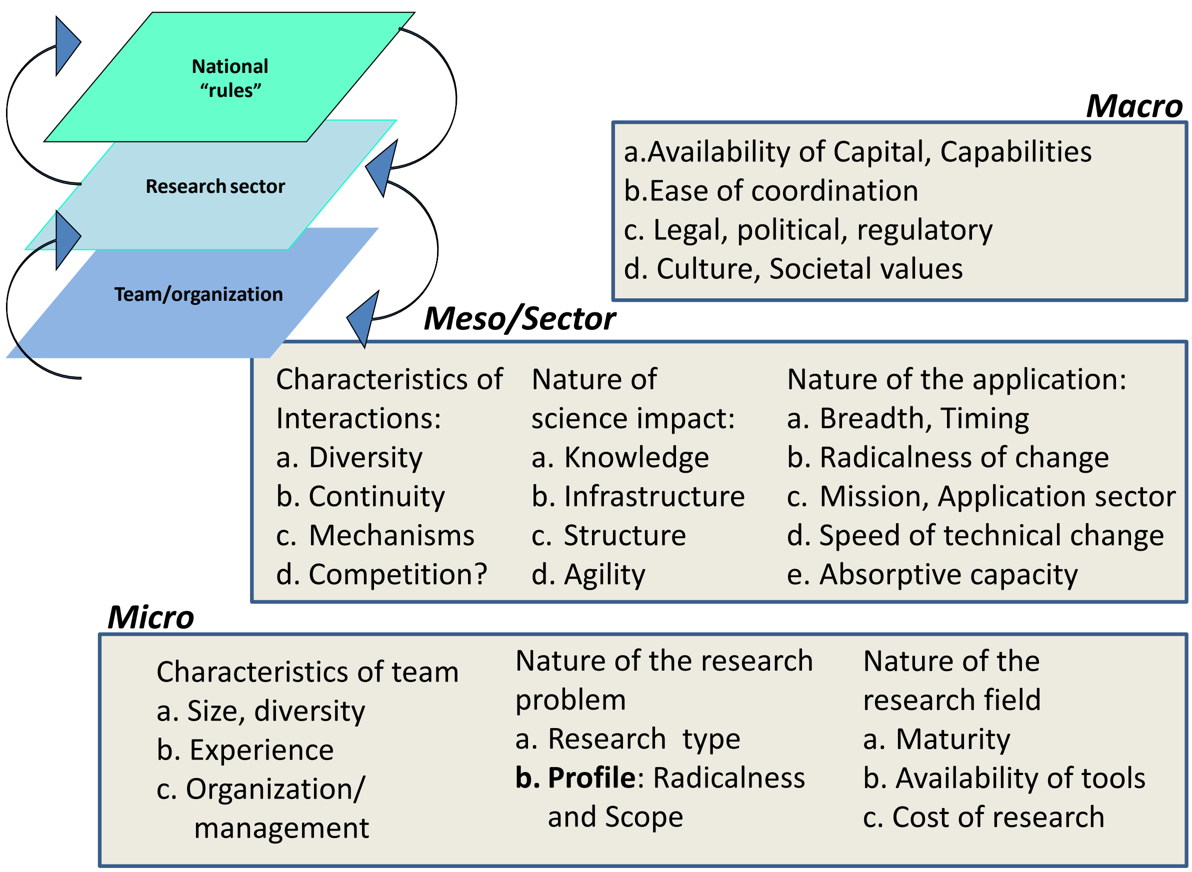
Research evaluations can be informed by awareness of the four profiles and competing values. The four profiles have different objectives, which means different activities, outputs, partners, audience, ways of interacting, and pathways to applications. In the application space there can be huge differences in context, any of which can play a major role in driving or restraining the advance of a particular effort toward impact on science or broader societal or economic impact.

Characterizing Context

Characterizing, measuring and understanding the context in which management and outcomes of science are determined is very important. If the evaluation is to inform improving the selection, management, and implementation of science, the variety of circumstances requires looking at context to be able to link outcomes to characteristics of research teams and policy instruments. For evaluation to demonstrate outcomes only, looking at context is needed to have a plausible explanation of how the program or teams contributed to outcomes because external influences also drive or restrain success.

The literature on system level evaluation (Arnold 2004) suggests looking at three levels, micro (individual or team or organization), the meso or sector that is the area for application (such as health, cancer prevention, energy, energy efficiency), and macro level which includes broadly influential institutions and rules (such as property rights, the banking system, free market vs. central control). The meso/sector level is particularly useful because it can serve as a link between the micro and macro levels. Effects on the healthcare system are linked to health research and availability of a healthy labor force, for example. Also there are major differences in S&T investment rates and time to market in sectors. For example, time to market for information technologies is short, and for energy technologies it is longer. See Figure 3 for more detail on what might be in each of these categories.

Figure 3. A systems view of possible contexts



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