Few Projects Are Islands: Issues with the Project Form in Publicly-funded R&D

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***Abstract*— The use of project and project funding has become ubiquitous in science management and policy. Despite the success of some high-profile projects, we question the general movement to funding short-term projects. In this paper, we discuss the project form in publicly-funded science and draw on over a decade of field research in a number of publicly-funded laboratories.**

***Keywords*-Projects, R&D, management, national laboratories.**

I. Introduction

The use of project and project funding has been ubiquitous in science management and policy. But in recent years, the concept of the project organization has gained leverage in the strategy and management literature. This thinking has also begun to creep into publicly-funded research laboratories and organizations. The project, as an organization form, typically refers to a "temporary endeavor, having defined beginning and end, undertake to meet particular goals and objectives" [1]. Similarly, the project organization can be temporary in nature or simply have the work flow organized largely as a series of discrete projects. However, the applicability or appropriateness of this organizational structure in science has never been adequately investigated.

Despite the success of high-profile projects (Human Genome, etc), we question the movement from longer-term funding of science to the shorter-term form of the project in science management and policy. In general, we would argue that science is a collaborative and cumulative endeavor. In contrast, an emphasis on science "projects" can potentially circumscribe, bind or inhibit the production of scientific knowledge, particularly basic scientific knowledge. As Engwall [2] discusses, projects are typically conceived of as "lonely islands" that is, separated from history and context. We would suggest the project form has its place in science, but that few projects are indeed islands. And the move toward greater use of the project form in publicly funded science has a number of unexplored implications.

We arrive at this assertion through several years of field research in a number of organizational settings. In general, we have encountered a wide range of variation in the project form across organizations: from field work proposals to research programs to projects, all are considered projects. With many of the scientists we have interviewed, in contrast to science administrators, the project is often seen as a necessary evil, that is, a way of packaging research in order to gain funding. While researchers typically have to "package" research to gain and retain funding, a greater emphasis on project funding can have potentially negative consequences for scientists by diverting focus and attention away from science toward "administrivia".

In this paper, we discuss the applicability of the project form in publicly-funded science. The question is not simply academic, as principal concerns of policymakers are project selection and evaluation, and administrators with the management of science projects. Moving forward, we first highlight some observations from our field research that led to our concerns about the use of projects. Next, we highlight some recent articles in the literature on projects, in R&D, science and in general. Next, we discuss some shortcomings with the use of the project form in science. Finally, we outline some potential issues for science policy and management with larger adoption of the project form.

II. A Tale of Two Labs

Much like Dickens' story of the similarities and differences in pre-revolutionary London and Paris, we have encountered a great deal of similarity and differences among the labs in which we have conducted research. From a superficial glance, the labs are generally structured the same, with the most noticeable differences being size and focus disciplines. While one would always expect these differences to result in additional differences, such as organizational culture, we were struck by the wide variation in project structure at each of the labs. In much of our research, the project is a primary unit of analysis, with survey respondents typically asked to indicate their number of projects, as well as respond to questions with their primary project in mind. As we have expanded the number of labs which we have studied, we have begun to question this procedure given the variation with regard to projects. In this section, we focus on two differences: number of projects and structure of projects.

A. Number of Projects

In general, we have begun to see an increase in the number of projects over the past decade, although this is not shared by all labs. In Tables 1 and 2 below, we highlight the average project of respondents in two labs where we have administered our survey on a regular basis.

TABLE I - Lab 1: Large, Multidisciplinary National Laboratory

	2001	***2003***	***2008***
Average Number of Projects	3.94	4.04	7.41
Median	4	4	5
N	1279	500	518

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TABLE II - Lab 2: Small, Mission-oriented Research Unit

	2005	***2007***	***2009***
Average Number of Projects	4.84	4.11	3.10
Median	4	4	3
N	57	44	37

Apart from the divergent experiences with the average number of projects, the respondents from the labs also reported much different experiences in satisfaction with the research environment. In Lab 1, the respondents generally rated satisfaction with the research environment lower every year. In contrast, Lab 2 respondents' satisfaction with the research environment stayed largely the same. While it would be a mistake to attribute the decline in satisfaction simply to the increase in average projects, the open-ended survey responses in the survey at Lab 1 showed an increase in the number of respondents concerned with greater uncertainty in funding and the need for identifying new sources of funding.

B. Structure of Projects

The field work proposal (FWP) is a standard document utilized by the Department of Energy (DoE), among others, for structuring and funding research at the national labs. Despite the standardization of the FWP, there is signification variation among the labs in how the FWP is implemented. Two national labs, other than the two mentioned above, in which we have recently conducted field research, one large and one smaller, highlight this variation. In both labs, we were primarily focused on research in the materials sciences. The structure of the FWP is largely the same in both labs, that is, personnel and research tasks are specified for a period of time. In the large lab, research personnel are shared across FWPs, and personnel are aware of their time commitments across FWPs, often acutely so. In the smaller lab, personnel are also shared across FWPs, but apart from the PI, research personnel were largely unaware, and unconcerned with, the commitment of their time across FWPs. This example perhaps highlights two polar opposites in FWP structure, from bureaucratic to fluid.

III. THE PROJECT FORM IN THE LITERATURE(S)

Encountering such project variation across labs, we sought to explore the treatment of projects in the literature. Most scholarly work done on or about projects comes from the project management literature. In general, the project management literature is practitioner-based and is often normative and prescriptive in character. Engwall [3] details how projects became a popular organizational concept after the Department of Defense (DoD) used the term project to describe the development of high-tech weapons. DoD work was no longer defined in terms of disciplines but restructured the development process in relation to its end objectives. More recent efforts have attempted to merge the normative research on project management with the more theoretically rigorous domains of organizational studies. Project networks, temporary organizations, project actuality, project complexity, project ecologies, project teams, and communities of practice have all emerged as important concepts in the literature on projects.

The standard definition of a project comes from the project management tradition. The PMBOK [4] was first published in 1992 as an attempt to standardize the vast array of publications and prescriptions for project management practitioners. A subsequent version defined a project as: "a temporary endeavor undertaken to create a unique product or service [4]." This definition highlights both the temporary nature of projects as well as on the uniqueness of what is to be undertaken.

Engwall [3] introduces two problems with the standard definition of project, what he calls the "demarcation problem" and "actor/object" ambiguity. The demarcation problem refers to the issue of project boundaries and demonstrates that how and where these lines are drawn depends on the observer's point of view. Actor/object ambiguity addresses what or who actually makes up a project. The basic actor/object concern is whether a researcher should focus on the project team or the project objective as a basic unit of analysis. Engwall demonstrates how these types of decisions have implications for research and questions the assumptions of the project as a lonely phenomenon, that is, divorced from context and history.

Coincident with greater attention on the project form has been effort to expand the project as the primary way to organize all work with an organization, referred interchangeably as either project or temporary organizations. In this literature, projects are typically treated as entities that are part of, or embedded in, larger organizations or firms, yet also distinct from them. For example, in a special issue on temporary organizations in the Scandinavian Journal of Management, Lundin and Soderholm [5] outline a theory of the temporary organization where the authors discuss four aspects that demarcate temporary organizations from their environment: time, task, team, and transition. The boundaries created by the characteristics of these four concepts are what create a project or temporary organization. The authors also offer sequencing concepts, in contrast to what is often called "planning stages" in the proscriptive project management literature. As Lundlin and Soderhold [5] discuss, project work within a temporary organization involves the setting up of brackets for the protection of the project and dissolving those same brackets on a regular basis

A more recent contribution highlights additional assumptions on the nature of the project as a temporary organization. Turner and Muller [6] highlight three features of a project: 1) uniqueness, 2) novel processes and 3) projects are transient. These features in turn create three pressures: 1) uncertainty, 2) need for integration and 3) projects are subject to urgency. The revised definition of a project proposed by Turner and Miller states: "A project is a temporary organization to which resources are assigned to undertake a unique, novel and transient endeavor managing the inherent uncertainty and need for integration in order to deliver beneficial objectives of change" [6]. Interestingly, the authors argue that projects acts as temporary production functions, which suggests the possibility of determining empirical boundaries of projects and potential resource allocation decisions.

Drawing on classical contingency theory, Shenhar [7] expands the project concept with the insight that projects are contingent on internal and external factors. In this study, Shenhar focused on individual projects as the unit of analysis and conducted in-depth interviews, observations, and questionnaires with project members and managers to develop a typology of projects. Respondents were asked to classify projects based on the level of uncertainty and the scope of the project, reflecting the classification framework being tested for validity by the research. Shenhar focused on technical and engineering projects in a variety of industries in Israel, including electronics, aerospace, construction, pharmaceutical, computer, mechanical, and biochemical. At least three respondents were interviewed per project but the method for choosing these participants was not specified. The main findings from this study suggest that project management should adopt a more project-specific style rather than a 'one size fits all' model.

While most work in the project literature adopts a more positivist approach, some recent work looks at the project experience from the perspective of the participants. For example, Cicmil et al [8] pursue what they call "project actuality research", which "encompasses the understanding of the lived experience of organizational members with work and life in their local project environments" [8]. This research does not take projects as a given entity but adopts a 'becoming' ontology. For example, the authors argue that "projects do not exist as given, readymade and neutral, but are constituted by the actions of interdependent actors through the process of power and conversational relative in the medium of symbols which act as representations of shared meaning and direction for action" [8]. An article that they do draw on highlights the tension between team, project, and its members. In this study the authors conduct empirical research on a construction project and are mainly concerned with project team integration. They employ the concept of 'project complexity' as a framework to help understand the process of team integration. Interestingly, as the authors conduct their project actuality research they find that the project participants at times take issue with who is actually part of the project team and who is not. The boundaries of the project seem to come from the perspective of the client, while their research highlights the tensions between project members and the personal opinions on who is and is not part of the project team. The question then becomes, from whose perspective does the researcher decide how to bound the project team. Harking back to Engwall's discussion of the demarcation problem, Cicmil and Marshall's [9] decision to demarcate the project boundaries based on the client's point of view resulted in the inclusion in the project team of entities that from other perspectives were not parts of the team.

As project organizing has become more popular, projects themselves have become more 'complex'. At issue in the literature on project complexity is the definition of a complex project. Williams [10] argues that project complexity is made up of structural complexity and uncertainty, with structural complexity defined as involving 1) the number of organizational elements and 2) the interdependence between those elements. More elements and more interdependency imply higher complexity. Further, uncertainty is defined as 1) uncertainty in goals and 2) uncertainty in methods. In the domain of science and innovation, all projects are complex because uncertainty of methods is characteristic of most if not all endeavors.

Those concerned with knowledge and learning across and between projects and organizations have offered the concepts of project networks and project ecologies [11-14]. These concepts stress the embeddedness of projects within larger organizations as well as the tendency of projects to cross multiple organizational boundaries. Projects are understood as inherently innovative [11] and a major concern is the sedimentation of knowledge from a temporary project into the larger organization (preventing "organizational amnesia" [12]. Grabher [12] introduces the concept of "project ecologies" which places projects within their specific contexts in an attempt to develop a framework for project-based learning. Grabher explains that project ecologies have four organizational layers: 1) core team; 2) the firm, 3) epistemic community and 4) personal networks. Comparing an advertising company in London to a software company in Munich Grabher classifies project ecologies based on the type of knowledge sedimentation needed to achieve project success. Project networks are presented as potential resources for project forms of organization. Windeler and Sydow [15] argue that project networks extend beyond the boundaries of the firm in which specific projects are embedded. However, Grabher also refers to networks in project ecologies as "personal networks" to emphasize the learning that takes place outside of administrative project boundaries.

Taking the notion of learning in networks further, Rogers and Bozeman [13] introduce an entirely different language. These authors argue that talking about projects is convenient because it matches bureaucratic accounting structures but as a concept, projects belie actual work practices. This article introduces a "knowledge value" framework to replace the notion of projects. The framework has two core concepts: 1) knowledge value collective and 2) knowledge value alliance. There are no interaction requirements for inclusion in the knowledge value collective and it is defined as a loosely coupled collective of knowledge producers and users pursuing a unifying knowledge goal. A knowledge value alliance "is an institutional framework binding together, in a "knowledge covenant," a set of directly interacting individuals, from multiple institutions, each contributing resources in pursuit of a transcendent knowledge goal (the basis of the covenant)" [13]. Reminiscent of project networks, the knowledge value alliance extends beyond the members included in the knowledge value covenant. Covenants refer to grant proposals, contracts, licensing agreements and the like. Using this framework the authors offer a typology of different KVA's that are characteristic of publicly funded research.

The science of team science literature brings us firmly into the domain of innovation projects and science. Stokols et al. [16] clarify that the principal units of analysis in the science of team science "are the large research and training initiatives implemented by public agencies and nonpublic organizations and the various projects within each initiative conducted by scholars who work within and across their respective fields" (emphasis added). This definition places projects as a smaller part of the larger initiative that comprises the unit of analysis in the science of team science. When addressing research design and sampling issues, the authors admit that “team science initiatives pose several challenges related to sampling of participants and respondents, the establishment of appropriate comparison groups with which to compare …” [16]. They continue: “experimental and quasi-experimental evaluations of team science initiatives are difficult to achieve due to the nonrandom self-selection of scientists into collaborative teams”. In answering this dilemma, the authors propose that evaluations of team science initiatives require sufficient numbers of “relevant comparison groups” that are all “working in a common research area over the same multi-year period”. This suggestion does not address the level of projects but moves beyond projects to focus on teams and initiatives. The concept of the projects is overshadowed by the notion of teams and inter- and transdisciplinarity. The focus of the science of team science field is the success/failure and understanding the processes of collaboration and communication across traditional disciplinary boundaries as well as lay/expert binaries (delving into how scientific innovations translate into public goods). This conception implies that the appropriate logic of comparison is different teams within the same research arena/subject area (e.g. tobacco science, cancer communications). This article also suggest that quasi-experimental research designs incorporative multiple comparison groups is an important direction for the science-of-team-science.

In general, our brief review of the literature mirrors our experience with the use of the project form in the labs we have studied. There is tremendous variation among definitions of projects in the literature, from the instrumental to the social to the phenomenological. The strict conception of the project found in the project management literature, referred by Engwall as a “lonely island”, bears little resemblance to the reality of projects in different contexts.

IV. Projects In Science

Apart from contributions on the science of team science, the literature on the use of the project form in science, as opposed to R&D, is largely non-existent. Perhaps this is due to the ubiquitous nature of projects in science. Indeed, we typically first encounter science through experiments or projects in primary and secondary school. And experiments and projects indeed constitute the discrete steps in the production of knowledge. But long-term scientific endeavors consist of numerous experiments and projects, both failures and successes. In this regard, science is a cumulative endeavor, the outcome of a process of trial and error. While projects may indeed result in some tangible outcome, a prototype or product, most often the outcome is an increase in knowledge or understanding which is extended to the next project.

But modern science is also an organizational phenomenon, and thus takes on very concrete organizational form. In this regard, the nature of the “project” in science has a very different epistemological and ontological character. In this regard, the scientific enterprise can be conceptualized at three practical levels—national, organizational and individual. At each level, the organization plays a key role in determining the nature of projects in the modern scientific organization.

A. Individual and Organizational

Given the organizational nature of modern science, the individual and organizational levels are tightly intertwined. At the individual level of scientific pursuit, the scientist pursues knowledge and does so in discrete steps through projects and experiments. Beyond differences among individual tastes and curiosities, the nature of this pursuit is largely determined by the organizational setting in which the individual resides. Like the individual level, a project brings sense and purpose to the scientific process. Some organizations, like a large multi-disciplinary national lab, can be highly bureaucratic, while other organizations might be smaller and less bureaucratic. Within the organization, the project might be defined concretely, with scientists’ work detailed specifically, or the project might be defined more loosely, such as the field work proposals we encountered at a smaller national lab. Similarly, the timeframes for research are varied, from project funding of one to three years, or longer-term initiative funding of five or more years. In general, the organizational context typically dictates the nature of the use and structure of the project form in science.

B. National

At the national level, the role of the project is largely strategic in nature, determining who and what to fund. When large-scale projects of national importance are identified, such as the Human Genome Project, the strategic direction and funding are highly specific and centralized in nature. This is in large contrast to the overwhelming majority of research funding in the U.S. context which is decentralized and spread out over 20 agencies. Each agency is relatively autonomous and, to a great extent, the mechanisms for priority-setting and funding differ from agency to agency. Coordination among the agencies does occur, but is often the exception rather than the norm. Again, the Human Genome Project is illustrative, as it represented a joint effort of the Department of Energy (DoE) and the National Institutes of Health (NIH). This national, and subsequently international, effort to sequence the human genome was initiated through a special program at the Department of Energy in the 1980s. Given the importance of understanding the human gene sequence, the NIH established the Office for Human Genome Research in 1988 within the Office of the NIH Director, and worked out a memorandum of understanding with the DoE to "coordinate research and technical activities related to the human genome." Again, however, such high-profile instances of coordination among the agencies are the exception, not the norm. When agency coordination does occur, it is usually around smaller, and more focused, areas of research.

The diverse, and uncoordinated, nature of federal R&D funding contributes to an environment where there exists a wide range of funding outlets for science. Given our experience with the country’s national labs, we will focus the rest of this discussion on the Department of Energy (DOE). Unlike other agencies, the DOE pursues the majority of its research directly, through a system of national laboratories and user facilities. Because the DoE is principally a national security agency, all of its missions flow from this core directive to support national security, and these are managed by various program offices at the DoE. Of particular importance is the DoE's Office of Science, which is the single largest supporter of basic research in the physical sciences in the United States, providing more than 40 percent of total funding in this area. While funding programs are more narrowly defined and strategic, funding allocations are still made through investigator-initiated proposals and the system of peer review. Overall funding priorities are driven by the agency's mission, but the Office of Science recently undertook an extensive strategic planning process which provides a roadmap for its scientific priorities over the next 20 years. As with the NIH and NSF, the plan was develop with consultation from the scientific community, largely through ad-hoc working groups and committees.

Since 2006, however, federal funding of R&D, including support of academic R&D, has remained relatively static. In response, the national labs have begun to pursue more funding from outside the traditional funding programs of the DOE's Office of Science. In particular, a greater emphasis on funding and collaboration with industry has spurred laboratory management and staff to pursue funding from a wide range of industrial firms. Indeed, this emphasis on tech transfer has created numerous situations of not only competing funding outlets, but competing priorities, from basic and applied research to "deployment" and, in the cases of venture funding we witnessed, market potential. These priorities are not suggested to be negative or detrimental, but rather without any foresight or planning, the funding context at the national level could allow for significantly altered scientific priorities.

V. Implications for Science Policy

Given the variations in project structure, what are the implications for science policy? In this section, we identify three sets of implications: organizational, funding and performance management.

A. Organizational

The two primary implications are project fragmentation/project overload and the training of project managers.

If a research organization begins to emphasize the project form as a way to organize activities, either explicitly or as a way to increase resources, the result is an increase in the number of projects undertaken by research staff. Zika-Viktorsson et al [17] identify a number of psychosocial outcomes related to project overload, a construct they define as perceived fragmentation, disruption and inefficiency caused by switching between separate but simultaneous projects. The outcomes they identified were higher levels of stress, decreased competence development and deviations from time schedules.

Separate from the impact on research staff is the impact on research managers. As Sapienza [18] discusses, project managers are traditionally drawn from scientific staff, but are given very little, if any, training in project management. Such training is critical because most academic training emphasizes individualized research, leaving scientists qua project managers with little ability to navigate a multi-project setting.

B. Funding

We would suggest two important considerations with regard to funding in a multi-project setting.

First, from the individual researchers' perspective, a greater amount of time must now be invested in the identification and pursuit of project funding. One aspect of this involves the time that is spent on the funding proposals and, if successful, the funding report. But another aspect involves the need to build a social network dedicated to the pursuit of project funding. In this sense, one can imagine a direct competition for time and attention with the scientific network that the researcher draws on throughout a career of research [19-21].

The issue of competing networks dovetails with what Engwall and Jerbrant [22] call the resource allocation syndrome. In the move to a multi-project context, little attention is given to the organizational (and political) context of the allocation of resources among projects. As Engwall and Jerbrant [22] discuss, this allocation process can be characterized as a complex "process of politics, horse trading, interpretation, and sense-making".

C. Performance Management

From an evaluation methodology standpoint, the use of project as a unit of analysis raises a number of issues. If there are clear boundaries around a project and a direct linkage to a specific funding source, the ability to determine performance is relatively straightforward. However, it has been our experience that this is the exception, not the rule. While Georghiou [23] suggests that evaluations of multi-project programs run the risk of the under-evaluation of project outcomes, we would argue that the opposite is the greater risk. Assume a hypothetical example of a principal investigator pursuing five related projects. All five projects receive funding from separate funding programs, but research staff is shared across the projects in varying amounts of commitments. In terms of reporting project results to funding authorities, the ability to differentiate the results from among the projects would be difficult, as the results of one project might be shared with another. In this case, the result would be the over-evaluation of project funding, with shared results reported to various funding entities.

VI. Concluding Discussion

Research organizations have always been multi-project organizations in the sense that science proceeds on the basis of projects. The difference is when the research organization consciously seeks to organize activities, particularly resource allocation, on a project basis. A research organization might do this explicitly, such as adopting a matrix structure to foster cross-function research, or might evolve to this structure in response to the need to increase research funding. As Soderlund [24] discusses, the research on project management is still at a very nascent stage. Although the practice of project management has a long-standing history, and projects are typically conceived as "lonely islands" in this literature, separate from history and context [2]. As research organizations explicitly move towards a multi-project structure, the implications of the project form, both positive and negative, need to be understood better.

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