

Institutionalization of university research centers: The case of the National Cooperative Program in Infertility Research

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Abstract

This study uses an institutional design theoretical framework and a cross-case analysis qualitative research methodology to consider the National Cooperative Program in Infertility Research (NCPIR) centers as an effort to enhance scientific and technical knowledge by designing institutions (in this case the NCPIR centers) to promote the growth of knowledge by promoting collaboration, building collaborative networks and promoting “scientific and technical human capital.” In considering the NCPIR centers from an institutional design perspective, we consider their level and type of institutionalization of the centers. Then we seek to assess the extent to which the level and type of institutionalization developed within these centers optimizes the objectives that have been set forth. We found that although the NCPIR centers have some if not many administrative elements found in fully articulated research centers and substantial quantities and varied types of research and training outputs, they are not sufficiently institutionalized to achieve the ambitious and challenging goals of serving as a national infertility research source, national training resource, and national inter-institutional linkages over the long run.

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1. Introduction

Policy-makers in recent years have sought to stimulate the creation of new ideas and discoveries but also to further development of this knowledge toward new disciplines and fields. Our paper posits the notion of the research center as a policy tool, specifically the use of institutional design to achieve the advance of scientific and technical knowledge (Shangraw and Crow, 1989; Link et al., 2002). The specific role of the research center is that of an institution designed to promote the growth of knowledge by encouraging collaboration, building collaborative networks and promoting scientific and technical human capital.

We maintain that there is a dimension of institutionalization in research running from nascent network to

formalized research center and eventually to a stable field and academic discipline. Of particular interest here is the differentiation that occurs between the less institutionalized research or knowledge network and the more formally structured center. This differentiation is brought into consideration through a cross-case analysis of the National Cooperative Program in Infertility Research (NCPIR) science centers. These centers are compared with one another and with two other types of infertility research centers on a series of measures of research institutionalization and output. The results will show that although these centers are highly productive their level of institutionalization places them somewhere between a research network and a formally structured center.

2. Institutionalization in epistemic and organizational domains of science

The epistemic development of scientific and technical knowledge is posited to follow a set of stages of development.

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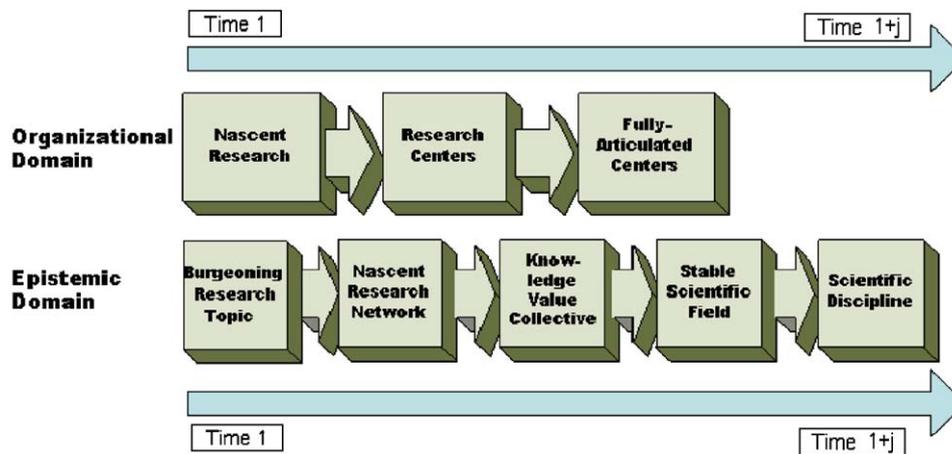


Fig. 1. Institutionalization in epistemic and organizational domains of science.

It is further conceived that an articulation and structuring of internal social arrangements or institutionalization can accompany and accelerate this epistemic domain. Our theoretical framework puts forward a parallel trajectory of knowledge and institutionalization which is illustrated in Fig. 1.

The epistemic domain of knowledge is portrayed in a stage model that distinguishes the “burgeoning research topic,” the “nascent network,” the knowledge value collective (Rogers and Bozeman, 2001), the “stable scientific field,” and the “discipline.” Excepting the first stage, each of these can be thought of as a type of research network according to Polodny and Page (1998). Stage models for the development of scientific knowledge and its organization are not uncommon (see Hull, 2001; Frängsmyr, 1990; Whitley, 1974) and most, including the one we present here, are not normative. Thus, there is not an implication that a discipline is “better” than a knowledge value community (KVC) or that a KVC is “better” than a scientific field. The differences among stage types are largely attributable to two sets of factors: the type and rigidity of boundaries setting the members apart and the level of articulation of social structures or processes. It is likely that the impact of the work is greater after the earliest stages simply because some social organization is useful in developing recognition for work (e.g. dedicated journals) and potential users (those wishing to apply the accumulated knowledge) are more likely to be aware of research work at its later stages of institutionalization.

The theoretical framework in Fig. 1 shows that at one extreme is the burgeoning research topic, “pre-network.” During this stage, several researchers have begun to work on a similar research topic, perhaps not even aware of the common attributes of their work. Gradually, the proliferation of the work is such that it leads to wider recognition among researchers and to an awareness of the need to collaborate not only on the research itself but in the sharing of research related information, resources, and availability and attributes of researchers and students interested in the

shared research topics (see Link, 1990). At some point, the unselfconscious group develops group awareness and sufficient institutionalization (i.e. shared social structures and processes) as to evolve into an informal network.

The term “research network” is quite encompassing and includes everything from “nascent networks” where there is a dawning awareness of common interests and the beginnings of collaboration to the most stable of all networks, the scientific discipline, which includes highly stable structures and process and sharp distinctions between network members and non-members.

One particular type of network is the KVC. A KVC is a set of individuals connected by their uses of a body of scientific and technical knowledge (for detailed treatment of the knowledge value collective and related concepts see Bozeman and Rogers, 2002; Rogers and Bozeman, 2001). It is a loosely coupled collective of knowledge producers and users (e.g. scientists, manufacturers, lab technicians, students) pursuing a unifying knowledge goal (e.g. understanding the physical properties of super-conducting materials), but to diverse ends (e.g. curiosity, application, product development, skills development). The persons within a KVC reshape information into new packages of knowledge (including technology, which we view as a physical embodiment of knowledge). Typically, the size of the KVC will depend on such factors as general awareness of the body of knowledge, the breadth of its uses, the skills required to obtain and apply information. There is no requirement that members of a KVC interact, know one another or even be aware of one another; the only requirement is joint use of a body of information (and, in their use, creation of knowledge value). In fact, case studies (Rogers and Bozeman, 2001; Bozeman and Rogers, 2002) have shown that persons engaged in the disparate uses were not aware of one another’s needs, uses, or knowledge contributions but, nonetheless, could be viewed as tied by a set of common knowledge needs.

As the KVC matures, it may take on the character of a sub-field or sub-discipline and may ultimately evolve into a

full blown discipline (but, of course, most KVCs do not ultimately evolve into recognized disciplines). Stable scientific fields tend to have degree recognition and certification, fully articulated and stable support structures emerging, at least one authoritative scientific or professional association. With the stable scientific field, the boundaries are sharper and less permeable as it becomes clearer what is expected of researchers in the specialty and as educational requirements and credentialing become routine (Lemaine et al., 1976; Lenoir, 1997; Gieryn and Merton, 1978).

The scientific discipline is the last stage of institutionalization of a scientific specialty and, due to the extensive requirements for disciplines, very few specialty fields evolve into disciplines. As noted in the extensive literature on disciplines (Lenoir, 1997; Bechtel, 1986; Lodahl and Gordon, 1972; Mullins, 1975; Germain, 1978), the most common prerequisites include: (1) the widespread granting of degrees from fully accredited academic departments; (2) agreement about the purview of knowledge and the conveyance of knowledge in standard textbooks; (3) agreement about the knowledge and often the actual course of study required for disciplinary training, often as determined by professional accrediting bodies; (4) a proliferation of journals and professional groups; (5) the development of multiple specialty fields under the disciplinary umbrella.

3. The multidiscipline, multipurpose university research center

Against the backdrop of this epistemic framework, we set the multidiscipline, multipurpose university research center (MMURC) as an institutional mechanism for accelerating the progression of stages of knowledge development. In the halcyon days before research centers proliferated, when academic departments and their subunits still monopolized academic organization, the ideas of planning research or accelerating knowledge development through proactive policies were not in common and, generally, not in favor (Mason, 1979). Today's academic research landscape is quite different, and the new more centralized, multipurpose, managerially complex research system has been well established during the past 20 years. While "small science" (DeSolla Price, 1963) is still very much with us—the majority of grants remain relatively small, principal-investigator initiated ones—small science now coexists with complex university research centers (URC) that have almost as much in common with large-scale industry research units or national laboratories as with traditional academic science.

While the URC has been proliferating for some time, many centers represent relatively modest departures from traditional academic research organization designs. Many URCs are independent from departments, but simply provide a separate organization for supporting disciplinary researchers in pursuit of their traditional research and

publishing activities. At one extreme is the URC that we have elsewhere designated as the "MMURC" (Bozeman and Boardman, 2003) that typically spans several disciplines and is devoted not only to research but also teaching and, generally, some type of externally oriented activity such as client service, industrial liaison, or technology transfer. They are organized around research topics rather than disciplines, they have strong inter-institutional ties, they often include researchers from industry and from more than one university, and their scientific and technical knowledge products are often diverse with respect to the basic-applied-development spectrum. Typical examples include the National Science Foundation's Engineering Research Centers (NSF ERC) and Science and Technology Centers (of which there are now more than 300) and the more than 100 state government sponsored "centers of excellence." In many respects URC, especially MMURCs, have been created in direct response to perceived limitations of academic departments both to work across disciplines and to develop the organizational capabilities to coordinate and implement a research agenda and to interact with persons and institutions external to the focal university, including interactions with multiple funding agents, clients, customers, patients, industrial affiliates and so forth. It is also the type of research center that has, of late, received the most attention from policy-makers, as well as billions of dollars of research funding.

4. National Cooperative Program in Infertility Research

The NCPir program was established in the early 1990s as a result of a Congressional recommendation for the creation of infertility research centers. Administratively, the NCPir program is part of the NICHD, the National Institute of Child Health and Human Development. The NCPirs were born of the NIH Reauthorization Act of 1993, which authorized the Director of the NICHD to issue grants or make contracts for the operation of two Centers. A primary goal of the centers has been to enhance the development of scientific and technical knowledge and application in the field of infertility research by promoting interaction and collaboration among and within the Centers and training a new cadre of clinician scientists.

NCPir centers address these objectives through several means. They develop, propose, and conduct a portfolio of inter-related research projects that promote collaboration between bench scientists and clinical investigators and submit grant proposals from other funding programs to complement and further this type of infertility work. NCPir science centers furnish training for postdoctoral students and trainees by involving them in significant roles in research projects. They can engage in practitioner collaboration through seeing and consulting on patient treatments. They disseminate research results through peer reviewed journal articles and reviews, presentations at medical society conferences, and through the development

of technologies and techniques such as assays, databases, and patentable intellectual property. And they participate in joint meetings with other centers in the NCPIR science center network to share research findings, gain critical feedback, and enhance the chances for collaborative work.

A competitive review process was used to select the centers. Across the history of the program three science centers were chosen. At the inception of the program in 1991, the first two NCPIR centers were based at Massachusetts General Hospital and the University of Michigan. The center led by University of Michigan became inactive in the mid-1990s due to loss of funding in a subsequent competition. The center at Massachusetts General Hospital received two rounds of funding, but was not renewed in the third round of competition in 2002. A NCPIR research center was established at the University of Pennsylvania in 1997, refunded in 2002 for a subsequent 5-year term, and is the only current official NCPIR center (Internal Report, 2003).

The NCPIR program and its centers are clearly an institution building approach to accelerate research in the infertility area. The statement of purpose from an RFP for the NCPIR Centers (NIH, 2000) indicates this:

Recognizing that the complexity of infertility research severely limits the progress that can be achieved by individual investigators working alone, the NICHD will support at least two Centers comprising biomedical research projects and technical service core facilities, organized to conduct accelerated preclinical and clinical research and development studies on promising new leads in human infertility research. The Centers will also serve as national resources for the career development of young scientists electing to pursue research in high priority areas of infertility research. The efforts of the NCPIR centers will be enhanced by interaction within and among them, as well as with other NICHD-supported cooperative research programs such as the Specialized Cooperative Centers Program in Reproduction Research and the National Cooperative Reproductive Medicine Network. The benefit of this activity will be to the infertile couples, their health-care providers, and the public.¹

From this statement, one might conclude that institutionalization was prominent, based on phrases such as “the complexity of infertility research”, “core facilities,” “organized to accelerate,” “interaction within and among [the centers].” However, as we shall see from the theory and findings presented here, the centers created under the program sometimes confirm and other times depart from the most common institutional designs for research centers.

5. Cross-case analysis

We employ a cross-case analysis drawn from intensive case studies of the three NCPIR centers, which involved site visits and interviews. In addition to the narrative case study, we have developed an extensive qualitative database that we employ to make inferences about the extent to which the NCPIR centers meet the objectives posed above. This NCPIR case analysis is supplemented with mini-case comparisons based on telephone interviews with center directors, investigators, and trainees at two other NIH centers, the Specialized Cooperative Centers Program in Reproductive Research (SCCPRR) and the Mental Retardation and Developmental Disabilities Research Centers (MRDDRC). The SCCPRRs also address infertility issues but from more of a pure research orientation. The MRDDRC focus on interdisciplinary research much like the NCPIRs but in a different field, mental retardation and developmental disabilities. Since the data from the SCCPRR and MRDDRC centers did not involve intensive case studies, narrative reports, or site visits, ours is a “cross-case comparison” based on comparing multiple data from the NCPIR centers with telephone interview data obtained from the SCCPRR and MRDDRC centers. A most important aspect of our cross-case approach is that we use the findings from the SCCPRR and MRDDRC centers to bring into relief our findings from the NCPIR centers, the later centers being the chief focus of our analysis regarding the applicability of measures of institutionalization.

We seek to assess the extent to which measures of institutionalization can be applied to the NCPIR centers. We have developed a measurement model that posits attributes of programs to enhance the production of scientific and technical knowledge through institution building, in other words, research centers. Our concept of a research center is a formal organization, developed by an external hierarchical authority, including identifiable boundaries, and aiming to influence the production of scientific and technical knowledge. Another way of thinking about research centers is that they are formal organizations designed to promote planned change. Unlike the structures and processes found within the domain of the scientific community (the epistemic domain), the research center includes at least some formalized structures and has identifiable boundaries that contain not only researchers themselves, but supportive personnel (e.g. administrators, funding agents, users).

A research center shares characteristics with other formal organizations, including formal goals, procedures and organizing principles, sustained patterns of organization, an organization form that can be charted, and a specific sense of place. But within that center there are researchers who are part of the center and, at the same time, part of research networks, some of which may have some type of linkage to the center, but many of which have no linkage whatsoever (except perhaps through the

¹<http://grants.nih.gov/grants/guide/rfa-files/RFA-HD-01-001.html>, November 2000.

individual member). In light of the above definition, it is plausible to say that a research center seeks to enhance the effectiveness of a set of researchers who see themselves as working on an allied set of topics.

Research centers are organizations supporting research networks of various kinds and at various levels of development and across or even in combination with various existing disciplines. Research centers are entities designed to bring together researchers (and, sometimes, students and research users), permitting them to share not only norms but funding resources, equipment, infrastructure and space. In many instances the shared space refers to a physical, constructed site, but oftentimes the space is either virtual or a combination of physical construction and virtual space. Thus, there is a physical construction that is CERN but there are also distributed CERN affiliates. Likewise, the familiar NSF ERC have both a physical space and “distributed space” as affiliates participate from around the United States. In short, the minimum conditions for a research center include (1) the recognition among the research specialists themselves as being affiliated with a center; (2) the provision of resources to be shared among researchers, (3) conditioned only by their agreement to certain rules for access to research. These rules may include, for example, agreements to communicate, collaborate, or to train new researchers. Most research centers are more elaborate than this and typically include some central, shared or potentially accessible physical space as well as a hierarchy of authority used in making decisions about the deployment of resources.

Table 1 provides a simple depiction of the organizational requirements for research centers, distinguishing the absolute minimal requirements for a center, the typical requirements for a center, and “accompanying characteristics,” which are ones that entail considerable variance even among fully articulated centers. The focus here is on organizational formalization rather than development

of research specialties. While the two are related it is nonetheless possible to have a highly articulated organizational form supporting a poorly articulated research specialty, just as it is possible to have a highly articulated specialty and either a poorly articulated organizational form or not supportive organization at all. As before, there is no normative judgment about the value of any particular combination of organizational form and research specialty development.

The importance of the table is that it provides an organizing framework for considering the level of articulation of research centers and, ultimately, the impact of various degrees and types of organizational (center) institutionalization on the level of institutionalization and even the productivity of research specialties. Moreover, the case study and interview evidence we have gathered is considered in the next section according to the variables suggested in Table 1. We seek to identify the level of organizational (center) articulation, its structures and processes.

6. Findings

The findings outlined in this section are informed by the attributes and characteristics of research centers depicted in Table 1 and drawn from the theoretical framework presented in Fig. 1. In the discussion below we will assess the NCPIR centers in terms of these variables. These results are summarized in Table 2.

The first set of measures we call minimal characteristics of research centers. We found that all these minimal characteristics resonated in the institutional status of the NCPIR Centers. Two of the three NCPIR centers—at Massachusetts General Hospital and University of Pennsylvania—were provided with a wide array of external resources, established resource sharing agreements with their highly reputable host organizations, shared common physical space, and exhibited a solid degree of self-identification

Table 1
Organizational measures of research centers

Minimal characteristics of research centers	Fully articulated research centers	Accompanying characteristics
Provision of external resources	Hierarchy	Grants and contracts; multiple resources
Agreements about resource sharing and about conditions of resource access	Administrative apparatus	Center-salaried personnel; formal personnel policies and guidelines
Internal recognition of center’s institutional status	Apparatus for authoritative allocation of common pool resources (i.e. beyond initial agreement)	Inter-organizational ties; multiple professional and organizational roles
Shared space (including “virtual space”)	External (beyond the research specialists) recognition of center’s institutional status	Multiple categories of research outputs
	Finite beginning and ending points; formal founding mechanisms	Students, educational function
	Authoritative plans and objectives	Multiple fields and disciplines
	One or more generally recognized entry portals for external actors	Diverse stakeholders; performance standards
		Research agenda setting processes

Table 2
Assessment of centers against institutionalization criteria

Characteristics	MGH NCPIR	Penn NCPIR	Michigan NCPIR	SCCPRR	MRDDRC
<i>Minimal characteristics of research centers</i>					
Provision of external resources	×	×	×	×	×
Agreements about resource sharing	×	×	×	×	×
Internal recognition of center's institutional status	×	×			×
<i>Characteristics of fully articulated research centers</i>					
Hierarchy	×	×		×	×
Administrative apparatus	×	×		×	×
Authoritative allocation of common pool of resources	×	×	×	×	×
External name recognition					×
Organizational timeline	×	×	×	×	×
Plans and formalized objectives	×	×		×	×
Entry portal	×	×		×	×
<i>Accompanying characteristics of research centers</i>					
Grants and contracts	×	×	×	×	×
Center-salaried personnel, formal personnel policies				NA	NA
Interorganizational ties				×	×
Multiple categories of research outputs	×	×			×
Students, educational function	×	×	×		
Multiple fields, disciplines	×	×	×	×	×
Diverse stakeholders	×	×			×
Research agenda setting process	×	×	×	×	×

Source: Cross case analysis of NCPIR, SCCPRR, and MRDDRC programs, February 2005.

with the center. According to the minimal criteria for establishing a research center, these two centers met all these nominal requirements and clearly qualified as a research center. The SCCPRRs and MRDDRC also unambiguously met these minimal criteria.

The third center formerly at University of Michigan, which lost funding several years ago, was supported with a range of external resources, managed a complex set of resource sharing arrangements with a few collaborating institutions. However, there was poor internal recognition of the Center's institutional status. Many interviewees did not even perceive the organization as a "Center" and several had considerable difficulty responding to questions about the NCPIR center. Some respondents who were listed as affiliates indicated they had had no affiliation. This center seems to have had an extremely low degree of institutionalization and may not be able to be accurately deemed a "research center" possibly because of the long period that had transpired since non-renewal of NCPIR funding.

A second category of measures defines the fully articulated research center. As mentioned previously, this type of research center features a number of attributes such as: a hierarchical structure; an administrative apparatus; an authoritative resource allocation mechanism; external name recognition; formal founding mechanisms; authoritative plans and objectives; and finally, one or more generally recognized entry portals for external actors.

These variables measuring hierarchy, administrative apparatus, authoritative allocation mechanism for com-

mon pool resources, external name recognition, finite beginning and ending points, authoritative plans and objectives and entry portals for external actors were applied to the three NCPIR centers. We found that all three NCPIR centers failed to meet at least one criterion to qualify as a "Fully Articulated Research Center." Two of the three were significantly institutionalized, at least given the age and size of the respective centers. However, both of these two centers self-expressed some lack of widespread external name recognition as a "center." That is, the individual researchers in the center and their work were believed to be more well known than the center itself, and Web sites (or lack thereof) were also perceived to have less renown. The third center at University of Michigan had a very low level of organizational institutionalization relative to the usual requirements for status as a "research center." It lacked a hierarchy, administrative apparatus, planning document, an entry portal as well as external name recognition. The MRDDRC were the most fully expressed research centers that have met all the requirements delineated in these institutionalization measures including a nationally organized user community. The SCCPRRs were also institutionally articulated, but also expressed that individual researchers and their work tended to be more externally well known than the center per se even given the centralized hosting of the centers' Web site by Stanford.

A third category consists of accompanying characteristics. These are the features and attributes of a research organization that solidify the formalization and institutionalization of a fully articulated research center. These

are usually associated with older, well-established research centers. We identified eight accompanying characteristics: grants, contracts, and multiple resources; center salaried personnel, and formal personnel policies and procedures; inter-organizational ties and multiple professional and organizational roles; multiple categories of research outputs; students and educational functions; multiple fields and disciplines; diverse stakeholders; and a research agenda-setting procedure.

We found that all three of the NCPIR centers had a strategic grant management strategy that aimed to preserve and sustain operations of the research center as a social entity. These centers also evidenced a research agenda-setting process.

The role of these three centers in the training and development of a cadre of career scientists in the field of infertility research was congruent with the primary objectives of the NCPIR program. Some but not all of these trainees were funded through the NCPIR program, and the program elicited less awareness among trainees than among the centers' principals. SCCPRRs and MRDDRC do not provide funding for trainees and postdoctoral students, so they are mostly funded by external grants or fellowships.

Multiple and diverse categories of research outputs from the centers at Massachusetts General Hospital and University of Pennsylvania were exemplary by any standard. University of Michigan's Center also had a set of publications, although limited clinical research and challenges resulting from unsupported hypotheses mediated these outputs. We also saw considerable evidence of an increasing degree of institutionalization of the scientific field of Reproductive Medicine (i.e. the epistemic domain as discussed in previous sections of this report). There was some diversity in the nature and extent of the user community for the research output produced by the NCPIR Centers comprised of basic and clinical researchers in reproductive medicine and related areas such as oncology and radiology, although this connection was attenuated at the level of the practitioner or patient. In terms of outputs, the NCPIRs fell in between the SCCPRRs, which were more oriented toward research than toward translational outputs, and the MRDDRC, which had an active and connected user community.

A set of the accompanying characteristics associated with highly institutionalized research centers was not as strongly present in the NCPIR centers. Inter-organizational ties—which reflects the ability to access resources and exploit synergies—were somewhat constrained by forced collaboration and inter-center competition for ongoing support. Interviewees at SCCPRRs and MRDDRCs also expressed issues in inter-organizational collaboration, but they were of the usual kind associated with distance and cost (Kogut, 1988; Croisier, 1998; Olson and Olson, 2002) rather than more difficult issues of acquaintance and trust and alignment of incentives that affect collaborating partners (Link et al., 2002; Krige, 1993;

Gulati, 1995; Santoro and Saporito, 2003; Hagedoorn et al., 2000; Holmstrom and Milgrom, 1991; Tosi et al., 1997). There were also indications of a lack of institutionalization of personnel procedures for NCPIR research staff who are instrumental to the work of the center but who are marginalized in terms of guarantees for leave-time, full benefits, and other usual categories for full-time university employees.

7. Conclusions

The centers examined in this cross-case analysis do not conform closely to either archetypal model. They are not sufficiently articulated and formalized to correspond closely to the MMURC model. At the same time, they are more complex and multifaceted than most KVC networks.

The cross-case analysis suggests that most if not all of the centers had some degree of institutionalization. All of the centers leveraged very high quality institutional resources and relationships with their host universities and hospitals as well as with a segment, if not all of, their partner institutions and affiliates. The centers at Massachusetts General Hospital and the University of Pennsylvania also exhibited well-pronounced leadership hierarchies, administrative apparatus, planning documents, and other attributes of fully articulated research centers. University of Michigan's center registered a lesser degree of institutionalization, but for its part that center had not been funded as such for several years.

We also saw a substantial level of outputs from these NCPIR centers. The centers at Massachusetts General Hospital and the University of Pennsylvania showed notable levels of research and translational outputs ranging from publications to clinical trials, treatments, assays, and databases. They also trained a reported number of new specialists in the reproductive medicine field. The field appeared to have grown in stature and developed into a distinctive field since the NCPIR centers first started.

At the same time, these centers did not express the full range of features of a highly institutionalized MMURC. As with many centers, it was difficult to separate the additional effect of the NCPIR funding from other grant mechanisms that supported the activities of these organizations. We also heard reservations about whether the NCPIRs were externally well known and in some cases in-house investigators did not self-identify with the center. While there were multiple co-authored papers which involved researchers from other institutions, we saw difficulties in these centers' ability to leverage inter-organizational ties because of competitive forces among other factors which likely hampered the ability to foster a geographically broad network of centers such as the MRDDRC had.

Compared to the typical MMURCs (Bozeman and Boardman, 2003), the NCPIR centers are not as old, they are smaller (in that they consume fewer resources and

include fewer researchers), have fewer and less complex boundary interactions, are less formalized and have a lesser degree of institutionalization. These characteristics are not randomly associated. Typically, formalization is associated with organizational age as is level of institutionalization.

It is not a criticism to say that the NCPIR centers are less formalized and institutionalized. There was never an intention that the NCPIR centers should mimic other MMURCs and, indeed, there was no commitment to new bricks and mortar or to the type of institutional revolution that motivated the earliest MMURCs, the NSF ERC (see [Bozeman and Boardman, 2003](#)). There is no express intention to increase the formalization or institutionalization of the centers beyond their current level of articulation.

Is the degree of institutionalization at the level of an MMURC really necessary to promote the advancement of science from topic to discipline? We saw that the NCPIRs had substantial outputs even despite not having all the features of a highly articulated research center. To be considered is the desire to avoid “over formalization.” Institutionalization is not a value to be approached without limit. Given the current highly competitive and ever-changing world of research grants and contracts, centers that have the ability to flexibly respond to these vicissitudes can be very successful.

That said, we maintain that it is vital for a center-building program to have a fully articulated degree of institutionalization. Institutionalization can help to fully accomplish ambitious goals such as those stated in the NCPIR program such as being a true national resource for “accelerating” research, for developing inter-institutional linkages and for implementing a “bench to bedside” research approach. More policy, more funding as a proportion of available funding, more intensive monitoring of the ability to meet program requirements, and much more elaborate and routinized administrative structures than are currently present are required to accelerate the research advancement trajectory. Just as important, the centers would need to develop a stronger identity as centers, rather than leveraging existing programs, even though there seem to be efficiencies in embedding the NCPIR centers into larger units and programs. Relying on existing institutional supports, renowned researchers, and other funding programs currently available from existing resources is a good way to pursue incremental goals but not necessarily a good way to pursue the creation of new fields and disciplines.

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