CATALYZED NETWORKS: GOVERNMENT AS A NETWORK FACILITATOR IN REGIONAL ECONOMIES

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A thesis submitted to the

Graduate School-New Brunswick

Rutgers, The State University of New Jersey

in partial fulfillment of the requirements

for the degree of

Master of Science

Graduate Program in Industrial Relations and Human Resources

written under the direction of

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and approved by

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New Brunswick, New Jersey

May, 2014

ABSTRACT OF THE THESIS

Catalyzed Networks: Government as a network facilitator in regional economies

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This thesis presents a case study of a government-led effort to foster inter-industry linkages in central New Jersey's biopharmaceutical cluster. It uses in-depth interviews to inform a framework explaining how a government-funded intermediary functioned to stimulate economically valuable collaborations between key and previously unconnected regional stakeholders. It also employs a quasi-longitudinal network analysis to measure the network growth and relationship quality of a sample of 38 individuals who had varying levels of participation in the effort. Discussion and possible implications for regional economic development policy are offered in closing.

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INTRODUCTION

Deregulation and technological instability have outdated the bureaucratic model of vertical integration that was dominant from the late nineteenth through mid-twentieth century. The organizational model now ascendant is one of vertical *dis*integration, where fewer organizational roles are kept in-house but are instead contracted out to peripheral agents specialized in some relevant and supportive task. The advantage to this mode of organization is that it prevents organizations from locking capital into what may be a transient technological phase. In short, vertical disintegration allows for flexibility in terms of production and strategic direction (Piore and Sabel, 1984).

The proliferation of global supply-chains over recent decades speaks to the magnitude of this organizational transformation, or *industrial divide* (Piore and Sabel 1984). Deregulation and advancements in communication technology have made outsourcing viable over vast distances, with various resources, services and human capital widely available in global markets (Porter, 2000). Yet, despite the proliferation of global networks, there remain significant and enduring benefits to geographic co-location. Such benefits come in the observation that global networks provide poor conduits for complex and tacit forms of information and knowledge (Audretsch and Feldman, 1996), and that synergies among specialized regional agents – including buyers, suppliers, schools, and research universities – may provide self-reinforcing systems (Finegold, 1999) that are difficult for isolated organizations to copy. Hence, as Porter (2000) as pointed out, geographic proximity, or industrial clustering, may provide opportunities for comparative advantage.

Finegold (1999) has conceptualized high-tech regions as self-reinforcing *ecosystems*, requiring catalysts, nourishment, supportive environments, and connections. Catalysts refer to the research breakthroughs and intellectual property of researchers and start-up companies that often give rise to high-tech clusters. Nourishment is analogous to the strength of regions' human capital; such human capital stimulates innovations while bringing them to market and ultimately to consumers. Supportive environments refer broadly to the social, institutional and regulatory climates that either support or undermine the cluster's operation. Connectivity, finally, refers to the tendency for regional actors to be heavily interdependent with one another, and for social capital among regional actors to accumulate by way of proximity. These four elements are common both to thriving ecosystems as well as successful high-tech clusters (Finegold, 1999).

Often in piecemeal fashion, policies have incorporated many of these dimensions in efforts to create and strengthen regional economies. For example, governments have tried to foster supportive environments by way of establishing environmental infrastructures (e.g. transportation and housing) and regulatory climates desirable for business and investment (Storper, 1997). Policy efforts have also turned to the developing of "soft capital" (Markusen and Glasmeier, 2008), or regional *nourishment*. Such policies have focused on the design and implementation of educational systems to strengthen the caliber and industrial relevance of the local workforce (Finegold and McCarthy, forthcoming). Despite numerous efforts at regional economic development across the globe, however, successful industrial clusters are very difficult to intentionally create and sustain (Sabel, 1993; see also Bresnahan, Gambardell, and Sexenian, 2001). This is in

part because, as natural ecosystems, the absence or attenuation in any aspect of the environment (catalysts, nourishment, supportive environments, and connectivity) can have devastating consequences to the broader system (Finegold, 1999).

In recent years, several regional governments across the world have turned attention to a part of the ecosystem, *connectivity*, which for long received comparatively little institutionalized support (e.g. Ceglie, Clara and Dini 1999). For example, Legendijk and Charles (1999) observed in their research in Scotland, Whales, and England "cluster initiatives [that] emerged both as a part of the desire to improve the benefits from foreign investment by supporting supply chains and other forms of inter-firm relationships, and to support networking among local firms […] (p. 127). Similarly, Cooke and Morgan (1998) overviewed supply-chain building initiatives in Whales, including the Source Whales program, launched in 1991, which aimed "to identify supply opportunities (sourcing) and enhance supplier performance development." To facilitate this, the authors continue, "the [Welsh Development Agency] acts as an intermediary in the supply chain, seeking to build and develop long-term, high-trust partnerships between major corporations and buyers and Welsh-based suppliers" (p. 154-155). Closer to home, McEvily and Zaheer (2004) documented a government-led effort in western Michigan's furniture district, where a central facilitator encouraged cooperation and coordination around standardizing practices between local buyers and suppliers.

The central position taken in this thesis is that the shift from climate-setter, where government establishes regulatory climates and general infrastructures, to network-facilitator, where inter-organizational relationships are consciously encouraged, constitutes an empirically understudied but theoretically important transition in policy

orientation. Even as efforts to promote regional collaboration have become more common (e.g. Ceglie, Clara and Dini, 1999), research into the effectiveness of these efforts, as well as theoretical frameworks to explain them, are nearly absent. This research investigates one case of government-led network facilitation in Central New Jersey's pharmaceutical cluster. Titled Bio-1, this effort has attempted to bring together an institutionally diverse body of local entities and professionals around participation in the sciences and developing an industry-ready workforce. A corollary hope has been that, through involvement, the social networks between key regional stakeholders would deepen in lasting and meaningful ways.

This study uses in-depth interviews to inform a theoretical framework explaining Bio 1's role in network facilitation. This study also employs social network analysis to measure the extent to which networks have grown following varying degrees of participation, as well as the nature of emergent relationships. The following reviews a brief history of vertical and horizontal integration. This leads to the argument advanced by economists and regional scholars that when horizontal integration occurs proximally, or within a region, advantages accrue to resident actors and the local economy more broadly. The mechanisms behind this perceived advantage are elaborated, as is, in turn, the role of government in regional economic development. Next, the scope, context and methods for this study are formally introduced. Results follow. The discussion offered in closing considers the extent to which the tactics for network facilitation undertaken in Bio-1 generalize to other sectors, and to different types of intra-regional relationship-building efforts.

LITERATURE REVIEW

From mass-production to vertical disintegration

The process of industrialization through the mid- to late nineteenth century brought dense industrial activity to some areas while others were left virtually barren (Scott, 1998). This industrial "unevenness," according to Scott (1998), resulted from naturally irregular territorial endowments, including physical resources as well as the unique transportation opportunities available to regions. In organizational terms, it encouraged a core-periphery arrangement such that the industrial epicenters, existing at the core, relied through external interdependencies on the agricultural, resource, or service zones that lay scattered about (Scott, 1998).

Marked changes occurred through the late-nineteenth through mid-twentieth century that shifted industrial organization away from the external craft-based system toward vertical integration, or mass production. Chandler (1977) has asserted that the growth of corporations during this period corresponded with growing economies of scale. To Chandler, smaller companies were no longer viable in these economies without amalgamating under some central authority. Because of this, new corporations gained dominance and combined what were once independent and externally-contracted functions in order to improve control, coordination and reliability. There were still core-periphery arrangements in the sense that peripheral regions tended to provide the raw materials for the core regions (Storper and Scott, 1992). However, as Frieden has (2006) pointed out, the mass production model "brought together in one enterprise disparate

activities – research, design, production, distribution, advertising – that had previously been carried out separately" (p. 160).

Rather than relying on externally-based partners, the entire process of production under mass-production could be consolidated under the direct and immediate auspices of the parent firm. Newspaper companies purchased forests and paper mills. Movie studios purchased theatres, scriptwriters, and the actors (Kerchner, Koppich and Weeres, 1997). This process of internal consolidation minimized the time spent in production as well as the uncertainties involved with relying on external dependencies (Frieden, 2006). Production could be managed scientifically and organized for maximum efficiency. Such often obviated the need for skilled and costly artisans (Womack, Jones and Roos 1990). Furthermore, it provided corporations maximum control and leverage over the means of product development. Thus, although mass-production was perhaps not a *best* practice (Piore and Sabel, 1984), it suited the marketplace well. Corporations were well insulated from global competition, which left with consumers few alternatives beyond their standardized outputs.

But mass production as a dominant organizational model also proved unstable. Globalization, deregulation and the advent of the silicon chip in the 1960s gave birth to a new industrial order that effectively outdated the bulky and stable production facilities characteristic of mass production. Technologies advanced rapidly and unpredictably; competition swelled to heights not before seen. As variety flooded consumer markets, companies could ill afford to settle comfortably into standardized products, and tailor their production process rigidly around it. Innovation and flexibility became tantamount to survival. Japanese firms gained market share quickly by pioneering new organizational

forms that leverage learning, teamwork, and interorganizational networks (Best, 1990). American industries followed suit, if tepidly. It became clear across developed economies that, rather than aggregating knowledge and decision-making wholly in management, and under one roof, flexibility and innovation could be better secured through the flattening of organizational hierarchies, the pooling of knowledge through teaming, and, to facilitate flexibility, the outsourcing of various services and aspects production to specialized agents (Best, 1990).

Flexible specialization and regional economies

Piore and Sabel (1984) viewed the shift away from mass-production as a second industrial divide. A central argument of their book was that, where mass-producing firms are often characterized by rigidities that prevent them from innovating and adapting to technological shifts, outsourcing, or vertical disintegration, allows for both flexibility and specialization as each partnering organization, or input, becomes adept in some service or facet of production. Such outsourcing provides nimbleness in response or even anticipation to environmental uncertainties, including technological advancements, changing consumer tastes, and concomitant uncertainties in labor demand (Piore and Sabel, 1984; Best, 1990; Storper, 1997). Succinctly put, vertical disintegration allows global competition to be managed more effectively by preventing technological lock-in and allowing firms to hone precisely on their competitive and often knowledge-intensive niche.

The proliferation of global value chains seen over recent decades speaks to the magnitude of this industrial divide. Advances in communication technology have made

outsourcing viable over vast distances, with various resources, services and human capital available in global markets (Porter, 2000). Thus, where proximity was critical to the core-periphery arrangements common before mass-production, as well as to mass-production manufacturing itself, modern business, it seems, has in some respects become less confined by physical boundaries. Economic activity is no longer bounded by the natural resources or manufacturing infrastructures resident within a particular territory. Capturing these sentiments, Kelly (1998) has argued that contemporary economies exist in dynamic webs of global networks as opposed to locations in their traditional sense. Negroponte (1995) has anticipated that the emerging "[…] digital planet [will] look and feel like the head of a pin" (p. 6).

Yet, research indicates that there remain significant benefits to spatial agglomeration, or the geographic clustering of related industries, organizations and institutions. One such benefit comes in the observation that global networks provide poor conduits for complex and tacit forms of knowledge, as these are likely to be personal and context-dependent (Audretsch and Feldman, 1996; Morgan, 2004). An additional benefit comes from the fact that synergies among regional organizations – including buyers, suppliers, schools, and research universities – may provide self-reinforcing systems (Finegold, 1999) that are spatially contingent and therefore difficult for isolated organizations to copy (Porter, 2000). The comparative benefits to localized and dispersed networks may thus depend on the nature of the particular transaction in question. Both forms of organization may exist but target unique objectives (Belussi and Sammarra, 2009). As Scott (1998) has summarized, tendencies toward geographic clustering often

rise "[…] wherever we find industries that face unstable markets whose contestability is focused mainly on product quality and innovativeness rather than cost" (p. 61).

Applegate (2006), for example, has emphasized that "stronger, deeper differentiated nodes in a network are required in environments characterized by increased complexity, uncertainty and turbulence" (p. 359). One advantage to regional clusters is therefore the possibility of establishing stronger business partnerships that are reinforced through regular face-to-face communications. Proximity encourages familiarity and interpersonal relationships. Norms evolve, as do shared understandings of how regional business operates (Saperstein, 2002). Business transactions become personal and more reliable. Risk, and the potential for opportunism, may be minimized. The clustering of related businesses may therefore give rise to forms of social capital that are more difficult to imitate along globally dispersed networks (Porter, 2000).

Knowledge spillovers provide another potential benefit. Griliches (1992) has summarized that spillovers occur as organizations are "working on similar things and hence benefiting from each other's research" (p. 112). Empirically, for example, the productivity of university research has been linked to the sum of corporate patents (e.g. Jaffe, 1989). Gittelman (2006) likewise found that patents were more likely to be coauthored by scientists of firms and universities that were proximate to one another. Beyond formalized partnerships, such diffusion may occur through informal communications, professional relationships, and intra-regional workforce mobility (Saxenian, 1994; Almeida and Kogut, 1999). A well seasoned employee amasses social capital within the region that serves as a steady source for information. In Von Hippel's (1994) language, forms of tacit or "sticky" knowledge may accumulate. When seeking

employment, such workers invariably bring with them knowledge and secrets garnered through neighboring organizations (Saperstein 2002). Thus, the regional workforce in itself may become a vibrant source for comparative advantage (Porter, 2000).

For example, Pinch and colleagues (2003) have made a distinction between architectural knowledge and component knowledge. Architectural knowledge involves understanding the broader significance of a technology, and tends to accumulate collectively among members of a cluster. Component knowledge in contrast is accessible to anyone, at any location. The authors point to the designers in Motor Sport Valley, who became proficient in aerodynamics, while the Italian-based Ferrari group, which was located outside of the cluster, focused narrowly on engine performance. Aerodynamics proved more effective. However, a broad architectural understanding aerodynamics (i.e. how the system worked together) proved difficult to copy for those beyond the cluster, even if the disparate "components" could be readily accessed and understood.

A related benefit to geographic clustering may come from catalyzed investment, both from related businesses as well as talented, job-seeking workers. In the example above with Motor Sport Valley, for example, Pinch and colleagues (2003) noted that Ferrari relocated a design office within the cluster so as to gain access to the cluster's accumulated knowledge – namely from employees working at local competitors. Cooke (2002) has noted that the presence of a successful industrial cluster also lowers entry barriers for start-up companies: Gaps in service and unmet needs are more readily perceived. Local suppliers are established and available. Human capital is plentiful and well-trained. The availability of jobs across common industries may incline additional workers to take residence within the region (Storper, 1997; Saperstein, 2002). Moreover,

because these outsiders are likely to be adept in some cluster-specific capacity, the region may grow increasingly specialized and thus of greater value to local businesses. For example, labor market specialization may reduce the costs borne by local employers on training and recruitment.

Beyond seeking opportunities for employment, Florida (2003) has argued that talented and creative individuals may also favor regions that are diverse and innovative. In his words, "creative centers are not thriving due to traditional economic reasons such as access to natural resources or transportation routes. Nor are they thriving because their local governments have gone bankrupt in the process of giving tax breaks and other incentives to lure business." Rather, as he continues, "They are succeeding largely because creative people want to live there." (p. 9). A cluster's success may therefore contribute to a self-reinforcing process of skill accumulation and specification. Talent fuels the local industry, helping to get it off of the ground. As the industry prospers, further employment opportunities become available. Talented workers with industry-specific skills continue to seek out regional employment, both for the availability of jobs, as well as, possibly, the innovative climate characteristic of the area. These workers are likely to become further specialized through years in industry and transitioning between regional employers.

Given the value of human capital to regional economic development, various researchers and policymakers have identified how the surrounding educational infrastructures – including regional schools, universities – play an influential part in their emergence and sustainability (e.g. Finegold, 1999). The intellectual property of university faculty as well as their doctoral students may provide fuel for new services and

technologies. For instance, Zucker, Darby and Brewer's (1998) study of 183 biotechnology regions lent evidence that "the growth and location of intellectual human capital was the principal determinant of growth and location of the cluster itself" (p. 302). Scientists at universities with strong research traditions serve as catalysts for innovation. And the ability for a prestigious school to attract top quality PhD students provides additional stimulus, as these researchers may develop and deploy their own technologies or move directly into industry following the completion of their programs (Finegold, 2006). Indeed, the innovations and entrepreneurial activities born in local universities and research institutions have often proved foundational for a cluster's development and continued health.

Yet, when appropriately deployed, regions' educational infrastructures may contribute not only to research but to various layers of the regional workforce, and in turn across different stages of the innovation process (Finegold, 2006). Highly skilled graduates are critical in shaping new technologies and moving them into the marketplace (Zucker and Darby, 1996; Zucker, Darby and Brewer, 1998). Those holding first-degrees, diplomas or apprenticeship training, meanwhile, play critical roles in commercializing new services and technologies (Finegold, 2006). The consolidation of demand in regional economies also allows educational centers in collaboration with the private sector to create degrees and training programs that specifically target the cultivation of cluster-specific skills.

The Role of Government in Regional Economic Development

Successful industrial clusters often come to exist naturally by way of naturally occurring territorial endowments or serendipity. The growth of one of the world's most successful

biotech clusters, located in La Jolla, surrounding the University of California in San Diego, provides a useful illustration of unplanned cluster evolution, as the founders of over 80 key companies in La Jolla emerged from an unsuccessful merger between Hybritech and Eli Lilly (Casper, 2007). Despite the strong role of good fortune, however, the appeal of generating relatively high skilled, "sticky" jobs has led many government-led efforts to try and stimulate cluster development through policy.

Cluster development initiatives have taken various forms. Some efforts, for example, have sought narrowly to improve the general business environment through tax policy, lightened regulation, or R&D incentives. Some governments have tackled infrastructural issues by, for example, funding technology parks and better modes of public transportation. Others have targeted market imperfections, including imperfect information, by publicizing "economic trends as well as information and data on markets, customers, competitors, and technological trends specific to clusters" (Enright, 2002, p. 118). Education and the development of human capital has also been an enduring focus of public policy. More directly, governments in some regions have even assumed venture capitalist roles, providing seed funding for emerging technologies and firms committed to creating good jobs in the regions (e.g. Bresnahan, Gambardell, and Sexenian, 2001).

A popular item among policymakers, the appropriateness of government intervention in regional economic development has been widely contested. Sabel (1993, p. 141), for example, stated that most "economic development programs […] are either well-intentioned failures or publicity-minded frauds." Likewise, in reviewing the recent literature on the subject, Stam (2009) concluded that top-down efforts at cluster building are doomed to fail.

Part of the failure behind most regional economic development efforts may be attributable to piecemeal manners by which they have been adopted. Finegold (1999), for example, has conceptualized high-tech clusters as self-reinforcing ecosystems. As with real ecosystems, successful clusters require four key elements: 1) catalysts (i.e. research generating new intellectual property and innovation) to spur economic momentum); 2) sustained nourishment (i.e. skills, human capital and financial) to facilitate innovation and bring products to market; 3) supportive environments (i.e. social, institutional or regulatory frameworks) to maintain vitality and support new firm-creation, and 4) connectivity -- strong linkages (i.e. networks and social capital) between key regional stakeholders. The absence of any aspect of the regional ecosystem can have devastating consequences for the whole. Many regions have invested heavily in new infrastructure and tax incentives, for example, but lack top-quality research universities to catalyze innovation. On the other hand, other regions, including Los Angeles, produce top-caliber research but may lack the infrastructural means to facilitate quality connections between the key actors (Finegold, 1999).

Government as a Network Facilitator

Organizational theorists have attempted to explain the emergence of inter-organizational networks across various levels of analysis. One level considers basic organizational factors, including necessity, asymmetry, reciprocity, efficiency, stability and legitimacy (Oliver, 1990). Asymmetries refer to power imbalances between organizational actors whereby one actor has "the potential to exercise power or control over another organization or its resources" (p. 243). Organizational size, reputation, and access to

alternative routes (i.e. to viability of *not* collaborating) are all determinants of power that determine the degree to which an organization can coerce another with a scarce resource into exchange. Meanwhile, collaborations formed around reciprocity are motivated by "cooperation, collaboration, and coordination among organizations, rather than domination, power, and control" (Oliver, 1990; p. 244).

Inter-organizational collaborations are also subject to the overarching social, political and institutional climates present within an environment (Ebers, 1997). And these environments are naturally subject to government's influence. For example, organizational theorists Scott and Davis (2007) have pointed to the Sherman Act of 1890, which limited firms' ability to form trusts and thereby gave rise to mergers and the behemoth enterprises emblematic of the late nineteenth and early twentieth century. Through tax policies, governments can also incentivize businesses to invest in a region or relocate elsewhere. Government can also make inter-organizational collaboration safer and in turn alliances more desirable. Establishing supportive legal climates, for instance, such as those acknowledging contract rights, makes inter-firm transactions less uncertain and more likely to evolve trust (Ebers 1997; Lane and Bachmann 1996; Sydow 1998). The absence or attenuation of such policies makes collaboration risky and so less likely to occur (Lane and Bachmann, 1996).

While the role of government is indirect in these examples, Heckscher (1988) provided evidence of the state playing a more direct and proactive role in network facilitation. Heckscher detailed a case involving a 1985 pollution control dispute in New Jersey, where "Poor towns lacked the money to pay for cleanup of their pollutants [and] richer towns resisted picking up any extra share of the tab […]" (p. 195). In this scenario

the judge did not resolve the issue outright but instead brought the disputants into dialogue to form their own resolution. Thus, in this case, government" was used to "prod" the collaborative process between organizations (Heckscher 1988; p. 199).

Government agents have also begun trying to facilitate inter-organizational linkages in an effort to vitalize (or revitalize) regional competitiveness. Sexenian (1994) advocated early on for regional policies that target network building, especially in the form of public forums for debate and information exchange across various levels of government. Legendijk and Charles (1999) observed in their research in Scotland, Whales, and England "cluster initiatives [that] emerged both as a part of the desire to improve the benefits from foreign investment by supporting supply chains and other forms of inter-firm relationships, and to support networking among local firms […] (p. 127). Similarly, Cooke and Morgan (1998) overviewed supply-chain building initiatives in Whales, including the Source Whales program, launched in 1991, which aimed "to identify supply opportunities (sourcing) and enhance supplier performance development." To facilitate this, the authors continue, "the [Welsh Development Agency] acts as an intermediary in the supply chain, seeking to build and develop long-term, high-trust partnerships between major corporations and buyers and Welsh-based suppliers" (p. 154-155).

A recent chapter by McEvily and Zaheer (2004) documented a government-led effort in western Michigan's furniture district to encourage supplier development in the industry. This effort came in the form of the Office Furniture Industry Council (OFIC), which was supported by the federally Western Michigan Manufacturing Technology Center (WMMTC) in conjunction with local manufacturers and suppliers. The OFIC's

focus was to develop a set of standard practices around packaging, quality assurance, electronic data interchange, and color that could improve firms' competitiveness by reducing redundancies and inefficiencies. For this effort to succeed, there needed to exist high levels of trust between the competing businesses participating in the project. According to these McEvily and Zaheer, network facilitators in this district were able to cultivate such by identifying actors' shared interests, creating shared expectations, leveraging a critical mass of influence, and bringing actors together in physical space and time. The standardized practices that resulted allowed suppliers to eliminate duplicities in systems and processes that existed with different manufacturers. In this case, then, collaboration and trust were successfully orchestrated for mutual benefit

SETTING AND RESEARCH QUESTIONS

The argument guiding this study is that this shift from *climate-setter*, where government establishes regulatory climates and general environmental factors, to *network-facilitator*, where interorganizational relationships are proactively encouraged, marks an empirically understudied but theoretically important transition in policy orientation. Indeed, although several case studies have recently emerged that document government's role in network facilitation, few if any have attempted to quantify the growth of resultant networks, or measure their nature or sustainability. Moreover, from the standpoint of theory, few researchers have attempted to develop guiding frameworks for future policymakers and researchers of regional economic development (see McEvily and Zaheer, 2004, for exception). The motivations behind the current study are thus two. First, this research aims to work toward a theoretical model that explains the components behind successful (or unsuccessful) network facilitation in regional economies. The second motivation is measure the extent to which one government-led network building initiative, Bio-1, developed relationship between key regional actors.

In 2007, central New Jersey's became one of the 39 regions to receive federal funding from the US Department of Labor's Workforce Innovation in Regional Economic Development (WIRED) Initiative. Titled Bio-1, this effort has targeted the bioscience-based biotechnology cluster that runs along the Route 1 corridor in Central New Jersey that connects Princeton and Rutgers/the University of Medicine and Dentistry of New Jersey (UMDNJ). In addressing the criticism that government-led skill building initiatives seldom produce industry-appropriate skills (Lynch, 1993, "WIRED

goes beyond traditional strategies for worker preparation by bringing together state, local and federal entities; academic institutions (including K-12, community colleges and universities); investment groups; foundations; and business and industry to address the challenges associated with building a globally competitive and prepared workforce[1]." Bio-1's effort, then, has aimed to raise the caliber of the region's pharmaceutical workforce by bringing various local institutions together continually in common dialogue around various aspects of improving and broadening bioscience workforce. In all, six strategies were enumerated (see http://www.bionjtalentnetwork.org/about/), including an efforts to build collaboration between K-12 schools, university, and industry.

This research looks closely at Bio-1's collaboration-building process, as well as the various organization-level and inter-personal relationships that resulted. Formally, this study's research questions are stated as follows:

1. Through what mechanisms has the WIRED Bio-1 Initiative attempted to facilitate collaborations between diverse industrial stakeholders?

2. To what extent have participants' social networks grown since the WIRED Bio-1 Initiative commenced? What is their nature?

RESEARCH METHODS

This study employed two research methods: in-depth interviews and exploratory social network analysis. The former was used to establish a theoretical understanding of the WIRED Bio-1 Initiative as a network-facilitating institution: how it worked; how it was experienced; whether or not participants felt that it contributed positively to the regional economy. Quasi-longitudinal social network analysis was then used to capture the extent

[1] http://www.doleta.gov/wired/about/

to which social networks grew from pre-Initiative to post-Initiative from a sample of Bio-1 participants. Social network analysis was also used to capture the nature of interactions – including how they occurred, as well as the quality of ties between actors.

In-depth Interviews

Twelve different affiliates of the WIRED Bio-1 Initiative were interviewed at length to develop and understanding how the network facilitation process operated, whether new relationships were being formed, how relationships were being utilized, and to get feedback on the positives and shortcomings of the effort more generally. These interviews proved important in understanding the (sometimes) subtle mechanisms that gave rise to Bio-1's collaborative infrastructure.

Interviews occurred in-person and over the telephone over a period of six months, from mid-September, 2009, to mid-March, 2010. Interviews ranged from 11 minutes in length (for a busy business professional) to slightly over an hour; the average interview ran for roughly 40 minutes. Interviews were solicited based on level of involvement. I was given contact information for all of those participating in these committees and teams, as well as those with more passive involvement, which took the form of attending Bio-1 sponsored/orchestrated events and activities or merely receiving a monthly newsletter. Because informal conversations with Bio-1 personnel indicated that the majority of relationship-building was occurring within the committees and teams, participation was solicited most heavily from team and committee members. Three interviews were solicited from non-team members. One of these was with an individual who was solicited for an interview after distributing the network survey and exchanging

several emails. One non-team member was mistakenly labeled as being a team member. It did not come out that this person was not involved in the teams until the in-person interview. Nonetheless, this individual provided several significant insights related to WIRED Bio-1. Another interviewee was an individual who wrote a grant-request to WIRED Bio-1 that ultimately received funding.

In terms of institutional diversity, the sample of interviewees came mostly from local universities and community colleges (7), as these participants were the most eager and willing to participate. However, participation was also obtained from the private sector (2), as well as from a Bio-1 administrator (1) and from local government representatives (2). Two people were interviewed on more than one occasion. Representation was secured from all of the strategy teams. Each interview participant was ensured that their identity would remain private in the eventual publication of these results so as to protect their reputation and to maximize accuracy in their responses.

The questions shown were not followed verbatim but served as reference points for key topic areas. Thus, interviews for the most part were conversational and free-flowing around issues of regional collaboration within the context of the WIRED Bio-1 Initiative. Individuals were encouraged to relay their histories of involvement (e.g. how they became involved; what the process of involvement has entailed), as well as their personal opinions about why certain practices occurred in certain ways, and whether or not they could be improved. Interviews generally began with open and unguided reactions. Each respondent was asked to identify his or her role, and the teams or projects that they partook in. They were also asked to explain what motivated them to become involved in the Initiative, and what they perceived as the project's overarching

goals. I probed for examples of Bio-1-facilitated collaboration; I encouraged stories. I also asked respondents to identify key strengths and weaknesses of the Initiative.

The interview questions evolved as the interviews progressed and as a better architectural knowledge of the collaboration process accumulated. From the standpoint of collaboration, for example, it became clear from several participants that personal passions were an important precursor for enthusiasm and willingness to participate. Subsequent interviews thus tried to unpack the relationship between personal interests and participation. Similarly, it became clear from several speakers that Bio-1 facilitated communications were occurring in different settings, such as sponsored events and summits, not only in teams or among formal "participants." With this insight in tow, subsequent interviews probed for extra-team, event-centered relationship-building more closely.

Exploratory Social Network Analysis

Social network analysis is the study of the interactional patterns among people and groups (Ennett and Bauman, 1993), including organizations. Network data for this study come from completed surveys from 38 participants, all of whom were involved in the WIRED Bio-1 Initiative in some capacity but to varying degrees. Data collection occurred from June through December, 2009, which spanned the second-to-last year in which the WIRED Bio-1 Initiative received federal funding. A mailing list of all of the recipients of Bio-1's newsletter was made available by administrators. This list at the time it was received contained 588 names and email addresses; 55 these email accounts were later returned as being invalid. Although this newsletter was used to keep regional

constituents apprised of Bio-1's progress, the vast majority of recipients had very little to no affiliation with WIRED Bio-1. They may have been placed on the mailing list after attending a sponsored event or a summit that was attended by hundreds of other community members. They may have signed up for the newsletter via Bio-1's website and therefore had no interpersonal participation with WIRED Bio-1 whatsoever.

In all, 38 usable surveys were returned from the 533 valid email addresses, representing a response rate of 7.13%. It is important to note that there was a conspicuous disinclination for those with extremely weak levels participation to participate in filling out the survey. Over one dozen people responded to my request by indicating that they had no involvement beyond the newsletter. For example, as one person replied: "I'm sorry to say that neither I nor my organization has any involvement with Bio-1 aside from subscribing to their newsletter. Did you mean to reach someone else?" Another explained: "I'm afraid I have not used any of the wired Bio-1 services, I was simply on their mailing list - sorry that I can't be more useful to you." Another tersely responded: "Actually I don't think I know much about [Bio-1]." More tersely still, another responded: "What is a Bio-1?" It is highly unlikely that the 14 who replied indicating they were just newsletter subscribers were the only individuals on the mailing list of this sort. A conversation with a representative familiar with the mailing list suggested that participation for the majority of people on the newsletter list was in fact limited to receiving monthly newsletters. It is difficult to see how measuring network growth among newsletter subscribers is of practical or even theoretical relevance. The response rate provided above is thus artificially low.

21% of the 143 *organizations* identified to be WIRED Bio-1 participants were accounted for in the 38 surveys[2]. Survey-takers included participants on Bio-1's formal committees and teams, as well as individuals with more peripheral involvement, such as through Bio-1 sponsored events or communications with the more active participants. 15 participants were involved in the formal teams; 23 were not team members.

Nearly every completed survey represented a unique organizational entity (35), which allowed individual attributes (e.g. whether or not a survey-taker participated in teams) to be applied to organization-level data[3]. However, six collected surveys were redundant with other surveys from the same entity; that is, six surveys were representative of organizations that were already represented by at least one other survey-taker. To account for the fact that an organization's network may be best captured by an amalgam of individual networks (Marsden, 1990), redundant surveys were combined in these instances such that all linkages indicated by either party were accounted for. This presented a dilemma for coding survey questions that address the nature of relationships (explained below). For example, it is possible that a representative from Organization A would have reported high goal sharing with another organization, Organization B, while another survey taker from Organization B reported low goal sharing with the same organization. It is also possible that a survey taker from Organization A communicates with Organization B primarily via email, while another survey-taker from Organization A communicates with Organization B primarily in person. Naturally, both responses could

[2] As is explained more carefully momentarily, not all surveys were unique to one organization, thus resulting in the percentage shown above.

[3] Identities were still protected, as organizations were coded by industry.

be accurate if the two survey takers from Organization A are referring to different *individuals* within Organization B.

A clear fix to this dilemma was not found in existing literatures. Fortunately, for two of the organizations (four of the surveys) for which this was an issue, only one survey taker completed the longer version of the survey (explained below) that included these additional questions; there was no need to deal with overlapping numerical or categorical responses. That there was no variation among survey-takers in team-membership status meant that, for network purposes, the organization's node and corresponding linkages could be considered representative of the same participatory background. The two overlapping surveys for the other organization both completed the longer version of the survey. Here, however, only one selected contact overlapped between the two surveys. For this overlapping survey, nearly every single response was identical. The only differences were that one survey-taker identified communicating with the overlapping organization about "communicating to learn new information useful to your organization" and indicated that this communication linkage helped the individual to "do their job." The other survey taker did not. In this case, because responses are to be representative of *organization*-level communications, the former's responses were used as the organization-level proxy. We can say that the linkage between the two organizations represents helps at least one person to gain new information, and helps them to do their job. As above, there was no variation in team-membership status among these two surveys.

Several (5) departments within a major research university were treated as unique "nodes" to better capture the extent to which the Initiative brought unique and

disconnected organizational divisions into the regional ecosystem, as opposed to organizations broadly defined. The survey instrument allowed us to measure department information if survey-takers were willing to provide it. However, measuring intra and inter-organizational collaborations simultaneously presented a dilemma. Social network analysis is best performed when respondents are presented a bounded list of possible communication contacts. This "bounding" prevents estimate biases that may arise from varying memories. For example, one respondent may recall communicating with person X, but may fail to recall that they also communicated with person Y. It became clear from conversations that an important part of the network story was inter-departmental linkages between universities. However, we did not have a list of all participating *departments*. Including every possible department would have also made the survey instrument too long. The list was bounded by mostly by organization name.

Consequently, while respondents (egos) filling out the survey were asked to identify their department of affiliation if they were comfortable doing so, their choices for communication contacts remained at the organization-level. This meant that network reciprocity at the department level was never possible: A representative from an organizational department could select other organizations as communication contacts, but other survey takers could not reciprocate communication to the department because department-level communication contacts were not listed as possible choices; they could only reciprocate to the department's overarching organization. For example, a university employee in a bio-sciences department could indicate a communication linkage with a private sector business, but the business could only reciprocate by indicating a communication linkage back to the university, broadly defined. This meant from the

standpoint of the network that there would be duplicate ties. In the example just provided, for example, the linkage indicated by the private sector business and the university could potentially represent a duplicate tie if the private sector business only communicated with that one department.

In order to retain department-level communication patterns while eliminating the potential for duplication, the one *organization* for which this was an issue was removed from the final network, while the communication linkages indicated by the *departments* within this organization were retained. To continue the example above, therefore, linkages from the private sector business *to* the University were ignored, while communication linkages *from* the University Department to the private sector business were kept and considered representative of the organization. This approach was imperfect. However, the decision to remove the organization node and inbound communication linkages was supported by the observation that departments within it were highly active in the WIRED Bio-1 Initiative; it is likely that any ingoing to ties to the university reported by other contacts in most cases represented ties two at least one, if not more, of these department representatives.

Accounting for redundant organizations (3) and departments that were treated as unique nodes (5), 30 of the 143 organizations in the Bio-1 system were accounted for, thus resulting in representation of roughly 21% of the organizations participating in the WIRED Bio-1 Initiative.

Survey and Measures

Web- and Excel-based applications were created to capture the extent to which organizations communicated with other participating organizations, and whether these relationships came to exist or increased in intensity after the WIRED Bio-1 Initiative began. Questions also addressed the nature of participants' relationships, including why communications occurred, and the degree to which participants shared goals with one another.

Each survey application functioned in a similar way. One difference between the two was that the web-based application required a user log-in ID and password, which was provided to respondents in private emails. Surveys completed via the web were also stored on a remote server and eventually downloaded by the researcher. This created difficulties early on as an undetected programming glitch allowed the webpage to effectively "time out" if users spent too much time on it. If this happened, the "submit" survey button would fail to successfully send to the server. Two completed surveys were lost to this glitch. Fortunately, one such participant graciously agreed to retake the survey. The Excel-based survey was emailed directly to respondents; it did not require login credentials nor did it require that users submit to a remote server. Upon completing the Excel-based survey and saving it to their computer, respondents returned it to the principal investigator via email.

As suggested above, there were two versions of the survey instrument created with each platform (two for web and two for Excel). One survey version was shorter, requiring only that respondents indicate whether or not their relationships existed prior to the WIRED Bio-1 Initiative, or were newly formed. The longer version included a set of additional questions that are outlined below. Respondents were generally given the longer

version of the survey unless they voiced discontent with the survey's length, in which case they were given the shorter version. The one individual who resubmitted the survey after a programming glitch lost the original submission was also given the shorter version of the survey, out of respect for the person's time. 32 long surveys were submitted; 6 short versions were submitted. The following section details the format of the survey and the questions it included.

The First Survey Page. Respondents were first asked to identify their organization of affiliation. Below this, they were then asked to mark-off by check boxes all of the other organizations that they had communicated with both before and after the start of WIRED Bio-1 Initiative. By measuring the relationships that existed both before and after the Initiative began, I was able to assess the growth of networks retroactively.

The list was bounded by the 143 organizational actors provided by Bio-1 administrators. With input from Bio-1 administrators, each organization in the list was categorized by industry.These categorizations consisted of: Associations; WIB and One Stops; External WIRED regions; High Schools; Non-Profits; College Universities/Research Institutions; Corporations; Government; Venture Capitalists; Government; and Other. This categorizing was done to make the large list of possible communication contacts less intimidating and finding certain contacts more efficient.

The Second Survey Page. After identifying each of their communication contacts, respondents were taken to an intermediary page that clarified the format of the second survey page, as well as its questions. The organizations selected on the first survey

populated the rows on the second survey page. Questions pertaining to the nature of inter-organizational relationships filled the columns immediately to the right. Respondents indicate a response to a question by inputting values in the cell where the question and communication contact's name intersect.

The questions asked of respondents fell into one of three categories: communications and frequency; purpose of communications; and social capital.

Communications and frequency. The first question asked respondents to distinguish between relationships that existed prior to their involvement in Bio-1 versus those that materialized afterwards. Respondents were asked whether or not they "communicated regularly with this organization before the state of Bio-1." Possible responses, provided in a drop down menu, were "No;" "Daily;" "Weekly;" "Monthly;" "Quarterly;" and "Yearly." In a similar manner, the following question then assesses the frequency at which they currently communicate: "Daily;" "Weekly;" "Monthly;" "Quarterly;" and "Yearly." These two questions were the only questions included in the short version of the survey. The questions outlined hereafter appeared only in the longer version.

In the long version of the survey, the question subsequent column asked respondents to indicate the number of individuals with whom they share communications for each selected organization. Possible choices for this question were: "One;" "Two;" "Three;" "Four;" "Five;" "Six to ten;" and "More than ten." The primary motivation behind this question was to get a sense of how deeply inter-organizational communications were occurring for each survey respondent.

Purpose of communications. Respondents were then asked in the five subsequent questions to provide information on the purpose of their communications for each contact

by way of binary check boxes. Respondents were instructed to answer "yes" if they communicated for the given purpose, and leave questions blank if they did not. The first of these questions asked whether respondents communicate for securing additional resources. The second asked whether they communicate to partner for new activities. Third, respondents were asked whether they communicate with each organization to learn information that is useful for their organization. The fourth question asked whether they communicate to engage in problem solving. The fifth and final question asked whether the information obtained through the relationship helps respondents to do their job.

Goal Sharing. The final question asked respondents to indicate the degree to which they share goals with each organization. Responses are captured in ordinal form, ranging from 1 (being low in goal sharing) to 5 (being high in goal sharing).

Variables were created from each of these survey questions, as well as from additional information made available by Bio-1 administrators. These additional measures include:

Team membership. Six task teams were created by Bio-1 administrators, each with a specific goal. These teams brought various organizations, and types of organizations, directly together around common goals, and would expectedly have an impact on network formation. As such, a variable was created to identify which members were team members, versus those who were not.

This information was made available by Bio-1 administrators. With these data included, one concern was that, because the identities of respondents in this survey are confidential, a comparison of team membership by organization network might allow individual identities to be deduced. For this reason, the particular team-name was not identified.

Moreover, organizations were coded broadly by their type (universities, private sector, venture capitalist, etc), of which there were many in each team.

Institutional background. Each ego (respondent) and alter (communication contact selected by ego) were assigned to an industrial category. These categories included K-12 schools, universities, associations, government agencies, WIBS and one-stops, WIRED regions, company, non-profit agencies, venture capitalists, other, and international contacts.

Percentage network growth at the respondent level. The percentage of network growth for each respondent was calculated by dividing the amount of new linkages secured post-WIRED Bio-1 Initiative (preexisting linkages – post-Initiative linkages) by the number of linkages that were present before the WIRED Bio-1 Initiative began, and multiplying the product by 100. This variable allowed me to assess whether certain variables (e.g. team membership) predicted network growth at the respondent level.

Proximal communications. The survey question pertaining to how communications occurred was used to form a measure for proximal and distal communications. Communications were considered to be proximal if the respondent indicated that they occurred primarily in-person (i.e. were reported as being "face-to-face," or occurring in "conferences"). Communications were considered to be distal if the respondent indicated that they occurred primarily via some technological medium, and over distance (i.e. "email" or "phone"). Proximal communications were assigned the value 1; distal communications were assigned the value 0. Respondents who indicated to communicate with a partner primarily through a "mixture of methods" were not included.

Analysis of Survey Data. Network data were imported into adjacency matrices suitable for Pajek and UCINET, two software packages designed for network analysis. These packages allow for the creation and manipulation of network images. They also allow me to conduct exploratory work into the patterns of inter-organizational networks. Because this analysis occurred at the organizational -level, it was expected that a respondent representing one organization would be in contact with another organization, while the representative from the other organization was not in contact with the original respondent's organization. For example, a representative from Organization A may communicate with an individual from Organization B. However, if that contact from Organization B is not the person filling out the survey on behalf of University Y, she or he may not be in contact with anyone Organization A, and therefore may not report the presence of a connection. Thus, reciprocity was assumed among all respondents; the presence of a linkage reported by ego was considered accurate even if that linkage was not indicated by alter. Reliability for the questions on the nature and quality of relationships was assessed by comparing responses across participants.

RESULTS

Every individual who was interviewed reported that their participation in the WIRED Bio-1 Initiative drew them into collaborations with individuals and industry leaders with whom they were previously unfamiliar. Nearly all of these relationships (and communications) were around issues of workforce development, or other issues related to WIRED Bio-1. Several of these speakers predicted that many their relationships would endure beyond the life of the Initiative. Not surprisingly, the impact of participation on social network growth appeared to be strongest for those involved in the committees and task teams. However, there was considerable evidence that collaborations expanded deeper into the regional community, primarily through sponsored events and participant outreach. The following provides background on Bio-1's history and organizational structure. The insights gleaned through the interviews are developed into a theoretical framework explaining the antecedents to government-led network facilitation in the Bio-1 context. Several overarching factors were identified as being important and potentially generalizable. Figure 1 summarizes these into a model.

Background

The WIRED Bio-1 Initiative commenced November 2007, receiving $5.1 million in funding from the US Department of Labor. Bio-1 was designed to solicit and make decisions on proposals centered on workforce and economic development. The $5.1 million was designated for staff expenses and the funding of accepted proposals.

The majority of other WIRED regions throughout the United States have adopted top-down governance models where one central administrator or group assumes sole responsibility for designing strategies and making allocation decisions. However, from the perspective of the administrator set in charge to oversee Bio-1, as well as others who were responsible for writing the grant request, this top-down approach failed to take advantage of the wealth of knowledge resident within the regional community, and in particular in the various institutional bodies that had familiarity with or leverage over key parts of the system. Maximizing the outputs from workforce investments required ongoing articulation not only from those responsible for nurturing regional skills (e.g. K-12 schools and universities), but also those most familiar with the types of skills in demand – namely, employers in the region. From the start, then, it was intended that Bio-1 be a highly inclusive and collaborative enterprise. As was expressed by the project's administrator:

> I wanted a grass roots governance structure, instead of a centrally focused one. There are 39 WIRED regions throughout the US, and some of them operate such that the person in my role really does everything. I really wanted to make this more inclusive and of the people […]. The more people you have involved in the decision making process, and you make it a clear decision making process - you have more buy in, you also have strong ideas because you bring in diversity of opinion.

A corollary hope was that the collaborations that emerged through this process would spark personal and professional relationships that would endure beyond the life of the Initiative's formal funding, thus providing a source of sustained benefit.

Bio-1 would come to adopt a non-profit-like management model. Headed by a central administrator and small administrative staff, a diverse team of leaders from different stakeholders, many of whom were architects of the initial grant, would come to form a 20 person governance committee, which would meet quarterly, and would be

responsible for clarifying and articulating Bio-1's strategies. A subset of this group would form the executive committee, which would be responsible for making key strategic decisions and funding recommendations. Based on their expressed interests and industrial background, members from these committees would assume leadership roles over six teams, thus ensuring a direct line of communication between teams and the higher levels. Each team would center on a unique strategy (http://www.bionjtalentnetwork.org/about/). Bio-1 would solicit proposals for projects differentially centered on increasing participation and capacities in New Jersey's science workforce. From here, an institutionally diverse body of team members, which met at regular intervals, worked collaboratively to reach consensus upon which proposals, if funded, would have the strongest and most lasting impacts on the regional economy. Teams ranged from 11 to 26 participants; the average team size was roughly 14 members.

These committees and teams, as well as numerous sponsored activities, provided the formal structures within which collaboration and relationship building occurred. But developing this infrastructure posed challenges, for it required amassing a large participation base from a diverse range of stakeholders, and mobilizing these already-busy professionals to volunteer time and energy toward something that, at first blush, offered little in the way of personal benefit. As detailed in Figure 1, building Bio-1's collaborative capacity, or its base of participants, relied on several parts. The first of these leveraged existing social networks and the networks of new recruits via boundary spanning. The second part in building collaborative capacity involved developing a compelling, personally relevant identity and brand and creative and sustained publicity efforts to disseminate it.

Insert Figure 1 about here

Bio-1's Model of Network Facilitation

Leveraging Existing Relationships and Boundary Spanning. Especially in its infant stages, building Bio-1's collaborative base relied on leveraging the preexisting social capital that the administrator and architects of the grant brought with them from their professional histories. In the words of one of these architects:

> [Filling] the Governance Board was a combination of personal networks and roles. We were looking to represent all of the key players in the 5 country region and different types of stakeholders, and then to use all of our personal networks to find the best qualified and interested people to serve, ideally looking for those with authority to represent their organization.

This account was corroborated by the administrator:

> At first, we relied on our personal networks to fill roles. This helped us to seek out people who we knew might be interested in participating. […] So, in the beginning it was a little bit of a sell job.

Indeed, this administrator was hired in large part for her background in New Jersey's biopharmaceutical industry and the professional relationships and insights that accompanied that background. In the administrator's words, "They hired me because I had the corporate side of the relationships, which are the harder relationships to cultivate." Adding: "So I think that's why I was hired - because I had an existing network of corporate people and I could speak to their needs. And they're not going to come to the table unless they see a benefit."

But building Bio-1's collaborative base extended beyond the administrator's personal networks, and even the relationships held by the architects of the project's grant.

Bio-1 leveraged the relationships of contacts, and of contacts' contacts, and so forth, thus beginning a process of snowballing. "I had to work with people that I knew, and then it snowballed," the administrator explained. They would say "You know, you really should talk to this person, or this person." An interesting element in this story is that Bio-1 not only leveraged the contacts embodied within individuals, but also, more powerfully at times, the social capital embodied within local associations with established histories in the region. Through one such boundary spanning linkage, for example, Bio-1 was able gain access to a group of K-12 school teachers who would have otherwise been inaccessible. In this case, because one member knew the president of a local science teachers' association, Bio-1 was able to gain access to a cohort of science teachers who already held strong normative commitments to improving kids' interests and participation in the sciences. Naturally, then, their interest in Bio-1 as a force for institutionalizing educationally-centered projects was high. As was explained by the administrator:

> K-12 schools were a difficult population to reach because in every school district there are different people, different channels - and you can't directly talk to the teachers. So, the best thing that we did was we [recruited] the president of the Biology Teachers' Association of New Jersey. […] [This relationship] brought us a network of science teachers who were […] the more interested ones – […] the ones that were going to do a little extra because they belonged to this organization.

Association-level linkages to, HINJ and BioNJ, two local biopharmaceutical associations, also became valuable, as these associations held long histories and well established networks throughout the region. One of the Initiative's governing board members, for example, a manager at Bayer Healthcare, was recommended for the position by an affiliate of HINJ, who was also participating in Bio-1[4]. Through BioNJ, Bio-1 was also able to directly access a group of industry representatives that were affiliated with BioNJ.

[4] http://www.bio-one.org/content/gary_surmay.html

In this way, Bio-1 was able not only to leverage the relationships of its individual members. It was also able to capitalize the social capital that partnering organizations had accumulated through collectively decades of working alongside the very businesses that Bio-1 sought to engage.

Thus, personal networks and boundary spanning helped to establish a governing hub and, with participation from several deans and executives, provide legitimacy to the project. A final step in outreach involved aggressive media and articulation to the broader regional community. Over the course of its lifespan, Bio-1 tried to generate interest and participation through hosting events, presentations, through media, and through their website. As one participant recalled, "Every year we did a NJ Life Sciences week where we hosted 40-50 events throughout the state to try and generate media interest and constituent interest. That's when we really began getting known [in the community]." The speaker added: "We did presentations. Any time we had opportunity we had to do presentations -- or have a booth some where -- we did it." These activities and the publicity that accompanied it appeared to channel considerable activity to the Initiative's website. Just as important, these activities provided opportunities to solicit additional participation:

> People would come up to you at the end of an event and say, 'Hey, I'm really excited about this, or that.' I would then take their card and ask whether they would be interested in participating in any of the teams that makes funding decisions. […] This helped to fill in some of the holes.

Identifying and Accommodating Personal Interests. Leveraging existing relationships facilitated outreach, but securing participation required identifying and accommodating the various and at times idiosyncratic interests of organizations and their employees. The strategic directions included in the initial grant proposal were broad and multilateral; they

reflected the various orientations and concerns of several distinct parties. An emphasis on women and minorities involvement in the sciences was included, for example, even though, in the words of one of the grant's foremost proponents, "it didn't need to be something that the grant focused on, or the group had to focus on, given its main economic purpose." The six strategies finalized by the governance committee also derived from a collaborative, bottom-up process. That Bio-1 aligned with personal interests – and was flexible enough to accommodate personal interests – was instrumental in generating buy-in.

> You have to discover what's in it for the other person. When I would go [to meet with prospective participants] I would ask them immediately "what are your needs, what is it that you would like to get out of this?" Whatever they told me, I would try to make sure that they would get it.

There was evidence that some of the organizations that were solicited for participation failed to take seriously the types strategies that Bio-1 was attempting to further. Worse, a few apparently perceived that the workforce development programs that Bio-1 was sponsoring were not contributing to any real value: "The truth is," one speaker charged, "that the businesses that [I work with] will not hire any of the workers coming out of these [retraining] programs. By the time that they come out [of the programs] their skill sets are already out of date." The speaker added that business and government operated under different standards. The former demands some quantifiable output to justify the investment of time and resources. Government, in contrast, does not abide by the same rigorous commitments to output. The speaker's point was that businesses would be reluctant to participate unless they had confidence that the workforce development programs that Bio-1 was sponsoring would have a legitimate impact on the quality of the human capital at their immediate disposal. Even though Bio-1 sought to address such

issues of mismatched skills, some appeared skeptical that its efforts would pay off in meaningful ways.

There was consensus that, while participation from academia, government, and non-profits organizations was generally enthusiastic, private sector participation was more difficult to secure and sustain. Several major businesses – and many mid-level professionals within these businesses – did become involved, however, albeit for different motivations, and at varying levels of intensity. Some companies, including PTC Therapeutics, accessed interns through the course of their participation. Some of these interns were ultimately brought on-board as full-time employees. Other potential benefits included free customized training, job matching, and opportunities to help displaced workers locate new jobs. There was even evidence that some companies saw direct value in industry working collaboratively with training institutions and universities to shape curricula around industry's needs. As a private sector employee explained, "[…] if our employees are trained in local school and universities, it's to our benefit that these schools and universities are teaching and instilling in students the types of skill-sets and expertise that we currently need."

But social, community-focused strategies became a major force behind individual participation, as well. Involvement in the committees and teams was seen by many as an opportunity to advance a social or normative concern that was of longstanding personal interest. The administrator recalled telling people: "Here are the six strategies, is there one that you're really passionate about." Adding, "It turns out that most people have some hot button that they're passionate about." One notable "hot button" was the team centered on exciting young people, and in particular women and minorities, about the sciences.

With 26 members, this team was by the far the most popular, nearly doubling the membership totals for the next largest team[5]. Several academics recounted long histories contributing individually toward similar missions. Their enthusiasm for Bio-1 clearly came from its muscle and capacity to improve areas of personal concern. As one explained, for example:

> This is something that I've been doing since I've been in college - is going out to into the community, to women in particular, and encouraging them to get into the biosciences industry. […]I saw Bio-1 as an opportunity to really provide the needed government-level support to get that message effectively across.

The private sector also appeared drawn to the social nature of Bio-1's efforts. At times this interest manifested in corporate social responsibility, where businesses viewed Bio-1 as an opportunity to fulfill some mission of corporate altruism or community outreach. For example, the administrator explained one instance where Johnson and Johnson solicited participation with Bio-1 because Bio-1's strategy aligned closely with Johnson and Johnson's strategy of corporate contributions. For others from the private sector, participation appeared to be less about CSR than about breaking away from one's regular work routines and servicing the community or contributing positively toward an area of personal passion that had, to that point, been largely suppressed or underexplored.

> Getting businesses involved meant looking lower down in the food chain. Now, we weren't looking for the people who sweep the floors – but for scientists and mid-level managers. We wanted to sell strategies that struck a chord with people. We wanted to explain how what we were doing was relevant to areas that people found personally interesting. […] I started making cold calls to people I knew. So, for example, I knew a guy that I used to work with at Roche who now works at Bristol Myers Squibb, and I wanted to bring Bristol Myers Squibb to the table. I called him up and said, you know, 'I'm doing this project and I'd really like to have Bristol Myers involved. Here are our six different strategies. I'd love to have you one of the teams – or someone else at your company. So what keyed in for him [was the strategy] on exciting young people about the bio-sciences, since [he] had a real

[5] The next largest team had only 14 members.

> passion about getting Latinos [and other minorities] more represented in the sciences.

Creating Forums for Common Interests and Synergies. Forums for common interests and synergies refer to orchestrated, hierarchically flat gatherings between institutionally-diverse stakeholders by way of committees, teams and sponsored events. These gatherings facilitated buy-in and commitment by providing individuals with the opportunity to work toward areas of personal passion, by introducing participants into a network of similarly impassioned people, and by providing voice and agency to all in the process.

Governance committee members assumed leadership roles over the strategy teams that aligned with their personal interests or motivations for becoming involved. The strategy teams were also populated on the basis of articulated interests. The alignment of interests and roles appeared to keep intrinsic motivation high. It appeared to help some of the groups to gel quickly, as participants, especially in the strategy teams, departed from similar concerns. For some, then, the incentive to participate, and to continue participating, became Bio-1 itself, for it provided an opportunity to work alongside, and develop relationships with, community members who were similarly impassioned. That voice and agency was given to each participant throughout this process meant that all shared genuine ownership over the collective output. As one team member recounted "This whole experience has been highly collaborative. Everyone one that I've been working with [on my team] has been so enthusiastic. […] Being a part of [this] has basically plugged me into a network of passionate people just like myself." Another indicated: "What has been great about this experience since I started has been the

relationships – meeting and working with people who share my concerns – important concerns – and are also motivated to affect change."

Whereas common interests aligned goals, stakeholder synergies refer to the idea that the outputs of collaborations would be strengthened when diverse, value-adding insights, resources and access were brought to the table. The administrator explained, "I made sure that I had representation from every county in our region -- that I had someone from education, someone from industry, someone from non-profits, someone from government. [I made sure that] I had all of the various dimensions covered on every team. From the perspective of a team member (who participated on multiple teams):

> There needs to be connected to industry - to know what needs are; what's out there; new fields, etcetera – so that academia can create those curriculum. Bio-1 has [provided] the opportunity to connect academia to industry, and to government. In the teams that I'm on, for example, we have representation from all of the stakeholders, […] which has been extremely helpful.

But this stakeholder diversity proved to be value-adding not only in terms of maximizing the impact of funded proposals but also because participants were brought into contact with others who held unique resources, and therefore were well positioned to be of direct and immediate assistance. A dean from academia, for example, related how participating in Bio-1had introduced her to a group of business professionals who, along with the administrator, helped her to establish a focus group with over a dozen industry leaders around curricula alignment. The participants in this focus group were not formal Bio-1 participants but peripheral contacts who were accessed, in part, by intermediary members.

While a great deal of Bio-1's orchestration stemmed through these teams and committees, it also became clear through interviews that similar dynamics were extending throughout the broader community, primarily through sponsored events. The

impact of sponsored events on social network growth was well captured by the experience of a university employee, who recalled how in attending a Bio-1-sponsored summit she developed several enduring friendships with local professionals from the pharmaceutical industry who shared an interest in increasing women's participation in the sciences. The employee explained how the summit provided a common space for community members from different industrial backgrounds to come together, build relationships, and exchange ideas around an area of common normative interest. The group had stayed in touch via emails for months following the summit. The email list expanded as this group copied other people that they suspected might also be interested. After meeting over the summer, the speaker recalled:

> We were like 'wait a minute, since we're all so passionate about this topic, why don't we get together and think about ways we can raise funds, or bring in grants, to address for the people that we're interest in.' The speaker added: "The cool thing about this group is that it's, you know, HR professionals, industry leaders, as well as people like myself. And we're meeting again tomorrow to start looking for at potential grant opportunities.

Articulating a Common Framework. The preceding highlights Bio-1's process of generating participation, and, in teams and sponsored events, how compressing common interests and synergistic industrial backgrounds maximized not only collaborations but also the capacity for collaborations to contribute fruitfully to the regional economy. A final step in this process involved a articulating the vision, and the broader significance of the Bio-1 enterprise in terms of regional economic development.

The administrator repeatedly emphasized the broader regional or economic significance of Bio-1's efforts. Placing strategies of personal interest into the broader economic panorama appeared to help participants understand that their efforts were of a broader regional and economic value. Bringing women and minorities into the sciences

would not only help to promote equality and economic betterment among these disadvantaged populations. Greater involvement in the sciences meant that a richer labor market would potentially be available to regional employers down the road. Creating and articulating clear pathways through which young people could earn advanced science degrees at local universities would help the development of human capital, as well as industry-moving innovation. Stimulating the growth of new companies and jobs would assist displaced workers and help keep the state's economy strong. The administrator explained:

> [It was important] to articulate the vision, and the strategy, over and over and over again. For example, I have a set of three or four charts that I always start every meeting with, and it sets the whole stage. It shows how all the projects fit in the overall economy- it puts everything into context.

The nexus between this articulation and network facilitation was not immediately clear in my interviews. What was clear was that this message penetrated deeply, as nearly every team member who was interviewed understood and was able to rearticulate Bio-1's broader thrust of economic revitalization. "One thing that [the administrator] has gotten through to us is that Bio-1 – what we're doing - fits in a bigger context." The speaker added: "That context is the strength of our industry, and its ability to compete globally." This higher-order understanding was less obvious to those not actively involved in the committees and teams. For example, one peripheral participant viewed Bio-1 as little beyond an institutional force through which he and others might reach out to underprivileged inner-city areas to generate awareness and interest in the sciences. While, of course, this ambition aligned closely with one of Bio-1's main strategies, the speaker had little understanding of the Initiative larger function beyond facilitating this outreach.

From the standpoint of network facilitation, then, this common, overarching framework may have helped deter normative shortsightedness and fertilize the understanding that broad stakeholder involvement – and input – was a necessary precursor to effective and sustainable change.

Bio-1's Impact on Participants' Social Networks. These preceding factors – leveraging existing relationships, boundary spanning and publicity efforts; identifying and accommodating personal interests; creating forums for common interests and stakeholder synergies; and a articulating common framework – provided the foundation for economically meaningful inter-industry relationship-building. Qualitatively, every interviewee reported to have developed strategically meaningful relationships through the course of their involvement. There was variance in the quality and intensity of relationships, to be sure. A few respondents kept in touch primarily via emails. Some also saw their developed-relationships as being limited to their involvement in teams and the funding and overseeing of projects; thus, for some, Bio-1-facilitated communications appeared to be somewhat prescribed and unlikely to ensure in meaningful ways. On the other hand, over half of the interviewees predicted that some of their Bio-1-facilitated relationships would endure beyond the life of the project's funding. Whether or not these relationships do in fact maintain is an empirical question that we cannot yet answer.

The following statistics attempt to unpack Bio-1's impact on participants' networks over the period of Bio-1's funding. Guided by the interviews, several hypotheses are expected to be borne out in the data. First, I expect the two administrative officials surveyed to demonstrate strong linkages to critical sectors (academia, the private

sector, and key local associations) prior to Bio-1's inception; these two administrators should assume central positions in the post-Initiative network, given their heavy coordinating functions and levels of involvement. Second, I expect to see sizable growth in survey participants' social networks from pre-Initiative to post-Initiative. However, because team members appeared to be far more engaged relative to non-members, and were frequently brought together in a common physical setting, it is expected that that network growth of the former group will be markedly higher relative to the latter group. I also expect that team members will more often report communications that are proximal ("face to face" or in "conferences) relative to non-members, who may be more likely to use some technological medium (e.g. "email), and that team membership will associate with more frequent communications.

Descriptive network data are available in Table 1. The number of surveys by industry is shown in the parentheses under each sector title in the top row of the matrix. Eight of the initial 38 respondents came from the private sector. Two respondents were classified as associations. Two were classified as non-profits. Fourteen respondents came from local research centers, community colleges, or universities. Three came from K-12 schools. Six came from government and One Stops. Two were from representatives from WIRED regions, one being a WIRED region outside of New Jersey. One participant came from an organization that did not fit cleanly into these other sectors, and was categorized as "other." No surveys were obtained from venture capitalists. As explained earlier, three collected surveys were redundant with other surveys from the same organization or department, meaning that the surveys were representative of organizations or departments that were already represented by at least one other

participant. Redundant surveys were combined such that all linkages indicated by any party were accounted for. For each redundant survey, only one had answered questions on the nature and quality of each relationship; the other only answered questions on pre- and post- Bio-1 Initiative linkages. This meant that there was no need to derive averages for overlapping questions (e.g. goal sharing); it also meant that there were not multiple categorical responses for the same relationships. Combining redundant surveys meant that there are a total of 35 ego-nodes represented in the network.

The values in the matrix in Table 1 illustrate how post-Bio-1 linkages were distributed within and between industry sectors. The heavy connectivity between colleges, universities and research centers and other sectors is clearly attributable to the overrepresentation of academic institutions in the dataset. In any case, the data show a comparatively high number of linkages between academia and other academic organizations (70), the private sector (66), and government (68). The private sector is also well-linked to associations (28), government (19), and WIRED regions (14). K-12 schools are well-linked to colleges, universities and research centers (19). Additional statistics on intra- and inter-industry communication frequencies are available in the table below.

Insert Table 1 about here

Preexisting Linkages. A key theme that emerged in the interviews was the importance of preexisting social capital in getting Bio-1's administrative structure formed off of the ground. Many of these relationships were held by the Initiative's administrator and a

group of individuals that were responsible for the grant who worked closely with this administrator. For example, this group was able to leverage preexisting contacts into local companies to solicit private sector involvement. They were also able to leverage relationships with already-established associations targeting the biopharmaceutical industry to improve articulation.

Figure 2 depicts the preexisting relationships held by the administrator's organization as well as one such close contact. In this sociograph, the "administrator" nodes are colored black. Nodes that unique to the left-side administrator are colored blue, while those unique to the right-side administrator are colored red. The two nodes that represent shared communication contacts are shown as pink. This figure shows that right-most administrator held comparatively few connections prior to Bio-1's inception; however, and consistent with the interviews, three ties of these ties connected to large pharmaceutical companies operating out of central New Jersey. Two ties were to government and one was to a local research university. The right-side administrator, a university representative and grant writer, held five pre-existing ties to the private sector and five to government agencies or one-stops (government-funded skill development agencies), eight to colleges, universities or research centers. Two ties were to local biopharmaceutical associations with longstanding histories in the region, which interviews revealed severed as key ports of access into the private sector. Two ties were to organizations classified as "other;" one of these organizations included a local news media agency.

Insert Figure 2 about here

Network Growth. The network image presented in Figure 3 illustrates the pre- and post-Bio-1 networks as given by those that participated in the survey. In these images, the nodes are colorized such that survey respondents are coded black, while those identified as communication contacts by these individuals are colored gray. Out of the 498 total linkages identified in the post-Initiative network, 252 (50.6%) were reported as being newly formed, representing a 102.4% increase from pre- to post-Bio-1.

Insert Figure 3 about here

Administrative centrality. In considering these networks, it must be emphasized that the networks depicted do not represent the overall nature of relationships among all organizations participating in the Bio-1 Initiative. They narrowly illustrate the inter-organizational relationships as experienced by the sample that participated. As such, the centrality of certain organizations as it relates to the whole may be overstated, while the peripherality of others relative to the whole may also be overstated. Still, notwithstanding these limitations, the networks do implicate highly central roles for both administrator nodes, as would be expected.

Network density. Density in social networks represents the number of linkages present out of the total number of linkages possible. The density in the pre-Initiative network is .0382, while the density in the post-Initiative is .0464, representing a 21.47% increase. This comparatively small increase in network density is due to the fact that only a minority of organizations included in the dataset participated in the survey.

Consequently, the total number of linkages increased from pre- to post-Initiative, as did the number of nodes. However, linkages between selected-but-not-surveyed nodes could not be identified. The resultant increase in nodes and the lack of intermediary linkages therefore artificially lowers density statistics. This limitation makes it difficult to gauge accurately the changes in density from pre- to post- Initiative networks.

Network growth by team membership. The matrix shown in Figure 6 presents pre- and post- Initiative network images for those involved in teams versus those who were not involved in these teams. Twelve of the 35 nodes depicted in the survey are representative of the communication patterns of team members. 23 are representative of non-members. Pre- and post-Initiative networks are shown in the rows; team-member and non-member networks are contrasted across the two columns. Team-member nodes are colored blue; non-members are colored red. The linkages in focus in each image are colored maroon to better illustrate differences between the cells in the matrix. As expected, the team members in the sample, nearly all of whom regularly attended scheduled meetings, reported substantially stronger overall network growth relative to those not involved in the teams (144.9% for team members versus 44.15% for non-members).

Insert Figure 5 about here

How did communications primarily occur? Across all relationships that provided an answer to the question (364), 33.24% of linkages were reported as being primarily email-based. 12.9% were reported as being primarily “face-to-face.” 7.7% were reported as

occurring mainly via conferences. Less than one percent of linkages were reported as being primarily telephone-based. 46.7% were reported as occurring via a mixture of methods.

Table 2 shows percentages for how communication primarily occurred by team membership. Data for this table came from the longer version of the survey, for which there were only 32 unique surveys. It is also important to emphasize that these linkages include all reported ties by every survey participant who answered the question on how communications primarily occurred. It does not account for duplicate ties, which means that it is possible and indeed likely that some linkages represent overlapping relationships. That surveys were completed at the level of organizations meant that a participant from Organization A could report communicating with Organization B face-to-face, while a person from Organization B reported communicating with Organization A primarily via email. To the extent that the individuals were referring to different people, both responses could be accurate. These data treat each linkage as unique. Accurately stated, therefore, Table 2 reports "how communications primarily occurred" patterns as reported by team membership status.

Vertically, Table 2 is broken into two parts. The top of the table presents communication linkages for the entire dataset (pre- and post-Initiative linkages combined). The bottom part of the table presents only those linkages that were formed after Bio-1 began. This format allows us to easily contrast communication patterns across the entire dataset against those that are newly formed. As expected, the data show that team members in the sample were more likely to report communicating with their selected contacts in-person, whereas those who were not team members more often

communicated via some technological medium. For example, among those not participating in teams, 46% of communication linkages were reported as being primarily email-based, while 11 percent (4% via "face-to-face" and 7.3% via "conferences") occurred through in-person interaction. 38 percent occurred via a mix of methods. One communication linkage was reported as phone-based. In contrast, only 18.72% of the linkages were primarily email-based for those participating in teams. Roughly 27% (18.72% via "face-to-face" and 8.3% via "conferences") occurred through in-person interaction. 54% occurred via a mixture of methods. No team-member's linkage was reported as being phone-based.

These disparities remain largely intact when considering the networks that are newly formed. As shown in the bottom half of Table 2, 41% of team-members' new linkages were reported as being proximal (27% for "face to face" and 8% for "conferences), versus 15% for non-members. Non-members also reported that 60% of their newly-formed communication linkages were facilitated primarily via email, whereas only 10% of team members reported the same. Team members also more often indicated that communications were occurring primarily via a "mixture of methods" relative to non-members (49% for team members versus 25% for non-members).

Insert Table 2 about here

How frequently did communications occur? Table 3 presents data on the frequency of communications as reported by team membership status. The same caveat as above applies here. As above, the top part of the table presents communication linkages for the

entire dataset (pre- and post-Initiative linkages combined). The bottom part of the table presents only those linkages that were formed after Bio-1 began. Counter to my expectations, there is no clear trend between team-membership and communication frequency for the pre- and post-Initiative networks combined. Non-team-members were markedly more likely to report weekly (21% for non-members versus 2% for team members) communications relative to team members overall. However, as shown in the bottom half of the table relationships (2% for non-members versus 1% for team-members), many of these communications appear to represent preexisting ties. Perhaps these linkages are between individuals that communicate regularly through work and not through WIRED Bio1. One peculiar statistic for newly formed relationships is that team members are much more likely to report "yearly" communications than are non-members. This disparity suggests that many of newly formed relationships may represent weak ties that were facilitated mainly through annual events (e.g. summits) or other irregular activities.

Why did communications occur? Several binary (yes/no) questions were used to measure why communications occurred. 48% (out of 356) of inter-organizational linkages were reported as being for securing additional resources. 63% (out of 359) of linkages were reported as being for partnering for new activities. 60% (out of 361) of inter-organizational linkages were reported as being for learning information that is useful for their organization. 41% (out of 361) of the linkages were reported as being for problem solving.[6]

[6] These percentages should not add up to 100% given that each communication topic was a unique question.

Table 4 presents a series of stacked matrices depicting why communications occurred by various sector-to-sector relationships. The reason for communication is shown in the vertical text in the left most column of each matrix. Percentages for communication topics are shown in the cells, while the number of valid linkages between sectors is shown in parentheses. It should be noted that sector-to-sector ties with low frequencies make it difficult to draw meaningful insights from these percentages. Moreover, these statistics do not account for the fact that some survey-takers may have had a tendency to rate relationships high or low, which could bias these data substantially. The data are nonetheless presented for descriptive purposes.

As is shown in the table, the most common communication topic for linkages between academic institutions (70%, and for linkages between academia and the private sector (76%), was partnering for new activities. Government agencies' linkages to academia were also most often to partner for new activities. Government agencies' linkages most frequently engaged with other government agencies around issues of problem solving (.73%). In contrast, government linkages least often communicated with the private sector around issues of problem solving (39%), while academia linkages least often communicated with the private sector for issues of problem solving.

Goal Sharing. Across all relationships that were given a response to the goal sharing measure (358, via 32 surveys), the mean was 3.74. For those involved in the teams, the mean level of goal sharing was 3.86. The mean was slightly lower, at 3.64, for those not involved in teams.

Insert Table 4 about here

DISCUSSION

This study set out with two objectives. The first was to understand the elements behind Bio-1's model of network facilitation. The second was to quantify, as best as possible, the extent to which relationships grew, among whom, and the nature of emergent relationships.

Bio-1's model of network facilitation relied on several parts. The first – leveraging existing relationships, boundary spanning, and publicity efforts – allowed Bio-1 to identify community members were the most likely be interested in participating, and, at times, apply social pressure to become involved. In turn, Bio-1 leveraged these contacts, and accompanying legitimacy, by way of aggressive publicity efforts to the broader regional community. The second factor built from this foundation. By being flexible and accommodating personal and at times normative interests, Bio-1 was able to create buy-in and enthusiasm throughout the committees and teams. Creating forums for stakeholders with shared passions and complementary backgrounds also helped to generate enthusiasm and commitment. The alignment of shared passions meant that team members and event attendees departed from common and sometimes normative footings. This allowed relationships to gel naturally and efficiently. The stakeholder diversity that was infused into these settings also meant that collaborations were value-adding, as each collaborator carried a unique insight or vantage point. Fourth, and finally, the Bio-1 Initiative institutionalized and articulated a common framework. This framework attempted to articulate the broader economic significance of Bio-1, and the fact that these issues cut across numerous regional stakeholders.

There were, however, two apparent constraints to collaboration that are important to mention. One of these was observed and criticized by participants; the other is a potential problem down the road. An area for improvement voiced by two interviewees was the lack of integration and articulation between strategy teams. As noted, participation for many occurred primarily through their team involvement. For many, moreover, team involvement meant meeting and interacting with the same cohort of people, continually, over the life of Bio-1's funding. Although several participants volunteered on multiple teams, these teams, for the most part, operated in relative isolation. That each team's leader assumed a post on the governance board allowed upward articulation. However, mechanisms for lateral articulation – and, thus, additional opportunities for network augmentation – appeared to be underdeveloped. It was suggested in two interviews that the collaboration process could be strengthened if mechanisms for lateral integration were better incorporated.

A second potential constraint may be the lack of a technology in place to institutionalize Bio-1's networks after its funding comes to an end and formal activities dissolve. The presence of a central administrator proved critical on several occasions in terms of leveraging and coordinating a vast body of diverse contacts scattered throughout the region. It is possible and indeed hopeful that Bio-1's facilitated networks will endure after its funding expires. However, it is not immediately clear what will come of the administrator's accumulated centrality if she pursues opportunities elsewhere. Given that this person was employed by Bio-1 and will no longer receiving funding once the grant expires, it is unclear the extent to which this centrality remain be accessible to the regional community down the road. Thus, here, it would seem valuable were Bio-1 to

have implemented some interactive technological medium that made permanent its fostered networks. For example, this medium could store and make contact information as well as brief biographies readily available not only of team-members, but of other peripheral participants who might nonetheless be of collaborative value in the future.

Regarding network growth, the results for the most part were not surprising. Selected communication contacts expanded substantially for surveyed participants from pre- to post-Initiative; network growth was markedly stronger for team members relative to non-members. Team members also had propensities toward more proximal communications ("face to face" or via "conferences"), whereas non-members more often used some technologically medium (namely, "email"). One surprising statistic in these data was the increased likelihood that team members would report annual communications for newly formed relationships relative to non-members. At first glance, it seems unlikely that such infrequent communications would lead to enduring and functionally meaningful relationships. A key but as of yet unanswerable question is whether any of these newly formed relationships maintain.

Implications for Policy

There has been widespread skepticism among scholars that government has any legitimate part in cluster building activities. Sabel (1993) proclaimed that most "economic development programs […] are either well-intentioned failures or publicity-minded frauds" (cited in McEvily and Zaheer, 2004, p. 191). Bresnahan, Gambardell, and Sexenian (2001) have argued that it is "[…] foolishness of directive public-policy efforts to jump-start clusters or to make top-down or directive efforts to organize them" because

"[c]lusters of innovative activity do not respond well to being directed […]" (p. 857). This skepticism is justified; as of this point, few if any government-led efforts to create innovative clusters have succeeded in their task.

From the standpoint of policy, part of the difficulty in designing and developing clusters is attributable to the systemic and often idiosyncratic evolutions of the regions that have proven successful (Finegold, 2009; Powell, forthcoming). On one level, successful clusters function as a system of interdependencies: Educational infrastructures develop and the talent behind innovative ideas and entrepreneurship. These educational systems also nourish the region with a ready supply of human capital. Social, cultural and regulatory environments make regional investment – by people and by firms – more or less desirable. Meanwhile, the social capital that materializes between actors at all levels provides conduits for regionally embedded ideas and knowledge. These networks, along with the condensing of innovative activity, may also facilitate intra-regional mobility and therefore make risk-taking more feasible. An absence or attenuation of any of these areas may stymie a cluster's evolution (Finegold, 2009). On another level, many successful clusters have formed by way of serendipity and unplanned historical contingencies. Powell (2010), for example, in tracing the development of the United States' most successful biotechnology hubs, concluded that several of the nation's most vibrant clusters derived from idiosyncratic good fortunes, such as, in Cambridge, Massachusetts, the abundance of pubs in the area where scientists invariably chatted after work.

The Bio-1 Initiative was not an effort to *create* an innovation cluster. It sought to improve an already existing one by strengthening the human capital resident within it, and by fostering linkages between key industrial stakeholders that could derive social and

regional benefits through the collaboration. The impact that funded proposals will have on the state's economic vitality is difficult to foresee and even quantify. Whether newly formed relationships endure in meaningful ways is also an empirical question that has yet to be answered. From the standpoint of facilitating inter-industry collaborations, however, Bio-1 sheds insight into the fundamental administrative problem of catalyzing relationships that are genuine as opposed to those artificial or contrived. Whether or not relationships stem from genuine social affinities may be an important precursor for trust and sustainability.

Traditionally, the types of relationships that have been theorized to give rise to vibrant regional economies were not between community members working toward some altruistic social goal, such as increasing minority participation in the sciences, or even workforce development more broadly. Instead, the relationships deemed most valuable in regional economies stem from buyer-supplier trust and coordination (e.g. McEvily and Zaheer, 2004) and informal information sharing (e.g. Jaffe, 1989), where linkages between scientists and other innovators diffuse knowledge that becomes "sticky," or regionally embedded. Strong economic arguments can be made for alignment between skill-building and employer demands (see Lynch, 1994). Moreover, fostering interest in the sciences among young could contribute to a deep, well-developed pipeline of talent, so long as the young people wish to reside in New Jersey following their graduations. However, for Bio-1, it is unclear whether relationships that endure from this effort will contribute to benefits on par with those provided by these more traditionally-recognized antecedents to comparative advantage. An important question is thus whether Bio-1's

model generalizes in ways that make possible the sorts of coordination and leakages that have proven valuable in other settings.

In McEvily and Zaheer's (2004) model of government-facilitated trust-building, competing organizations were brought together to exchange information on proprietary, firm-specific routines in order to improve efficiencies between regional buyers and inputs. A key contextual element here was the need to overcome employers' natural reluctance to disclose private information with direct competitors participating in the project. The task for the network facilitator was to appease these anxieties, in part by articulating the ways in which standardizing routines between local buyers and suppliers would prove mutually beneficial in terms of improved efficiency (McEvily and Zaheer, 2004). In sharp contrast, with Bio-1, pressures to reveal private information were far less intense, if they were ever present at all. The challenge was to motivate a diverse pool of regional professionals to contribute time and energy toward Bio-1's "public good" through individualized incentives.

Bio-1's model, it would seem, extends most plausibly to informal relationships of innovative knowledge diffusion – potentially between scientists, entrepreneurs, or venture capitalists, for example. An interesting thread in the Bio-1 story is that the network itself, for some participants, became a major part of the allure: Participants were drawn in to networks with others who shared similar goals and motivations. These networks provided value-adding services and resources not just for funding projects but also for activities that were of direct personal or organizational benefit. While not a government-led entity, UCSD's CONNECT program operates by a similar dynamic: CONNECT hosts several hundred events each year focused on legislative matter, capital

acquisition, training and education, and networking opportunities for local businesses, entrepreneurs, scientists, and other stakeholders. Membership has boomed since the project's inception in 1986: Hundreds of businesses, as well as individual members, have become actively engaged in the network[7]. The business case for participating in Bio-1 was not nearly as salient. But part of this is attributable to scope: CONNECT goals are broad and dynamic, whereas Bio-1's focused more narrowly on workforce development. The important generalizable theme is that networks in both cases were facilitated or strategically guided by way of meaningful incentives and network opportunities.

Limitations

There are several limitations in this study that must be addressed. First, regarding the interviews, comparatively low levels of representation from certain organization types, including the private sector, necessarily limits our understandings of how Bio-1 was experienced by these organizations. Many insights were garnered from team participants who worked closely with private sector members, including high level administrative members, who had intimate experiences with getting the private sector involved. More limiting is that venture capitalists, K-12 school representatives, and other types of organizations had no representation in the interviews whatsoever. Venture capitalists seemed somewhat peripheral to the effort. K-12 schools, however, were highly relevant to generating interest in the sciences among young people. Several participants suggested this sector was very difficult to reach. It is unfortunate that no interviews from this sector were secured.

[7] http://www.connect.org/members/investor-members.php

The network data were limited by several factors. Some of these limitations derived from the survey instrument itself, and the fact that most network surveys were distributed over a distance. The survey format was unconventional and not intuitive to people unfamiliar with network analysis. Several emails were exchanged between individuals who were confused in trying to complete the survey (despite its instructions). Although these individuals came to understand the process, it is possible that others who stayed silent attempted to fill out the survey without fully understanding the format. Related, the length of the survey was also problematic for some survey-takers. One survey-taker, after selecting a certain number of communication contacts, only answered questions for roughly 3/4^{ths} of these organizations; thus, I could only discern pre- from post-network growth for 3/4^{ths} of the survey-taker's selected contacts. This was an isolated instance. However, the fact that survey length corresponded directly to the number of communication contacts selected presented a disincentive to select more contacts – or, if someone was highly connected, to be honest about communication contacts. One might be inclined to select fewer communication contacts in order to shorten the length of the survey. This limitation is faced by nearly all network surveys.

Summary

This thesis has presented a case study of a government-led effort to foster inter-industry linkages in central New Jersey's biopharmaceutical cluster. It used in-depth interviews to inform a framework explaining how a government-funded intermediary functioned to stimulate economically-valuable collaborations, as well as friendships, between key and previously-unconnected regional stakeholders It also employed a quasi-longitudinal

network analysis to measure the network growth and relationship quality of a sample of 38 individuals who had varying levels of participation in the effort.

In-depth interviews identified four factors that were instrumental government-led network facilitation. The first of these relied on leveraging interpersonal familiarity through preexisting relationships and boundary-spanning ties. Preexisting relationships helped administrators to efficiently identify the prospective participants who would most likely be interested in volunteering. It also seemed to apply implicit social pressure to participate. Boundary spanning meant that administrators leveraged the contacts of contacts, thus beginning a snowballing process whereby outreach and the joining of new recruits continually expanded the project's network. The participation secured through this process helped Bio-1 secure some basic infrastructure and legitimacy. The aggressive publicity efforts that followed helped articulate the Bio-1 and brand and solicit further participation. The second factor built from this foundation; it involved an aggressive an ongoing push to build legitimacy and awareness in the region through sponsored events and presentations. It also involved articulating a diverse range of strategies and goals, as opposed to a singular mission. Diversity in goals and strategies increased the likelihood that community members would find at least one area that was of personal (and often normative interest), and therefore one that warranted an investment of time and energy. The forth factor created forums form shared interests and stakeholder synergies. The final factor involved creating a shared mental framework, which, among other things, contributed to the understanding that the outputs of collaborations from a regional standpoint could in fact benefit inter-industry exchange.

Network analysis revealed marked growth from pre- to post-Initiative. Network growth was much stronger for team-members versus looser, more peripheral participants. Team members also appeared more likely to engage in proximal communications ("face to face" or in "conferences") relative to non-members; non-members more often reported communications through a technological intermediary, such as email. One surprising finding was that team members were more likely than non-members to report "yearly" communications with new communication contacts, which may call in to question the enduring utility in some of these newly formed relationships. A second question is whether this model of network facilitation generalizes to other sorts of intra-regional relationships – such as, for example, relationships of buyer-supplier coordination, or relationships of knowledge-diffusion between co-located scientists.

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TABLES AND FIGURES

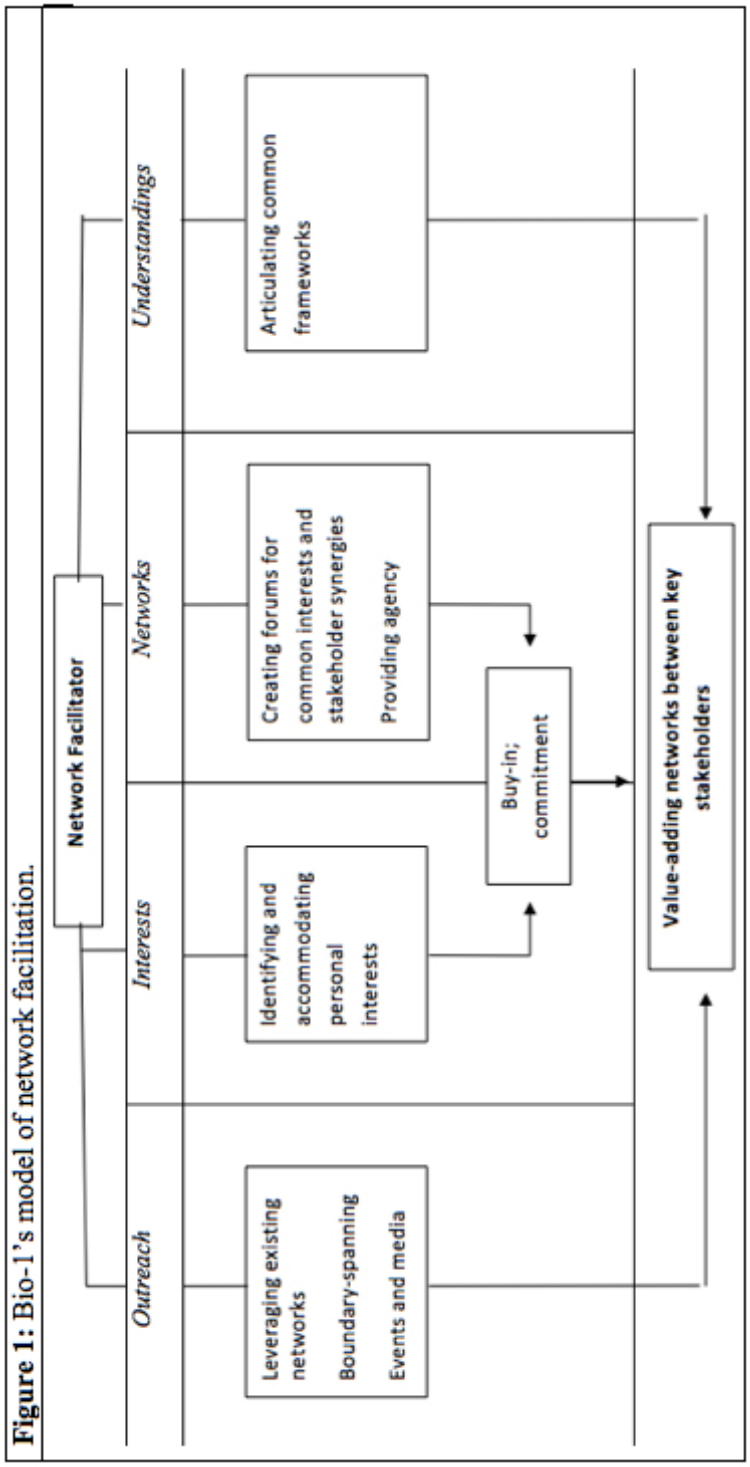
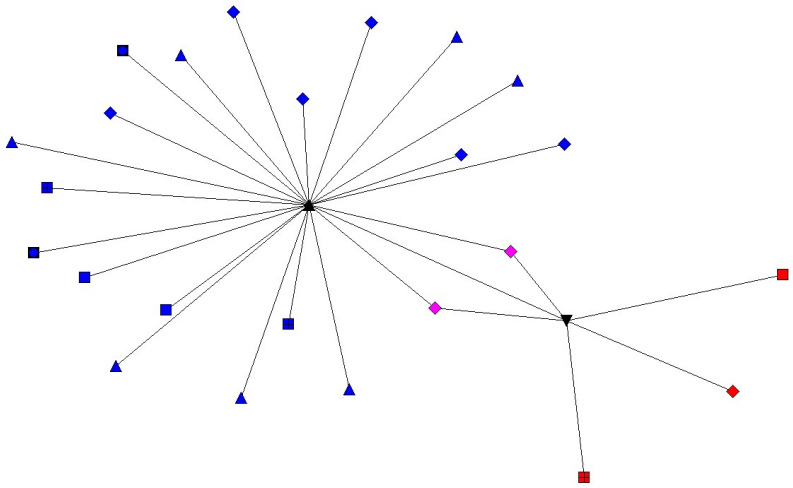


Figure 1: Bio-1's model of network facilitation.

Figure 2. A comparison of administrators' pre- Bio-1 Initiative communication contacts. N = 2, reciprocity assumed.

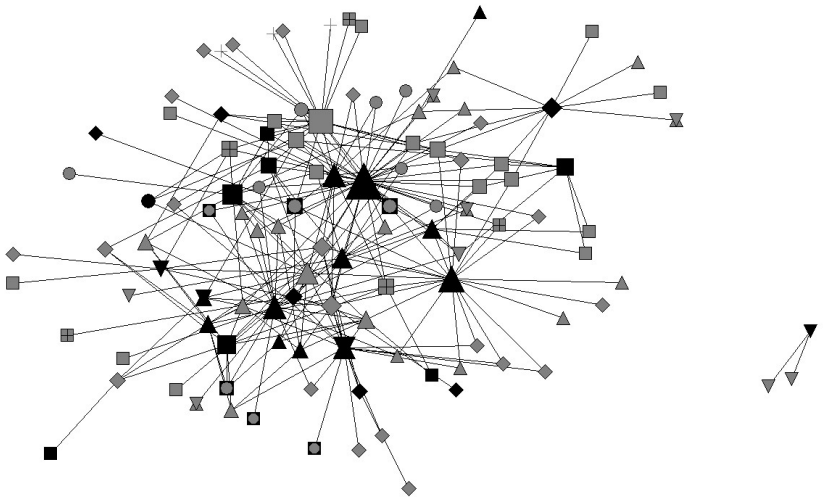


Key: The left-side administrator's unique communication contacts are depicted as blue nodes. The right-side administrator's unique communication contacts are depicted as red nodes. Shared communication contacts are shown as pink nodes.

Colleges, Universities and Research Centers	K-12 and Technical Schools	Venture Capitalists	
WIRED regions	Government and One-stops	Associations	
Non-Profits	Companies	Other organizations	

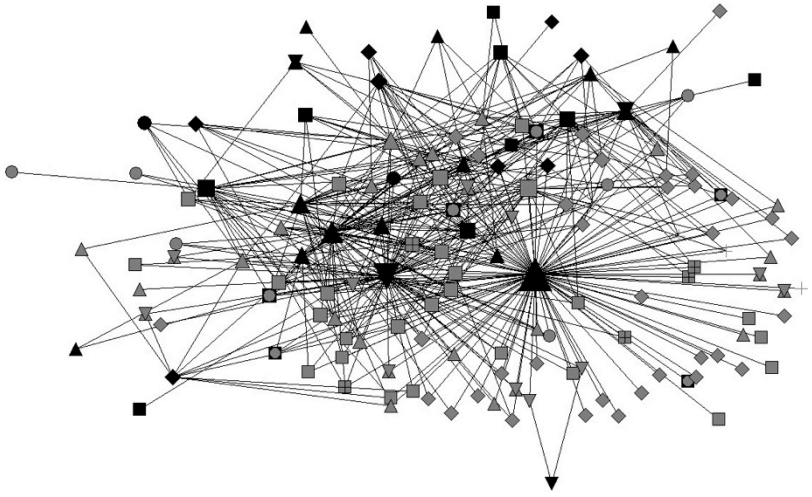
Figure 3. Comparison of pre and post-Bio-1 Initiative communication patterns as given by survey participants. N = 38, reciprocity assumed.

Pre-Bio-1 Initiative



Total Linkages: 246

Post-Bio-1 Initiative



Total Linkages: 498 (102.4% change)

Key: Survey participants are depicted as black nodes. Gray nodes were not surveyed but were selected as communication contacts by survey participants.

Colleges, Universities and Research Centers	K-12 and Technical Schools	Venture Capitalists	
WIRED regions	Government and One-stops	Associations	
Non-Profits	Companies	Other organizations	

Table 1. Sector to sector communication frequencies. Number of surveys per sector in parentheses. N = 38. Bio-1 Communications Survey, 2009.

	Private Sector (8)	Associations (2)	Non-Profits (2)	Colleges, Universities, Research Centers (14)	Government and One Stops (6)	K-12 Schools (3)	WIRED Regions (2)	Venture Capitalists (0)	Other (1)
Private Sector	3	28	1	66	19	-	14	-	5
Associations		7	1	37	9	1	5	-	2
Non-profits			1	11	1	-	5	-	-
Colleges, Universities and Research Centers				70	68	19	21	4	13
Government and One Stops					22	6	24	3	2
K-12 Schools						-	4	-	1
WIRED							6	1	4

Table 2. How communications primarily occurred as reported by team membership status. N = 32. Bio-1 Communications Survey, 2009.

		Number of ties	Proximal		Distal			
			Face-to-face	Conferences	Email	Phone	Mixture	Total
Pre and Post-Initiative linkages combined	Ties reported by team-members	201	19%	8%	19%	0%	54%	100%
	Ties reported by non-team-members	146	4%	7%	46%	5%	38%	100%
Linkages formed Post-Initiative	Ties reported by team-members	110	27%	14%	10%	0%	49%	100%
	Ties reported by non-team-members	48	2%	13%	60%	0%	25%	100%

Table 3. Frequencies of communications as reported by team membership status. N = 32. Bio-1 Communications Survey, 2009

		Number of Ties	Daily	Weekly	Monthly	Quarterly	Yearly	Total
Pre and Post-Initiative linkages combined	Ties reported by team-members ties	230	5%	2%	24%	35%	34%	100%
	Ties reported by non-team-members	146	1%	21%	31%	43%	29%	100%
Linkages formed Post-Initiative	Ties reported by team-members ties	114	2%	1%	13%	36%	48%	100%
	Ties reported by non-team-members	49	-	2%	16%	47%	35%	100%

Table 4. Mean goal-sharing levels by sector-to-sector communication linkages (frequencies in parentheses). N = 32. Bio-1 Communications Survey, 2009.

	Private Sector	Associations	Non-Profits	Colleges, Universities and Research Centers	Government	K-12 Schools	WIRED Region	Venture Capitalists	Other
Private Sector	3.67 (3)	3.64 (28)	2 (1)	4 (57)	3.29 (17)	-	-	-	1.75 (4)
Associations		3.14 (7)	1 (1)	3.68 (25)	5 (7)	4 (1)	-	-	2 (2)
Non-Profits			0 (1)	3.7 (10)	5 (1)	-	-	-	-
Colleges, Universities and Research Centers				3.58 (48)	3.9 (50)	3.64 (14)	3.67 (6)	5 (4)	4.23 (13)
Government					4.25 (20)	4.75 (4)	4.67 (3)	5 (3)	2.5 (2)
K-12 Schools						-	-	-	-
WIRED Region							3 (2)	-	-
Venture Capitalists								-	-
Other									-

Acknowledgment of Previous Publication

After this thesis was written and approved, but before I submitted it to the university, I used some of my writing, as well as several tables, in the following co-authored publication:

Finegold, D &**McCarthy, J.E.** (2010). Creating a Sectoral Skill Strategy: Developing High-Skill Ecosystems. In Transforming the U.S. Workforce Development System: Lessons from Research and Practice. Editors: D Finegold, M Gatta, H Salzman, and S Schurman. Labor and Employment Relations Series. LERA, Champaign, IL: 181-204

My co-author, David Finegold, did not write any part of the thesis, nor did he contribute directly to the data collection, analysis, or creation of the Figures used in this thesis and the publication.