Government Responses to Network Failures:
The Case of the Manufacturing Extension Partnerships
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Short Abstract:

While inter-firm networks provide an increasingly important alternative to arm's length transactions in knowledge-intensive industries, they are notoriously difficult to build and maintain. Various hypotheses have been advanced for the sources of such collaboration: cultural, organizational and institutional . This research attempts to quantify the relative importance of the factors contributing to the success of collaboration projects by developing and analyzing survey and interview-based indicators of public inputs to network production among small and mid-sized firms-with a particular focus on their provision through the Manufacturing Extension Partnerships sponsored by the Federal Government.

Intellectual Merit: This research contributes to the literature about the rationale for government intervention to foster innovation in the United States. Government intervention is typically justified as a response to market failure, and represents an effort to make markets more competitive. However, a growing body of literature argues that innovation tends to occur in "collaborative spaces" that are sheltered from market competition. The focus of the research is to examine whether there is a mismatch between the process of innovation and the rationale for innovation policy. The research examines the relative importance of public inputs to network production among small and medium-sized firms in a study of the Manufacturing Extension Partnerships (MEPs) sponsored by the National Institute of Standards and Technology.

Broader Impact: The research produces a publicly available data set that can be used to examine the relationship between government inputs and network production. The results inform a variety of different disciplines, such as economics, sociology and political science. The study also engages and trains graduate students in the research processes.

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Long abstract

This proposal outlines research that will address the empirical as well as the normative rationale for active science and innovation policy in the United States. It is premised on a distinction between policies that are designed to combat market failures and policies that are designed to address what we label "network failures." While the former are subject to frequent evaluation, and are therefore relatively well understood, the latter are misunderstood by policymakers, overlooked by program evaluators, and given short shrift in Science of Science and Innovation Policy. Such oversights are particularly troubling in light of a growing consensus that inter-firm networks provide a productive alternative to arm's length transactions in knowledge-intensive industries. We are therefore soliciting a three year grant to develop indicators of public inputs to network production among small and mid-sized firms with a particular focus on their provision through the Manufacturing Extension Partnerships (MEPs) sponsored by the National Institute of Standards and Technology. The research will include a survey of the nature and level of support for collaborative activity across 59 local MEP centers; an effort to test competing accounts (e.g., cultural, organizational, institutional) of the propensity to collaborate at the local level; and case studies of the impact of collaboration in different regional contexts.

Intellectual merit: While the literature on science and innovation policy in the United States recognizes that innovation frequently occurs in collaborative networks rather than arm's length markets, science and innovation policies tend to be justified in terms of market failures rather than network failures. This is due to a number of related factors including the hegemony of the so-called market failure paradigm, the fact that existing performance metrics tend to ignore network production, and the strength of a conventional wisdom that holds that US political and cultural institutions are irremediably hostile to network production in any event. In combination, these factors risk turning efforts to substitute market for non-market coordination into self-fulfilling prophecies. We therefore plan not only to develop a conceptual framework that addresses the problem of network failure but to use that framework to develop metrics to understand their potential mitigation. Our research will build upon our recent work on innovation policy in the US, explore a distinct rationale for the nation's public investment in science, and contribute to the development of a theory of network failure capable of guiding intervention into the network economy down the road.

Broader impact: What motivates science and innovation policymakers? While the conventional wisdom treats market failure as the primary justification for public investment in science and innovation, we have reason to believe that practice is running ahead of theory and that public officials are responding to the pressures that have animated the decentralization of production by building networks as well as markets. Our research will begin to make sense of their efforts and thereby yield three major impacts: first, a rigorous test of the correlates of collaborative innovation efforts in the United States; second, a publicly available data set on government inputs to network production; and third, a conceptual framework that will not only help make sense of our own findings but will also augment out understanding of the rationale for public investment in science.

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What is the rationale for an activist science and innovation policy in the contemporary United States? While mainstream economists take the market as their "starting point" (Powell 1990: 298), and therefore justify government intervention by way of reference to market failure, their critics hold that "network failures" (Schrank and Whitford 2009b) are neither less threatening to the post-Fordist innovation process nor less susceptible to policy intervention, and therefore imply that a new rationale is taking root "behind the backs" (Block and Keller 2009: 477) of both the actors involved and their observers in the academy. For example, Walter Powell and Stine Grodal hold that interorganizational networks provide a particularly productive alternative to arm's length transactions in knowledge-intensive industries (Powell and Grodal 2005). Joel Podolny and Karen Page worry that network arrangements nonetheless tend to fall short of their goals in practice (Podolny and Page 1998: 71). And Fred Block and Matt Keller therefore document the growth of government "efforts to overcome failures that are endemic in networked forms of economic organization" (Block and Keller 2009: 476).

Unfortunately, the science and innovation policy literature tends to give network failures and their correction short shrift for at least three related reasons. First, the so-called market failure paradigm (Crow and Bozeman 1998; Feller and Cozzens 2008) continues to dominate the theoretical debate. Efforts to combat network failure are less advanced in theory than in practice. Second, existing performance metrics tend to ignore network production. They track policy inputs and outputs at the firm—rather than the network—level (National Science Foundation 2007). And, finally, the conventional wisdom holds that US political and cultural institutions are irremediably hostile to network production in any event (Dore 2000; Nooteboom 2000; Hall and Soskice 2001b; Boyer 2005). Efforts to substitute market for non-market coordination therefore become self-fulfilling prophecies (Weiss 1998).

We plan to address the empirical as well as the normative aspects of network failures and their correctives and are therefore soliciting a three year grant to develop: (i) indicators of public inputs to network production among small and medium-sized firms; (ii) an account of their proliferation through the Manufacturing Extension Partnerships (MEPs) sponsored by the National Institute of Standards and Technology; and (iii) case studies of their impacts. The goal is not only to assess the variable government propensity to promote "innovation networks" (Helper and Stanley 2006) at the local level but to lay the groundwork for future studies that will assess the outcomes of public intervention in a more rigorous fashion. Our research therefore promises to build upon our recent work on innovation policy in the US (Schrank and Whitford 2009b; Whitford 2005), explore a distinct rationale for the "nation's public investment in science" (Interagency Task Group 2008: 13), and contribute to the "development of a *theory* of network failure capable of guiding intervention into the network economy" (Schrank and Whitford 2009b) down the road.

What exactly do we mean by network failure? Network failures arise where the social and political requisites of interorganizational collaboration fail to obtain and actors who would otherwise reap the rewards of reciprocity are tempted to abandon their network exchange

partners for less fruitful markets or hierarchies (Schrank and Whitford 2009b). While public officials combat network failures on a regular basis, they currently lack a theoretical language to describe and defend what they are doing, and they are therefore forced back into the market failure paradigm by default—with unknown consequences for American science and innovation.

The debate over the recently abolished Advanced Technology Program (ATP) provides a particularly apposite example. While the program's critics wholeheartedly embraced the market failure paradigm, and therefore derided government subsidies to firms that had "no trouble funding their own R&D" (Slivinsky 2007: 8), they ignored the fact that the ATP influenced the *nature* as well as the *level* of the innovative effort—and that the latter was not necessarily more important than the former. For instance, Maryann Feldman and Maryellen Kelley compared ATP award winners and non-winners and found that the former were not only more likely to collaborate with new partners but to sustain their collaborations into the future than the latter. "Paradoxically," they argued, "the profit incentive that motivates innovative activity by an individual firm also discourages information sharing and collaborative R&D activities between companies" (Feldman and Kelley 2001: 190). Efforts to enforce the market failure principle of "government by exception" (Zysman and Tyson 1984: 42) therefore run the risk of *provoking* network failures.

Efforts to combat network failure by "getting the relationships right" are nonetheless ill at ease on American soil. After all, the US is the very archetype of a "liberal market economy" (Hall and Soskice 2001a) and has therefore been widely portrayed as inveterately hostile to non-market coordination. Some trace the alleged US antipathy for network arrangements to laws and institutions that prohibit cross-shareholding, atomize employment relations, and fetishize shareholder value (Dore 2000; Hall and Soskice 2001a). Others focus on American individualism and values (Haake 2002; Halsall 2008). And Mari Sako identifies a "vicious circle" of "low trust" and "long term contracts" in the US automotive industry in particular (Sako 2000: 108).

Path dependent accounts go too far by half, however, for they simultaneously exaggerate the homogeneity and the distinctiveness of the American model. Thus, Sanford Jacoby characterizes the country as an admixture of communitarian and liberal beliefs that is no less hospitable to Silicon Valley than to the "Chandlerian corporation" (Jacoby 2005: 624). Gary Herrigel identifies "consortial, associational, and corporate" experiments in supplier upgrading in the Upper Midwest (Herrigel 2004: 68). And Michael Piore and Charles Sabel underscore the parallels between the liberal and communitarian models by invoking the lessons of agricultural extension in the farm belt. "The federal government provides independent farmers with detailed technical and commercial advice," they note, "just as regional technology centers in Japan and artisans' associations in Italy provide autonomous producers with the information they need to do business" (Piore and Sabel 1984: 303; see also Piore and Sabel 1983).

The Manufacturing Extension Partnership brought the extension model from agriculture to industry in the late 1980s, and thereby put Piore and Sabel's faith in the flexibility of the American arrangement to the test. After all, the MEPs are designed to disseminate knowledge and best practices to small and mid-sized manufacturers. They are sponsored by the National Institute of Standards and Technology, administered by more than 50 different state and local centers, funded by a more or less equal combination of federal, state, and local (i.e., fee for service) revenues (Shapira and Kuhlmann 2003: 276), and self-consciously modeled on Japan's regional technology centers (Fukugawa 2008; Shapira 2008), Italy's artisan associations (Rosenfeld 2002), and the more familiar experience of agricultural extension in the US (Hallacher 2005; Helper 2009). Ideally, the MEPs would not only disseminate new technologies

to small and medium-sized firms but would contribute to their development by fostering process and perhaps even product innovations (Ruigrok and Tate 1996).

The MEPs have been subject to ongoing and repeated performance evaluations for nearly two decades. External reviewers and program staff examine a range of metrics including the number of clients served, types of services offered, and volume of revenues generated by the individual centers as well as employment, sales, and productivity growth among their clients (Shapira 2001). The findings to date are ambivalent. While the MEPs perform well on a series of narrow targets like job creation and sales growth (NIST 2009), they arguably tailor their efforts to meet the demands of their evaluators—and in so doing overlook more valuable opportunities that are less likely to be reflected in their scores (Luria 1997). In fact, Philip Shapira worries that existing metrics overlook "hard to measure or intangible activities" like the promotion of "customer-supplier dialogue or inter-industry networks," and thereby give MEP officials "weaker incentives to conduct those activities—even though these activities may ultimately be more important for long-run fundamental upgrading" (Shapira and Kuhlmann 2003: 276). Nor are his worries anachronistic. While the Corporation for Enterprise Development advised the NIST to make inter-firm collaboration a criterion of MEP effectiveness more than a decade ago (Rosenfeld 2002, p. 43), the agency continues to ignore collaboration in favor of traditional metrics like revenue and job creation (NIST 2009; NIST 2008).

The disjuncture is particularly striking in light of the growth of "collaborative projects" at a number of local centers (Folk 2009: 7; see also Herrigel 2004) and the MEP's effort to take advantage of their apparent success by reinventing itself as the "focal point" of American manufacturing in the early twenty first century (Kilmer 2008, p. 6; (see also NIST 2008). How widespread are these experiments? Where do they garner their support? And what are their likely outcomes? The proposed research will address these questions in three sequential stages: first, a survey of the *nature* and *level of support for* collaborative activity across 59 local MEP centers; second, an effort to test competing explanations (e.g., cultural, organizational, institutional) of the *propensity* to collaborate at the local level; and third, case studies of the *impact* of collaboration in different regional contexts. Subsequent research can build upon our findings by developing longitudinal data, more rigorous performance assessments, and theoretical insights.

Phase 1. Survey design and administration, Summer 2010-Winter 2010.
Our research begins with a telephone survey designed to gather data from the 59 existing MEP centers. The survey will include a series of closed- and open-ended questions designed to elicit information on the nature and volume of services offered and delivered as well as background questions on the individual centers and their personnel. We anticipate: (i) *objective* questions on the supply, demand, and delivery of pre-packaged versus custom services, the frequency of individual versus collaborative service delivery, the demand for the different services and delivery vehicles, and the allocation of staff time to the different products and clients; (ii) subjective (i.e., Likert-type) questions on the perceived value of the different services and delivery vehicles to the centers, their clients, their workers, and their communities; (iii) background questions on the centers and their staff (e.g., budget, experience, training); and (iv) open-ended questions designed to probe for experimental or atypical projects unlikely to be revealed by the closed-ended questions. Because the open-ended questions will in all likelihood require follow-up questions "on the fly," we will use knowledgeable research assistants to conduct the survey rather than contracting with a survey research center.

We will design and pretest the survey in five stages. First, we will review the available documentation on the MEP. We have already noted the frequency with which the MEP is

evaluated. Extensive documentation therefore exists already. Our research assistants will help us collect, digest, code, and distill the existing literature in an effort to inform both the survey and subsequent research. Second, we will review the broader literature on "innovation and diffusion institutes" (IDIs) like the MEP including Japan's regional technology centers and corresponding agencies in Italy and Germany (Ruigrok and Tate 1996). A large body of literature suggests that foreign IDIs are more inclined to promote collaboration (or networking) among their clients than the MEPs (Rosenfeld 2002; Ruth 2006; Fukugawa 2008). We will draw upon their experiences during survey design and administration. Third, we will arrange interviews with NIST personnel in Washington, DC. Our goal is to tap their broad knowledge of the MEP and their understanding of the program's recent evolution in particular. Fourth, we will incorporate the knowledge gained from our document reviews and interviews into the design of the survey itself. One of the most important tasks will be distilling our understanding of the program into straightforward definitions and indicators of concepts like "pre-packaged service" and "collaborative delivery." Fifth, we will carry out a series of survey pretests. We want to survey the complete population of 59 MEPs and will therefore carry out the pretests not on MEP centers but on state-level IDIs that are not part of the MEP network (e.g., the Benjamin Franklin Partnership in Pennsylvania, the Thomas Edison in Ohio). The pre-tests will inform a final revision of the survey instrument, and the survey itself will be carried out in the winter of 2010.

Phase 2. Quantitative data analysis, Spring 2011-Summer 2011.
Survey data will allow us to map the distribution and weight of collaborative MEP efforts and to assess their correlates. The existing literature traces variation in the likelihood of network (or non-market) coordination to a number of factors including political culture (Trigilia 1986), social capital (Rosenfeld 2002), union density (Thelen 2001), industrial organization (Powell 1990), and government capacity (Hassink 1997). We will collect indicators of the alleged correlates of network coordination at the state and county levels in order to map the indicators to the (variable) jurisdictions of the MEPs. For instance, Joel Lieske has created a highly disaggregated measure of political culture (Lieske 1993). Robert Putnam has introduced a number of indicators of social capital (Putnam 2000). Barry Hirsch and his colleagues have derived disaggregated estimates of union density from the Current Population Survey (Hirsch, Macpherson and Vroman 2001). Katherine Barrett and Richard Greene have estimated state government capacity (Barrett and Greene 1999). And their data can be supplemented with more precise data on the capacities of the local MEPs from our survey. (We are by no means wedded to these variables and indicators; we introduce them for illustrative purposes.)

Our goal is to build a complete dataset in the spring of 2011 and to carry out the analyses in the summer. While the results will be interesting in their own right, and will lead to at least one publishable paper, they will also lay the groundwork for the comparative case studies we plan to carry out between late 2011 and 2013.

Phase 3. Comparative case studies, Fall 2011-Spring 2013.
Case studies of individual MEP centers and their communities are doubly advantageous. First, they will help us establish the "causal paths" behind the associations unearthed by the quantitative analysis (NSF 2007, p. 15). Qualitative data offer particularly valuable insights into the mechanisms underlying statistical associations. And, second, they will offer preliminary insights into the impacts of the collaborative efforts coordinated by the MEPs. By snowball sampling we will not only locate program participants but will also be able to map "the technology diffusion process at least one layer into the broader network by including in the case non-participating customers, competitors, suppliers, and other organizations" (Watkins 2001: 152).

The case studies will begin midway through the project and the individual cases will be selected based in part upon criteria derived from the first two phases. Our presumption is that centers in different geographic regions—with different industrial, political, and cultural characteristics—will behave differently, and our preliminary goal is therefore to study eight MEP centers classified along two dimensions: collaborative propensity (high or low); and geographic setting (rustbelt versus sunbelt). We will subject two centers from each combination to study and will choose the individual MEPs based in part upon additional criteria that emerge in the survey and initial interviews (e.g., organizational characteristics) as well as considerations of access.

Our approach to the case studies will necessarily be informed by our experience carrying out fieldwork in IDIs and industrial clusters in Europe, Latin America, and the United States. We will begin by reviewing existing studies of the centers in question and carrying out initial interviews with their directors. Our past experience suggests, however, that field staff and their interlocutors, including partner organizations involved in service delivery (e.g., community colleges), are no less important. We therefore anticipate 5-10 interviews on the delivery side per center. Service-side interviews will be supplemented with "demand-side" interviews with clients—including representatives of firms involved in collaborative activities sponsored by the MEPs in particular—and their associates (e.g., customers, competitors, etc.). We anticipate at least 10 demand-side interviews per MEP center. Our goal will be to develop alternative means of identifying and assessing the potential effects of program interventions on collaborative or network activities in particular.

Finally, we will adhere to the strictest ethical standards throughout the life of the project. Survey instruments and interview protocols will be subject to rigorous human subjects review at the lead institution. Respondents and interview subjects will be guaranteed confidentiality. And records will be organized by number rather than by name, address, or other identifying characteristic (See Whitford 2005 for an extensive discussion of the methodological and confidentiality issues that inhere in interview-based research on relationships between firms and between firms and other institutions).

Relationship with previous work

The proposed project builds upon years of individual and collaborative work on small firm networks, industrial policy, and the governance of decentralized production in the United States, Europe, and Latin America. We have extensive experience collecting and analyzing data from firms and government agencies, carrying out interviews with public and private officials, and developing the theoretical tools and background knowledge needed to execute the project. For example, Whitford's recent book includes a case study of a collaborative program in which the Wisconsin MEP worked with a consortium of large manufacturers to promote modernization and collaboration among their suppliers (Whitford 2005). He therefore has firsthand knowledge of the MEP and the cross-pressures confronted by program staffers who are frequently forced to choose between intangible experimentation and the delivery of measurable results.

In addition to his work on decentralized production in the US, however, Whitford has carried out extensive fieldwork in Italy. In 2005 he co-authored an article on the implications of Fiat's 2002 crisis for industrial policy in Piedmont (Whitford and Enrietti 2005), and in 2007-2008 he retuned to Italy to conduct a case study of the metal manufacturing industries found in Emilia-Romagna—a region that not only plays host to one of the canonical examples of an industrial district but has also informed the experience of the MEP (Rosenfeld 2002). Whitford and his Italian colleagues are currently using a combination of quantitative and qualitative data

collected in Emilia-Romagna to trace the changing network structure of the district (Russo and Whitford 2009).

Like Whitford, Schrank has carried out extensive research on industrial development in the US and abroad including studies of textile, clothing, and footwear clusters in Latin America (Schrank 2004; Schrank 2008a; Schrank 2008b), software development in the US and Mexico (Piore, Ruíz Durán, and Schrank 2005), and the renewable energy industry in the southwestern US (Schrank 2010). His recent work on the relationship between Sandia National Laboratories and the growth of the renewable energy industry in New Mexico links science and innovation policy to regional development, and his cross-national quantitative work addresses broader SciSIP issues including the reinvention of industrial policy in Latin America, the growth of biomedical research in East Asia, and the diffusion of intellectual property protection to developing countries more generally (Kurtz and Schrank 2005; Shadlen, Schrank and Kurtz 2005; Lee and Schrank 2009).

Our collaborative work on the specific issue of network failure dates to conversations inaugurated approximately two years ago in which we came to a surprising conclusion: While the buyer-supplier relationships we had been studying tend to go awry with great frequency and for systematic reasons, the literature on network forms of organization had produced no systematic notion of "network failure" akin to the notions of market- and organizational failure than inform the literatures on rival governance mechanisms. We therefore set out not only to develop a theory of network failure but to understand how it might inform public policy—and in so doing produced two forthcoming papers (Schrank and Whitford 2009b; Whitford and Schrank 2010) and a third paper that will be submitted to a journal by the end of the year (Schrank and Whitford 2009a). We expect the current project not only to advance our network failure agenda but to produce a publicly available data set that others can use for their own purposes.

Fit to SciSIP.
Our proposal treats the rationale for public investment in science and innovation as an empirical as well as a normative question. We ask not only what *should* motivate science policy but what *actually* motivates science policymakers. Are they addressing market failures, network failures, a combination, or something else entirely? And why are they doing so? And in addressing these questions we contribute to the SciSIP agenda in three ways: first, by directly examining the origins and development of communities of science and innovation; second, by indirectly exploring the development, adoption, and diffusion of innovation; and third, by building a conceptual framework that may change the way we think about the value of public investment in science.

Interdisciplinarity
Our research draws tools and concepts from sociology (networks), economics (market failure), political science (varieties of capitalism), and science studies (incremental innovation). It should inform debates in each of these disciplines as well as in the realm of public policy. Of course, the point is not that we will find converts to the network perspective in each of these fields; however, by placing our work in dialogue with several different disciplines, we believe that we can help foster meaningful debate among critics as well as sympathizers.

Education and training.
Over the course of the project's lifetime we will employ at least two, and in all likelihood more, research assistants. They will be involved in all aspects of the project and will thus gain experience in document review, survey design and administration, quantitative data analysis,

open-ended interviewing, and write-up. We have budgeted to include the RAs in the fieldwork and project meetings in order to maximize both efficiency and pedagogy. We believe that the project could ultimately give rise to at least two dissertations.

Dissemination.
We plan to disseminate written results at conferences and published results in a series of papers and ultimately a co-authored book. We also plan to make our working papers available to NIST and the MEP and to make our data set publicly available. Toward that end we have budgeted for the appropriate information technology and programming support.

Conclusion
What motivates science and innovation policymakers? While the conventional wisdom treats market failure as the primary justification for public investment in science and innovation, we have reason to believe that practice is running ahead of theory and that public officials are responding to the pressures that have animated the decentralization of production by building networks as well as (and sometimes in lieu of) markets. If we are to understand the origins, outcomes, and requisites of network construction, however, we must first transcend the market failure paradigm long enough to collect and interpret data on government science policy inputs at the network rather than organizational level. Our proposal constitutes a first step in that direction and in so doing opens the door not only to a better understanding of the "street level bureaucrats" who are administering American science policy but to a conceptual framework that may well place the case for public investment in science on a sounder theoretical footing.

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