Faculty Research Working Papers Series

Searching for Answers: Networks of Practice Among Public Administrators

Maria Christina Binz-Scharf
City College of New York

David Lazer
John F. Kennedy School of Government - Harvard University

Ines Mergel
Syracuse University

October 2008
RWP08-046

SEARCHING FOR ANSWERS: NETWORKS OF PRACTICE AMONG PUBLIC ADMINISTRATORS

Maria Christina Binz-Scharf
City College of New York
mbinzscharf@ccny.cuny.edu

David Lazer
Harvard University
david_lazer@harvard.edu

Ines Mergel
Syracuse University
iamergel@maxwell.syr.edu

ABSTRACT

The obstacles to innovation in government have been the subject of much academic scrutiny. Far less studied, however, has been the sharing of innovation among public administrators. How does a lesson learned, for example, in one agency provide insights that other agencies might borrow? Such sharing of experiences across agency boundaries, while at times potentially offering enormous value to the system as a whole, faces substantial challenges. In the US, one fundamental challenge is the natural dispersion of government across the country, within state and local government. We examine the alternative mechanisms that evolve within the public sector to compensate for this dispersion of expertise. In particular, we argue that the knowledge sharing practices of DNA forensic scientists working in government crime labs constitute such an alternative mechanism. Findings from an in-depth case study of this community suggest that concerns around trust, reliability, and cost, interacting with context specific features, result in the emergence of a network of practice that is fairly parochial, with a few dominant hubs, and a reliance on different channels depending on the needs for security in communication. We conclude by discussing the theoretical and practical implications of our findings.

Keywords: Knowledge sharing, search, innovation, network of practice, case study

Acknowledgements
Support by the NSF (grant #0621242) and by PSC-CUNY (grant #60098-3536) is gratefully acknowledged. *Any opinions, findings, and conclusions or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of the NSF or CUNY.* We thank Maya Benish-Weisman, Juliana Gorian, and Lauren Salvatore for their able research assistance. An earlier version of this paper was presented at the 29th Annual APPAM Research Conference in Washington, DC.

INTRODUCTION

The obstacles to innovation in government—inertia, the lack of competitive pressures, asymmetries in rewards and punishments—have been the subject of much academic scrutiny. Far less studied, however, has been the sharing of innovation among government actors. How does a lesson learned, for example, in one agency, one state government, provide insights that other agencies might borrow? Such sharing of experiences, while essential to the effective operation of any system, faces substantial potential challenges when it might usefully occur across government organizations. In the US, one fundamental challenge is the natural dispersion of government across the country, within state and local government. In contrast, in the private sector, knowledge spillover from one firm to another naturally leads to the organic emergence of clusters of firms and individuals within a particular industry (Krugman, 1991), with dense networks connecting individuals within and across firms (Podolny & Page, 1998; Powell, Koput, & Smith-Doerr, 1996; Uzzi, 1997). Silicon Valley, Hollywood, and Wall Street are but a few examples. Within the public sector, however, there is often less potential for this natural emergence of geographically concentrated clusters. In the US there is a constitutionally mandated dispersion of authority to state governments, and within states there are further pressures toward "geographic equity", translating into exogenous limits on geographical clustering in the public sector. This dispersion of authority leads, in turn, to a dispersion of expertise. Because spatial propinquity facilitates the development of knowledge spillover, this dispersion potentially undermines knowledge sharing across organizational boundaries, especially in knowledge intensive domains.

To compensate for this dispersion, there is a tendency for alternative mechanisms to evolve to facilitate knowledge sharing. As a point of comparison, in academia, which is also highly dispersed, there have arisen academic conferences, journals, listservers, and a variety of

Internet forums for sharing of research, information, and knowledge. The public sector, of course, poses a very different institutional setting than academia, where it is less clear that there is an alignment of individual interest in sharing and community needs for sharing.

However, the effective sharing of knowledge across organizational boundaries is essential to the performance of systems. Given the political and bureaucratic circumstances of the public sector, innovative knowledge needed to solve crime cases is not always systematically spread through the overall system. There are only a few examples where knowledge sharing has been institutionalized by law: The diffusion of legislative processes across states was introduced by law, when all felons had to be entered into a national database. We examine the diffusion of innovation at the administrative rather than legislative/high level policy level. So much of policy is at the street level, of small decisions by public employees; and surely much policy diffuses through informal networks of those employees that cross jurisdictional boundaries. However, most of the literature on federalism and diffusion, following Walker (1969) focuses on the legislative level (e.g., Soss et al. 2001). Here we examine those micro-level processes of knowledge diffusion across jurisdictional boundaries.

When it comes to individual practices and the need for interpretative knowledge based on prior experience, i.e. not available in form of manuals, the knowledge needed might not be an innovation for the overall system. It might simply be that it is only innovative to the individual knowledge requestor. Rogers defines the spread of innovative information (or innovations per se) as the diffusion process through which it is communicated through certain channels over time among the members of the social system (Rogers, 1995).

Here we are looking at knowledge diffusion from a different angle and focus on the individual sourcing strategies. We are adding an active component to Rogers' diffusion theory:

innovative knowledge is not passively transported through the social system, but actively sought for based on individual choices. This qualitative viewpoint of the procedural micro-level decision includes the individual's choice of source and the reason for the selection of the chosen specific source. Researchers, such as Nebus (2006) have suggested the use of individual choice models in theories of social structure (Coleman & Fararo, 1992; Lindenberg, 1985, 1990a,b).

In this paper, we aim to shed light on these processes in the public sector: What search strategies do individuals adopt when looking for information, and what determines their search strategies? That is, where and how do people search for answers?

In an in-depth case study, we explore a particular knowledge-intensive and geographically dispersed community — that of DNA forensic scientists working in government crime labs. The use of DNA in the criminal justice system has grown exponentially in the last decade (Lazer, 2004), and this growth, combined with the rapidly changing technology, has created a particular need for inter-organizational knowledge sharing among the approximately 180 government labs scattered across the country involved in forensic DNA analysis. The decentralization of the US system is particularly at odds with the functional needs for scale and knowledge sharing, potentially encouraging the emergence of alternative mechanisms. Many of these labs have just a handful of DNA analysts.[1]

Our case study highlights the complex calculus of government officials in choosing where to go for answers. Key drivers of the search process include: beliefs regarding reliability (in the quality of a potential source human or nonhuman); trust (that revealing ignorance through asking the question will not be held against the questioner); and cost (what gets an answer quickly and with minimal effort). Strikingly, we also find that the emergent structure seems to

[1] In contrast, in the UK, which has about the same sized database than the US, forensic analysis is largely done by a single organization.

take on some of the features of a virtual organization, with critical concerns about managing boundaries between people in the network and outside of the network, and an hierarchy built on experiences and expertise, with large labs acting as national hubs, and small labs revolving around the expertise of those large labs.

RELEVANT PERSPECTIVES ON NETWORKS OF PRACTICE AND SEARCH

Networks of Practice. In the knowledge-based view of the organization (Grant, 1996), knowledge is viewed as a scarce resource, and its creation and use is what determines the competitive advantage of an organization[2]. Within the organizational literature, the idea that there exist knowledge-based "communities of practice" has gained substantial currency. Communities of practice are sets of professionals dispersed within a well-bounded community who have similar responsibilities (Wenger, 1998). One of the most famous examples that have been studied is a community of Xerox repair representatives (Brown & Duguid, 1991) [3]. A related but broader concept is that of *networks of practice*, which can be defined as a set of loosely coupled relationships that serve as bridges across formal organizational boundaries. They emerge from connections practitioners establish among each other to share common practices and to support the knowledge flows within their community (Brown & Duguid, 2000, 2001). The reason why we refer to a network of practice rather than community of practice is that (1) the former evokes the key relational drivers of knowledge sharing (i.e., the knowledge is typically being shared between a source and a destination, not to and from the whole community), and (2) the populations we are interested in are not clearly bounded, and "network" suggests the reality

[2] Knowledge is different from information in that knowledge requires interpretation in order to be acquired, which generally occurs through a learning process (Nonaka, 1994).
[3] The term "communities of practice" was coined by Lave and Wenger (1991), who studied learning in traditional apprenticeship systems, such as that of Yucatec midwives.

that there is a wider system to which a particular "network of practice" is connected, where there is not a clear dividing line between subsystem and system.

We should note that networks can have analytically different roles. While there is a growing body of literature on public sector networks (e.g. Bardach, 1999, 2001; Meier & O'Toole, 2001; Milward & Provan, 2000), this literature mainly focuses on process interdependence, analyzing coordination networks among various agencies. That is, how do agencies need to communicate, for example, to effectively deliver particular kinds of services? Our focus here is on knowledge interdependence, which is more established in the disciplines of sociology, organizational behavior, and information systems. We therefore draw on these literatures to study networks of practice among bureaucrats.

Individual Search Processes. For any given question, there are a wide array of places an individual can go for an answer. For example, consider a scenario drawn from the domain we study in this paper: a DNA analyst has a question regarding how to calculate the probability that a known individual might have contributed some of their genetic material to a messy mixture found at the crime scene. This is a fairly common but particularly difficult problem, dealing with issues in interpretation of samples, rules governing the use of the database of profiles, and complex mathematical calculations. Potentially plausible paths for the analyst to go down include: posting a query to a listserver of other DNA analysts, calling up a known authority on the subject, tracking down literature on the subject, and so on. Or, framed more generally, for any question, government professionals confront a menu of alternative sources, and alternative media to reach those sources.

Such a construction of knowledge sourcing highlights the issue of where, given the vast menue of potential sources of answers, do people actually go? There is a substantial literature on what *human sources* individuals will go to (Nebus, 2006), highlighting that professionals rely on their communities of peers when it comes to specialized knowledge (Cross, Parker, Prusak, & Borgatti, 2001; Orlikowski, 2002). For example, predictors at the dyadic level (who will I go to) include: general strength of ties (Granovetter, 1973; Hansen, 1999), and friendship, in particular (Krackhardt & Hanson, 1993; Nelson, Bloomfield, Hales, & Libby, 2001), similarity (McPherson, Smith-Lovin, & Cook, 2001), and perceived expertise (Cross, Borgatti, & Parker, 2001). Unsurprisingly, one study on search behavior concludes that individual search strategies are in part contingent on the *type of knowledge sought* (McGrath, 2001). But also *who* is doing the search influences the strategy: Researchers in the library sciences analyzed the patterns of how professionals search for information. They found that the behavior of knowledge seekers is determined by the professionals' work roles, associated tasks, and the characteristics of information needs; and that awareness, sources, and outcomes affect information seeking (Ellis & Haugan, 1997; Leckie, Pettigrew, & Sylvain, 1996). Another study on search behavior of a particular group of professionals found that the *choice of a source over another* is determined by prior knowledge, where the perceived credibility, or trustworthiness of a source is the strongest predictor for choosing it (Kerstetter & Cho, 2004).

These studies, however, fail to capture the full richness of the phenomena. First, most of the studies on search behavior are mono-source—for example, which *people* do individuals go to (Nebus, 2006)? Or, which *reference sources* do individuals go to (e.g., Ellis & Haugan, 1997; Leckie et al., 1996)? However, individuals for any given question have a choice among types of sources, and media with which to reach those sources. Thus, for example, one might ask, when

do individuals turn to reference sources, such as the Internet or the library, when do they post queries en masse to a listserver, and when do they contact particular other individuals? Second, the focus has been on relational factors—e.g., do I seek answers from friends (Krackhardt & Hanson, 1993; Nelson et al., 2001)—but not on variables at other levels (e.g., systemic or individual). However, for example, at the individual level, there may be great variation in knowledge sourcing strategies. It is conceivable, for example, that individuals generally ask friends questions, but for there to be great individual variation in that tendency.

As noted above, the effective sharing of knowledge across organizational boundaries is essential to the performance of systems. This motivates understanding the process of knowledge sourcing within a particular system. Do people go to reliable sources? Do good practices disseminate within the network? Does bad information get dampened rather than amplified as it flows among individuals? Is it easy or difficult for individuals to get the answers they need? These are critical questions to understand whether the process of knowledge sharing within a network is facilitating the performance of its members.

RESEARCH METHODS

We are examining a domain—cross-jurisdictional diffusion of knowledge—in which there has been little research. When the subject of inquiry is a social phenomenon for which little or no theory exists, one way to cover that ground is to inductively generate new theory (Glaser & Strauss, 1967). This approach seems particularly appropriate to understand the processes and mechanisms of knowledge sharing among government actors, since not much is known about networks of practice in the public sector. We therefore chose to conduct a qualitative study aiming at generating theory that grows out of the knowledge sharing activities occurring in the empirical setting under inquiry (Emerson, Fretz, & Shaw, 1995).

Field Setting

We studied a network of geographically dispersed professionals who are each formally affiliated with a specific government crime laboratory anywhere in the US. [explain what disinguishes this profession from others, ref to Damanpour on professionalism]. These professionals, who are mostly forensic scientists[4], are all involved in forensic DNA analysis, which comprises tasks such as determining the usefulness of a DNA sample provided by crime scene investigators, the preparation of a sample for analysis, the interpretation of DNA mixtures (e.g. when the DNA of two or more individuals is present in a sample), and uploading the created DNA profile into a database. The minimum educational requirement for forensic scientists is a Bachelor of Science degree, most commonly in chemistry or biology. Many DNA analysts also have a Master of Science degree (often mandatory for supervisory positions) in chemistry, biology, or forensic science, and several among them have a Ph.D. in these or related disciplines. The work of forensic scientists is knowledge-intensive, specialized, and highly complex, and it is subject to constantly changing technology (Lazer, 2004). In addition, the profession has experienced an enormous rise in popularity thanks to the television series "CSI", a phenomenon insiders refer to as the "CSI effect". The two main exemplifications of this effect are (a) a dramatic surge in demand for forensic science education (and the subsequent mushrooming of such programs at colleges and universities across the nation), and (b) an increased demand by jury members for DNA analysts to testify at court hearings.

The nature of their work, as well as the fairly small number of forensic scientists involved in DNA analysis in government laboratories (there are about 180 such labs across the country, where the typical lab might employ a handful or so of analysts, with a small number of labs

[4] The field of forensic science is defined by the American Association of Forensic Scientists as "the application of the natural sciences to matters of the law".

which exceed 100 in size), has led many DNA forensic scientists to share the mutual feeling of being part of a network of professionals. Within this network, knowledge is shared across geographical as well as organizational boundaries on issues of varying complexity, such as the discussion of innovative techniques or interpretations of mixtures based on prior experience.

A particularly well-connected subset of DNA professionals is that of the so-called "CODIS administrators". Each state government laboratory employs one individual who is responsible for the state DNA database, a system provided by the FBI called CODIS (COmbined DNA Index System). The database contains the DNA profiles of qualified offenders (in most states, convicted felons) and profiles from crime scenes. The objective of the database is to link known individuals to crimes, as well as crimes to each other. However, only certain profiles are uploaded into the national system, which is governed by a complex and ever-changing web of rules and regulations set by the FBI. The CODIS administrator thus serves as gatekeeper for the database as well as liaison to the FBI for the laboratory. In addition, local laboratories within the same state submit their profiles to the state CODIS administrator for approval.

The figure below represents a highly stylized depiction of the system, where the large oval represents the system of state and local labs, the circles the state systems, some of which have multiple labs, and the small black dots individuals.

Insert Figure 1 about here

In sum, the knowledge-intensive nature of DNA forensic analysis in a manageable, closed universe makes this system an ideal setting for detecting and studying the overarching issues of knowledge sharing within government.

Data Collection

We selected the respondents for this study through purposeful sampling (Yin, 1994) according to the professional roles held by members of the community in a single case study design with multiple sites. All our respondents have similar skills, training, tasks and occupational positions within their organizational settings. Our initial choices of interviewees led us sequentially to additional important respondents within the community (Miles & Huberman, 1994). This method of sampling allows for comparability between the respondents, and at the same time incorporates the range of different realities that characterize the various US state governments. Our goal was to compile a comprehensive sample of individuals with the most common professional roles that reflects behavior across different types and sizes of state labs. We stopped recruiting additional respondents when we started getting very similar responses and therefore had reached saturation in our sample. Our final pool of respondents consisted of 28 individuals. An overview of respondents' professional roles and their affiliations is presented in table 2.

Insert Table 2 about here

We conducted semi-structured, open-ended interviews with these individuals lasting between 30 minutes and two hours each. The interviews covered the following topics:

Description of work function and work environment: the hierarchical relationships the respondent is embedded in and the proximity to peers within the lab;

Description of knowledge required for the job: the areas of expertise and the types of knowledge the interviewee required, such as technical or legal knowledge, advice, or opinions;

Habitual knowledge sources: the most commonly used knowledge sources for the identified types of required knowledge, media and venues used, and difficulties in retrieving knowledge from these specific sources;

Engagement in the community: the behavior of interviewees when approached with a question, in particular regarding their motivation to set aside time to answer questions from colleagues and peers, the content of questions, and reasons for answering certain questions rather than others.

Data Analysis

We transcribed and content analyzed all interviews using the qualitative research software package NVIVO (2006). Miles and Huberman (1994) point to two methods of creating codes. The first one mirrors essentially the grounded theory approach originally advocated by Glaser and Strauss (1967). The second method is to create a provisional start list of codes in the very early stages of the fieldwork (Strauss & Corbin, 1990). That list comes from the conceptual framework, list of research questions, hypotheses, problem areas and/or key variables that the researcher brings to the study. The latter method, which we chose to use in this study, has the advantage of bringing some structure into the coding process, as opposed to the completely unstructured (and consequently time-consuming and error-prone) process described by Glaser and Strauss.

Figure 2 shows a simplified version of our coding scheme. At the top level of the coding hierarchy are setting/context and activities/process. The *setting/context* category was constructed with the intention to capture accounts of the perceived reporting structure in the laboratories, e.g. whether individuals in the laboratories respect or bypass the chain of command, and what the role of the supervisor in the decision-making process is. The core subcategories of

setting/context address are aspects of culture, including the general workplace climate (open or closed doors? nice colleagues?), the predominant knowledge sharing practices at the organizational level, and the sense of belonging to a group as well as the perception of boundaries ("them versus us") at the community level. The category also covers facts about the laboratory, such as size, location, workspace, and general office characteristics.

In order to examine how and where individuals search for answers, we constructed the *activities/process* category. Here we recorded the interviewees' accounts of the online, offline, and human sources they use when searching for answers, the content (technical, legal, etc.) and the type (opinion, advice, confirmation, etc.) of information sought, as well as their rationale for choosing and sequencing their sources. Furthermore, this group includes references to interaction behavior, aimed at capturing aspects such as the individual's personality, motivation and willingness to share knowledge with others, and the means of communication employed in the interaction. Finally, we coded for personal challenges relating to the search process, e.g. difficulties in accessing information, feeling left alone, insecurities, and fear of failure.

Insert Figure 2 about here

Following the procedures outlined in Strauss and Corbin (1990), after an initial round of coding according to the scheme outlined above, we analyzed and cross tabulated the data. We then went back into the literature and searched for confirmation of themes that were emerging. Finally, we distilled our data into categories that were well supported. These categories constitute our first level findings, which we present in the next section. [5]

[5] The second level findings (i.e. the key drivers of search that emerged from the first level findings) will be addressed in the discussion section.

FINDINGS

Based on our concurrent analysis of case study data and relevant literatures, we identified several factors that influence knowledge sharing from the seeker's perspective. Our findings hint at various rationales for knowledge sourcing. In particular, we highlight how knowledge sharing is influenced by several contingency factors, such as the size of the laboratory the individual works at, acceptable or established work practices, and the degree to which communication is institutionalized. We then lay out how individuals choose a certain knowledge source because of its inherent characteristics. We discuss each of these findings in turn below.

Interactions With Knowledge Types

Consistent with the literature on search behavior, we observed that individual search strategies are in part contingent on the *type of knowledge sought* (McGrath, 2001). In particular, the type of knowledge individuals are looking for appears to be a good indicator for where they turn once they have assessed that they cannot find an answer in their lab's manuals. A generic search process, as it was described to us by the large majority of our respondents, is illustrated by this account:

> *The process goes from local manuals, [to] scientific publications, and then [to] peers. And when I say peers, now I'm talking outside of the laboratory. Because if we do not have it in our manuals, how to do something, we have to look outward.*

Especially the first part of the quote reminds us of the classical Weberian bureaucracy, which relies on the "knowledge of the files" by bureaucrats (Weber, 1946). The individual thus would refer to peers outside his lab only if he could not find the answer to his question in the procedural knowledge codified in manuals within his lab. We found, however, that search strategies varied at this point, according to particular types of questions individuals had.

Domain contingency. From our data, we identified three main groups of questions DNA forensic scientists commonly seek an answer to: (1) technical, (2) legal, and (3) interpretation questions. Examples for technical questions are how to calculate and present appropriate random match probabilities for a specific sample, how to manage lab procedures, or how to figure out who are good vendors for instruments or supplies. If the seeker has some seniority within the lab, these questions are often posed to peers outside the seeker's lab rather quickly, because the seeker either knows the manuals well, or has a good sense of what knowledge is present in the lab, as the quote below demonstrates:

> *We're limited on [statistical] knowledge, so we do need to go outside for that. From a casework perspective we'd like to think we've just about seen it all, here. […] We've been working with it for so long that, we'd like to believe that we can troubleshoot things here, with the knowledge base that we have. So I would say it's probably a statistic type issue. Maybe a kinship issue, relatedness. They're talking about searching databases now to find family members, the aspects involved with that. So that's probably just beyond where our comfort level is, and we would ask advice on that.*

Legal questions in this community often relate to figuring out CODIS rules, which are issued by the FBI and frequently changed. The FBI pays a contractor to maintain a CODIS helpdesk and generally discourages "informal" communication (i.e. bypassing the FBI) among labs, which affects the search procedure when it comes to legal questions for this individual:

> *I'd call the FBI [about CODIS rules]. […] But I wouldn't mess with anybody besides those people as far as from my perspective. Now we have somebody who's in charge of that in our laboratory, so if there's a general question, I'd probably go to our CODIS administrator first, ask them before we'd go to the CODIS people themselves. And that's how we generally handle that. I wouldn't necessarily go to another laboratory because those standards are open to interpretation and I figure, why mess with other peoples' interpretation, when the FBI's the one really making the ground rules. So I'll just go straight to them.*

Finally, interpretation questions address the correct interpretation of mixtures of two or more DNA samples, which several respondents referred to as "puzzle", and which requires a lot of expertise as well as teamwork. Individuals working "at the bench", i.e. DNA analysts who do the actual analysis of DNA samples, are generally required (as per their lab policies) to deliberate with their direct superior when it comes to the interpretation of mixtures, and therefore these questions tend to stay within the lab, as this description demonstrates:

> *Let's say somebody's got a real yucky mixture and they don't really know what to do with it or how to interpret it, we generally, if we have something that's not pretty straight forward, we will generally consult with each other. And consult with the people that are veterans that have been here for 9, 10, 15 years, or longer. So we kind of use each other, and try to make a decision amongst ourselves. And usually once we get a lot of input about a mixture or something that we don't really know what to do with, usually everybody will somehow help in making an overall decision on what to do with it.*

These accounts suggest that there is not a single strategy for knowledge sourcing, but that the strategy is deeply contingent on what questions the individual has.

Source-information contingency. As we stated above, we found that where people look for answers depends on what their questions are. In addition, source characteristics, especially those of human versus non-human sources, guide the type of source individuals will turn to with a certain type of question. Thus, for example, for certain types of questions there simply are very good non-human sources—e.g., in calculating match statistics. In other areas there are no good non-human sources—e.g., in searching for tacit knowledge about DNA data banking, which requires person to person synchronous communication.

> *[F]or an actual DNA data banking type question there is very little literature on it. It is all in people's heads, the information. So most of those issues are handled by calling people because there simply is not much to look for in print, either as a scientific paper or some kind of a text book because no such*

thing exists in this – that I'm aware of anyway – that is up to date and will give me information about a very specific new problem and so on.

Alternatively, if the knowledge is explicit and fairly simple (e.g., a yes/no question), a listserver offers a powerful tool to find answers, as another person expresses:

[On listservers] [p]eople are looking for practical answers, not theoretical. You have people asking it because they are facing […] something […] as simple as, "I keep getting a lot of duplicate offender samples being submitted by the prison. How do people deal with those?" That type – a simple question like that. And plenty of people would respond with how they deal with it, and whoever asks the question may not end up with a great policy, but at least they know how different people deal with it differently, and then they can form their own opinion and choose something that best fits their own state or own law or whatever.

However, as we briefly mentioned in the beginning of this section, the choice of the source is not entirely up to the questioner: Several restrictions are given by the rules and regulations that govern each lab. In particular, when dealing with the interpretation of a specific mixture of DNA samples that is being analyzed in a lab, the participants in our study consistently stressed the importance of keeping this discussion within the lab and subjecting it to the chain of command, as this individual points out:

Now if there was a conflict that would definitely be where you have to involve the supervisor. […] It's a requirement. If we have a conflict, it goes to a supervisor.

Clearly, the fact that a certain policy or procedural rule is in place does not mean that it is always followed to the letter. This is hardly a new phenomenon: In his groundbreaking study of interpersonal relationships in government agencies, Peter Blau found that practiced procedures often differed significantly from written procedures due to interpretive discretion (Blau, 1963). Similarly, we encountered several instances where individuals would reach outside their chain of command, or their lab, thus technically acting against official procedures, but in the end get the

answers they were looking for. Often, these practices morphed into pre-existing organizational routines, or triggered an adaptation of the procedures.

System Characteristics

Emergent hierarchies of labs. The DNA crime laboratories across the United States constitute a very heterogeneous population, and that greatly affects the knowledge searching of individuals. Labs range in orders of magnitude—from many labs with just a handful of examiners to a handful of labs with hundreds of examiners. We observed that within large labs, knowledge searching typically stays within the labs. However, large labs, by virtue of their sheer volume of experience, often become critical reservoirs of knowledge *for the system*. Our interviews suggest a large asymmetry in the flow of knowledge. Individuals from large labs report that they rarely go outside of their organizational boundaries to seek information, but also report a large volume of questions directed to them. Small labs have quite the opposite experience, as one interviewee describes:

> *I find that when you're a small laboratory and you don't have the time, money and personnel to put in to starting new programs, you're better off to sit back and listen to what everybody else has done, rather than reinvent the wheel. So that's kind of my philosophy on it. That's kind of how I go about getting information. If somebody has already validated a method or they're using a particular type of procedure and they say, "Hey, this is the thing to go to", I would defer to their judgment.*

The large labs therefore naturally become informational hubs, and the small labs informational spokes, with information flow from the large to the small:

> *The one resource that we've definitely leaned on a lot more than the others is the [name of biggest lab in state] lab. […]they're […] the cream of the crop basically.*

This quote reflects a broader tendency that we observed, where, for large states, for there to be one lab that was much larger than the others, where the small labs were informational satellites of the large lab, which highlights not just the emergent hierarchy of large and small labs, but also the importance of boundaries in the system, which we discuss later.

Context specificity. The underlying heterogeneity of labs presents a particular challenge for sharing knowledge. The utility of any information is tied to a particular context. How transcendent that context is defines the scope of the useful search for information. Thus, for example, the production of random match probabilities, in principle, should not vary from lab to lab. However, to usefully ask someone how to use a particular kit to analyze biological samples probably requires talking to someone from a lab that uses that kit; or to ask someone about state policies regarding disposition of biological samples will usually require talking to someone from the state. Further, for the many areas where there is unknown heterogeneity, finding out whether someone is in a useful position to answer one's question requires a search for information about their context in conjunction with searching for information about their solution, as one interviewee makes clear:

> *In terms of communicating with people, I don't necessarily just accept one person's idea on something as a standard. I kind of look at where they're coming from and I just then say, "What's going to work for us?" And I do that for a lot of different topics.*

Institutionalized processes. Much as organizational routines shape intra-organizational knowledge sharing, supra-organizational routines shape inter-organizational knowledge sharing. There were two types of institutionalized processes that we found to be particularly important in

shaping knowledge diffusion among DNA forensic scientists: (1) conferences and training; and (2) inspection processes.

There are two annual ***conferences*** that most forensic scientists attend: the annual meeting of the American Academy of Forensic Scientists (AAFS), and a conference organized by a large vendor (Promega). In addition, CODIS administrators attend an annual training, allowing them to make contacts with CODIS administrators from other states. Although CODIS administrators have access to each other's contact information through the CODIS website, [6] most of them reported to us that they are far more likely to actually contact a CODIS administrator from another state if they had previously met in person or had been introduced through a third party than if there had been no previous interaction at all. Moreover, the CODIS meeting is where stronger connections are made. One interviewee's experiences are typical:

> *You not only get that information during the day but I think the most important aspect of the meetings, is what happens in the evenings. Those bonds you develop as friends, allows you to develop those contacts over the years. And that has been an instrumental tool for me in my job. And I think it makes me twice as good as I would be otherwise. I mean my abilities are enhanced tremendously by my contacts.*

The ***inspection process*** plays an important control function for the FBI, but also facilitates peer-to-peer knowledge sharing—both at the time of the inspection, and subsequently. Each lab is regularly inspected for adherence to CODIS standards. The inspectors typically include examiners from other labs. The inspections thus take on a standard hierarchical function—facilitating control over the labs—but also an informal knowledge sharing function. Inspections require a fairly substantial engagement with the practices of another lab, and thus allow for the spread of a large amount of tacit knowledge. One individual describes the process:

[6] As we mentioned in the methodology section, there is no public record of CODIS administrators (and the list is jealously kept private by the FBI), making it very difficult for outsiders to get hold of this information.

> *We draw upon other agencies: their policies and procedures, and also just general experience and knowledge of the individual examiners. That includes the FBI. That includes the neighboring states. It is very common for us to go out and do an audit of another laboratory and bring some of that knowledge that we have gained in the audit home with us.*

Inspectors are thus a key conduit of information among labs—both among the labs that they inspect, as well as back to their home lab.

***Boundaries and Information Security*.** Our data also highlighted the paradoxical importance of needing to limit the flow of information to facilitate the sharing of information. This was particularly emphasized by the views of different people of the listservers. As one person from a lab recounted, a popular list regarding forensics expanded to include an increasing fraction of the outside community: *"So the interesting thing is that listserver evolved, and it evolved to include people who are non-forensic people. There were people on that list that were looking to overturn their convictions."* The inclusion of other people on the list—notably defense attorneys—created a concern that what was said on the list might come back and haunt individuals later. This provided the impetus to create another list that was invitation only: *"I felt like we needed a closed group because I wanted to discuss issues candidly and without intrusion or the feeling that you were being spied upon by all of these attorneys…. [W]e wanted a closed group, where we weren't going to have to eat our words on the witness stand, or eat somebody else's words or opinion."* Even with the closed nature of a list like this, some members of the community are unwilling to share answers on a listserver:

> *I don't respond usually to questions posted to the [list]serves…. I will respond to individual questions but I generally do not respond to the listserver questions, because I also don't know who's reading them. … It's not that I can't [respond], but I don't want if I'm going to court, I'm an expert in court a lot of times, something I say in the listserver to hit me in the face in court.*

Geographic, as well as virtual, boundaries also play an enormous role in the system. Geography often plays a key role in context (discussed above). There is clearly some convergence on local norms, which makes effective communication outside of a system more difficult. This seems especially true in larger states, which can achieve some scale internally. States may standardize technology (e.g., around the use of particular DNA analysis kits), and even mathematical standards (something one might anticipate would transcend boundaries), as this interviewee makes clear:

> *I don't think I ever have [gone outside of the system]. […] Going outside the system is a little bit problematic in that things are done differently in different places. We use random match probability, other places are using likelihood ratio or probability of exclusion or something, so, you'd have to consult with somebody using the same stat and interpreting in similar fashion.*

When we combine the geographic with contextual and hierarchy findings, the general picture that emerges of knowledge sharing is of large labs emerging as hubs in the system, with parochial labs within the state communicating largely just with those large labs, and, to some extent, with each other. Cross-state communication then focuses on issues that truly transcend state boundaries, such as around novel technology issues and the optimal design of new labs.

DISCUSSION

Paul Samuelson (1949) posited that an angel had conspired to create countries in which the factors of production were dispersed unevenly. His question: does international trade among nations reproduce the production of a single, integrated, economy. There is a certain parallel to the intellectual trade that occurs across state government. If one were designing a system from scratch, for example, one would probably not create 50 DNA database subsystems, which, in turn, were further divided into small subsystems. Samuelson's angel, at work again, can be seen as dividing up experience and expertise and dispersing them thousands of miles apart. What do our results suggest about the capacity of the emergent system to reconstitute and distribute knowledge in the dispersed system we call US government?

The first thing we would note is that the emergent system looks surprisingly similar to a formal organization, with the importance of hierarchy and boundaries. While formal authority stops at the border, informal authority (grounded in experience) does not. This highlights how powerful centralization is across organizational forms. Within hierarchies, capacities are formalized and consolidated; within markets, returns to scale lead to market concentration. Within the network we examine here, scale is (largely) exogenously determined (e.g., by the size of the state). The network essentially recreates some of the benefits of concentration, however, through the emergence of ties from the smaller labs to the larger.

There have also arisen a variety of institutions that facilitate the creation of cross-organizational social capital—most notably, national and regional conferences aimed at professionals in this domain. These conferences, in part reflect the control needs of the FBI (in particular, the CODIS managers meeting). However, most of these meetings simply reflect a

recognition that important sources of expertise exist outside of organizational and state boundaries.

These results also highlight the distinctive inefficiencies resulting from informal networks. Concerns regarding reputation clearly limit human to human questions, causing people to either seek nonhuman sources, or trusted human sources that may not have the appropriate expertise. The concerns about reputation as well as information leakage also severely limits the potential of communication technologies to bridge geographic gaps.

Our motivation in this paper has been to explore the network of practice that has emerged among DNA forensic scientists in government crime labs as a mechanism to compensate for the geographical and institutional dispersion of expertise that is characteristic of the US government.

We would synthesize our observations above into three key drivers: trust, reliability, and cost. We discuss each in turn.

Trust: Any exchange of information requires at least a small degree of trust—that the information being exchanged will not be used against either of the parties in the exchange. This is clearly true when people answer questions, but it is equally true when people ask questions, because the act of asking a question reveals ignorance. Trust is a particular concern in systems where there is the routine possibility of third parties using the information exchange against either of the parties—clearly an issue in the context we examine. The extent to which this is a concern will vary with the question. However, to the extent that it is a driver of the sequence of where people will look for answers, it will push individuals to first seek information from nonhuman sources, and then, among human sources, to trusted friends. Among various media for communication, it will push individuals toward sources that are not recorded (i.e., face to face

and phone), and, among media that leave a record, first to e-mail and away from listservers, and, among listservers, toward closed lists.

Reliability. Individuals have a clear interest in receiving accurate answers. For explicit knowledge, this pushes individuals toward published sources, and for tacit knowledge, toward experts/people with large volumes of experience. Among DNA labs, this leads to the centrality of the large labs in the knowledge network. Reliability of a potential source is also dependent on the knowledge of the source of the questioner's context—because the right answer is going to vary with the context. The need for contextual knowledge drives the parochialism of the network, so that for small labs, most of their questions are directed within the state.

Cost. Individuals also have an interest in receiving quick answers with the minimum of time invested. In this domain, given the complex and esoteric nature of the knowledge involved, nonhuman sources are often expensive to search and then process. This, in turn, pushes individuals to human sources—thus, for example, for that needle in a haystack bit of explicit knowledge—a listserver can be extremely effective. For more complex knowledge, engaging in a direct exchange with an expert can be vastly cheaper than attempting to process an academic tome. The desire to minimize cost also leads to parochial networks, because that shared contextual knowledge reduces the need for the questioner to share contextual information.

These issues of trust, reliability, and cost certainly transcend the particular case we examine. However, they interplay with characteristics of the case in ways that result in the emergence of a very particular network and pattern of media use. For example, the need for security certainly reduces the reliance on more transparent forms of knowledge sharing. Further, the need to deal with many state-based phenomena (e.g., courts, police, etc) and the particular

work processes involved pushes the network toward being more parochial; while some of the more transcendent features of the knowledge shared (e.g., around the science), and other work processes (e.g., the need to adhere to FBI standards) pushes the network toward being less parochial.

REFERENCES

Bardach, E. (1999). *Getting Agencies to Work Together: The Practice and Theory of Managerial Craftsmanship*. Washington, DC: Brookings.

Bardach, E. (2001). Developmental dynamics: Interagency collaboration as an emergent phenomenon. *Journal of Public Administration Research and Theory, 11*(2), 149.

Blau, P. M. (1963). *The Dynamics of Bureaucracy* (2nd, rev. ed.). Chicago: University of Chicago Press.

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities of practice: Toward a unified view of working, learning, and innovation. *Organization Science, 2*(1), 40-57.

Brown, J. S., & Duguid, P. (2000). *The Social Life of Information*. Boston, MA: Harvard Business School Press.

Brown, J. S., & Duguid, P. (2001). Knowledge and organization: A social-practice perspective. *Organization Science, 12*(2), 198-213.

Cross, R., Borgatti, S. P., & Parker, A. (2001). Beyond answers: Dimensions of advice networks. *Social Networks, 23*, 201-235.

Cross, R., Parker, A., Prusak, A., & Borgatti, S. P. (2001). Knowing what we know: Supporting knowledge creation and sharing in social networks. *Organizational Dynamics, 30*(2), 100-120.

Ellis, D., & Haugan, M. (1997). Modeling the information seeking patterns of engineers and research scientists in an industrial environment. *Journal of Documentation, 53*(4), 384-403.

Emerson, R. M., Fretz, R. I., & Shaw, L. L. (1995). *Writing Ethnographic Fieldnotes*. Chicago: University of Chicage Press.

Glaser, B. G., & Strauss, A. L. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. New York: Aldine Publishing.

Granovetter, M. S. (1973). Strength of weak ties. *American Journal of Sociology, 78*(6), 1360-1380.

Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal, 17*(Winter), 109-122.

Hansen, M. T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly, 44*(1), 82-111.

Kerstetter, D., & Cho, M. H. (2004). Prior knowledge, credibility and information search. *Annals of Tourism Research, 31*(4), 961-985.

Krackhardt, D., & Hanson, J. (1993). Informal networks: The company behind the chart. *Harvard Business Review, 71*(Jul/Aug), 104-111.

Krugman, P. (1991). *Geography and Trade*. Cambridge, MA: MIT Press.

Lave, J., & Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation*. Cambridge, MA: Cambridge University Press.

Lazer, D. M. (Ed.). (2004). *The Technology of Justice: DNA and the Criminal Justice System*. Cambridge, MA: MIT Press.

Leckie, G. J., Pettigrew, K. E., & Sylvain, C. (1996). Modeling the information seeking of professionals: A general model derived from research on engineers, health care professionals and lawyers. *Library Quarterly, 66*(2), 161-193.

McGrath, R. G. (2001). Exploratory learning, innovative capacity, and managerial oversight. *Academy of Management Journal, 44*(1), 118-131.

McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology, 27*, 415-444.

Meier, K. J., & O'Toole, L. J. (2001). Managerial strategies and behavior in networks: A model with evidence from US public education. *Journal of Public Administration Research and Theory, 11*(3), 271-293.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook* (2nd ed.). Thousand Oaks, CA; London: Sage.

Milward, H. B., & Provan, K. G. (2000). Governing the hollow state. *Journal of Public Administration Research and Theory, 10*(2), 359-379.

Nebus, J. (2006). Building collegial information networks: A theory of advice network generation. *Academy of Management Review, 31*(3), 615-637.

Nelson, M. W., Bloomfield, R., Hales, J. W., & Libby, R. (2001). The effect of information strength and weight on behavior in financial markets. *Organizational Behavior and Human Decision Processes, 86*(2), 168-196.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

NVivo. (2006). NVivo qualitative data analysis software (Version 7th). Melbourne: QSR International Pty Ltd.

Orlikowski, W. J. (2002). Knowing in practice: Enacting a collective capability in distributed organizing. *Organization Science, 13*(3), 249-273.

Podolny, J. M., & Page, K. L. (1998). Network forms of organization. *Annual Review of Sociology, 24*, 57-76.

Powell, W. W., Koput, K. W., & Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly, 41*(1), 116-145.

Rogers, E. M. (1995). *Diffusion of Innovations* (4th ed.). New York: The Free Press.

Strauss, A. L., & Corbin, J. (1990). *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*. Thousand Oaks: Sage.

Uzzi, B. (1997). Social structure and competition in interfirm networks: The paradox of embeddedness. *Administrative Science Quarterly, 42*(1), 35-67.

Weber, M. (1946). *Essays in Sociology* (H. Gerth & C. W. Mills, Trans.). New York: Oxford University Press.

Wenger, E. (1998). *Communities of Practice*. Cambridge, MA: Cambridge University Press.

Yin, R. K. (1994). *Case Study Research: Design and Methods* (2nd ed.). Thousand Oaks: Sage.

TABLE 1

Classification of Knowledge Sources

Source	**Interaction features**	**Considerations for choice**
Search engines	• anonymous	• Quality control through linking process • Cannot convey tacit knowledge
Professional websites	• anonymous	• Established practice • Helpful for directed search • Cannot convey tacit knowledge
Listserver	• one-to-many • asynchronous • not anonymous	• Fast answers because of large n • Prestige vs. embarrassment • Relevance of boundaries • Very limited utility in conveying tacit/complex knowledge
E-mail	• one-to-one • asynchronous • not anonymous	• Pre-existing relationship important • Easy to evade • Limited utility in conveying tacit/complex knowledge
Print publications	• anonymous	• Peer-reviewed/high reliability • Relatively hard to search • Generally cannot convey issues around *practice*
Phone	• one-to-one • synchronous • not anonymous	• Pre-existing relationship important • Relatively easy to evade • Good at conveying tacit knowledge
Face-to-face	• one-to-one • synchronous • not anonymous	• Pre-existing relationship important • Very difficult to evade • Ideal for conveying tacit knowledge

TABLE 2

Overview of Interviews Conducted

Professional role[*)]	Affiliation: State lab	Affiliation: Local lab	**Total**
Lab director	5	2	7
Technical leader	6	3	9
CODIS administrator	8	4	12
Total	19	9	28

[*)] In cases where individuals hold multiple roles, the highest-ranking role is indicated.

FIGURE 1

Stylized Depiction of the System

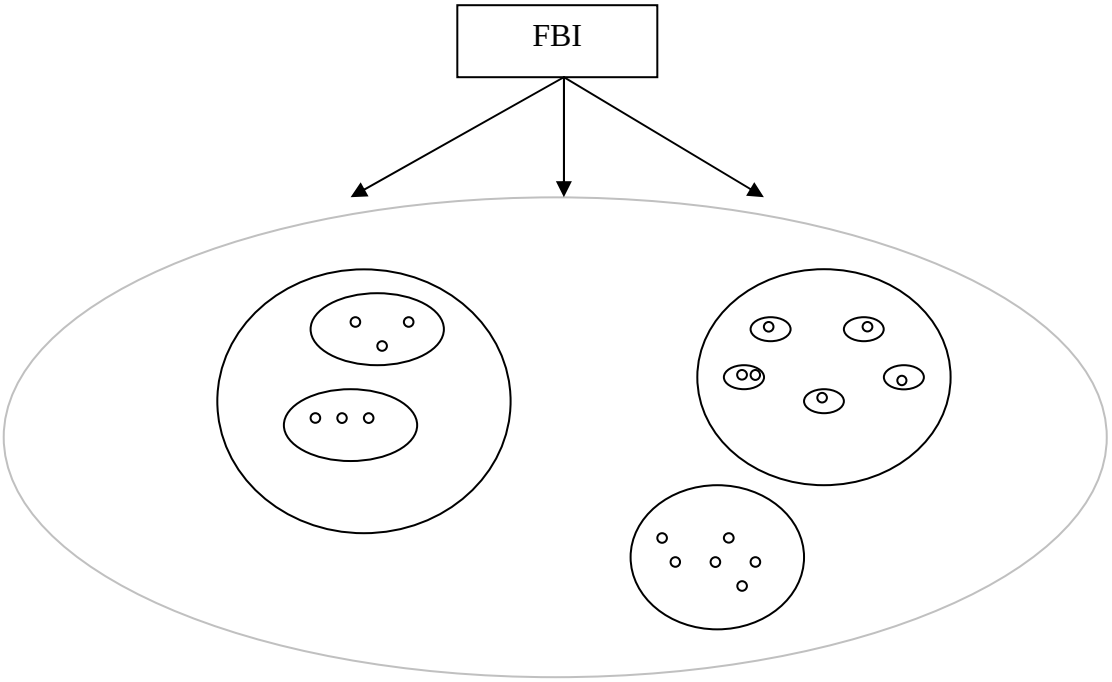

FIGURE 2

Simplified Coding Scheme