# The Scientist: Secretive, Selfish or Reticent? A Social Network Analysis

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**Abstract.** The central question of this paper is what influences collaborators in electronic work environments to decide what knowledge to exchange, how much to exchange, and under what circumstances. Are scientists motivated by purely selfish economic considerations, or is there a role for social relations to influence behavior? This paper develops an empirically-based theoretical framework based on Mark Granovetter's (1985) theory of social embeddedness that helps to explain the conditions for knowledge exchange in Grid environments. This is an early analysis based on interviews with a small population of researchers in molecular microbiology, molecular biology, and cell signaling in the United Kingdom. We conducted a small, preliminary social network analysis of this group to determine what they exchange, with whom, and under what conditions. By identifying the role that social embeddedness plays in motivating scientists, we not only begin to understand the contours of knowledge and information exchange in e-science, but we can also develop reasonable expectations of knowledge-sharing patterns across individual scientists and laboratories.

## Introduction

In 2006, Professor Carole Goble and Dr. Robert Stevens both of the School Computer Science of the University of Manchester observed that when scientists use Grid technologies they are relatively unwilling to share data and information with each other. Moreover, when they do exchange data or knowledge, they strategically time it after formal publication of research results. Finally, they choose carefully what they share.[1] Instead of working altruistically to push ahead collectively the frontiers of science, Goble suggests that scientists are principally motivated by publishing the best results first in order to maintain funding and increase their status. Stevens refers to such behavior as the behavior of "the selfish scientist."

An interest in the possible deviant behavior of scientists is nothing new. There has been an ongoing concern with the culture of science since at least the end of the Second World War when ordinary citizens believed that science, particularly chemistry, physics and biology,

1 For a basic reporting on Goble's and Stevens's analysis of 'the selfish scientist', see Thomson, Helen. "'Me Science' the new e-science" in *Grid Today* < http://www.gridtoday.com/grid/963514.html>, accessed 1 May 2006.

affected their day-to-day lives, and how science was put to use during the War. A critical issue was how scientists created and shared new knowledge. Over fifty years ago, sociologist Robert K. Merton (see, for example, (Merton, 1973), (Merton, 1966) and (Merton, 1993)) observed that the efficient unfolding of new knowledge in science rested on a set of idealized institutional norms, one of which was the norm of "communism" or the sharing of knowledge among both scientists and the wider public. Writing about the social dimensions of science from both a practitioner's and scholar's viewpoint, and directed to both the lay public and apprentice scientists, a contemporary of Merton's, the physicist John Ziman (1968) argued that scientific knowledge is *open public knowledge*. Part of their argument rested on the idea that science is an enterprise that creates and tests facts fairly, and verification can only occur with the free and open exchange of information and knowledge. By the end of the 1940s, it became widely accepted that the foundation of science rested on social interaction where knowledge was tested and replicated in a community. (Hagstrom, 1965) Fundamental to the functioning of science is the open sharing of knowledge. (Birnholtz and Bietz, 2003)

One idealized potential of Grid technologies is that they allow for the efficient, and effective, sharing of knowledge and data across research sites, and that they promise "frictionless" knowledge production in science much like the frictionless market that is meant to characterize e-Commerce. (See, for example, (Brynjolfsson & Smith, 2002)) The social and economic dimensions of science that tend to resist the open sharing of knowledge and data in Grid environments results in a form of friction that, if not properly understood by designers or evaluators, may undermine the goals of Grid technologies—something that Goble clearly recognizes. She therefore argues that understanding the underlying motivations of scientists is essential for the development of Grid technologies.

This paper develops an empirically-based theoretical framework based on Mark Granovetter's (1985) theory of social embeddedness that helps to explain the conditions for knowledge exchange in Grid environments. This is an early analysis based on interviews with a small population of researchers in molecular microbiology, molecular biology, and cell signaling in the United Kingdom. We conducted a small, preliminary social network analysis of this group to determine what they exchange, with whom, and under what conditions. By identifying the role that social embeddedness plays in motivating scientists, we not only begin to understand the contours of knowledge and information exchange in e-science, but we can also develop reasonable expectations of knowledge-sharing patterns across individual scientists and laboratories. Moreover, we can begin to explain what is shared, with whom, when, and under what conditions. The results from this work can also be used to inform realist evaluations that, in turn, can shape subsequent design decisions. (Pawson & Tilly, 1997)[2]

# Theoretical orientation

Let us distinguish what we mean by scientific knowledge. A single laboratory produces a range of knowledge, data, and laboratory know-how. Some of this is destined for journals, others for patents, some shared with colleagues, and some held in secret, perhaps to be used for future research or to support ongoing but not yet completed research. (National Academy of Sciences, 1996) McCain (1991) distinguishes between two classes of scientific information: Public, published results open to scrutiny and replication by members of the science community; and, Private physical research products and their techniques. Private research products are temporal and may include such artifacts as clones, workflows, software,

2 Realist evaluations address questions such as "How did it work? For whom? Under what conditions?"

algorithms, bench techniques (which often include tacit knowledge), datasets, and so on. Knowledge moves from the private sphere to the public sphere when research findings are presented in some public venue, such as a journal or a conference. A manifest problem in science would occur if data were not made available *post publication* because this would forestall efforts to replicate and validate results by the science community. While there is some evidence to suggest that the withholding of post-publication data occurs, especially in the genetics communities,[3] it is not clear how widespread this practice is. (Campbell, *et al*., 2002) Far more common in genetics, and among practitioners using Grid technologies interviewed for this paper, is the *selective* dissemination of private research products. The issue is not whether or not there is access, but instead how much access to provide, to whom, and when.

There are a number of factors influencing why an individual practitioner, or a lab, would restrict or time the release of private data. Campbell, *et al.'s* (2002) survey of geneticists suggests that the financial and resource costs of providing data act as a barrier. For example, twelve per cent of their sample reported denying a request in the previous three years. Eighty per cent of those reported that providing data and materials "required too much work;" overall, forty five per cent of the sample cited the financial burden of providing data and materials as a potential barrier. Indeed, the costs of providing tacit knowledge—lab-based know-how—can be quite large because such knowledge or practice often can only be understood through face-to-face encounters that demonstrate the practice. (Birnholtz & Bietz, 2003) (Collins, 1985) The reward system in science, however, exerts a powerful effect on the selection and timing of private data. Merton would explain so-called "selfish scientific behavior" by arguing that despite the institutionalized norms of science (communism, organized skepticism, disinterestedness, etc.—the "Mertonian norms"), the job of a scientist is to create and disseminate *new* knowledge. The scientist who publishes first is perceived by the scientific community as the one who creates new knowledge; if you do not publish research findings first, you, in effect, have not published at all. (Merton, 1957) (Mulkay, 1975) In addition, the reward system in science provides both tangible (research funding, job promotion, for example) and intangible (praise from peers, reputation) compensation for scientists who do publish first. (Merton, 1957) Moreover, past rewards *in themselves* as well as professional esteem accrued from publications tend to increase the chances of success in the future in a process one might call "cumulative advantage." (Cole & Cole, 1973) In science, it is fair to say that the winner not only takes all, but positions her/himself well for future rewards. Put another way, the penalties for not being first are generally large and lasting.[4]

The winner-take-all approach to scientific rewards has understandably created conditions that encourage intense competition in science, which greatly influences knowledge exchange behavior among individual scientists and laboratories. This is not a new phenomenon. For example, Hagstrom (1974) conducted a survey of scientists and reported that sixty per cent of respondents at some point in their careers have been anticipated in the publication of a discovery; almost thirty-three per cent were concerned about being anticipated in their current work. He observed that anxiety surrounding priority in science places great strains both on the individual scientist as well as on the norms of science. (Hagstrom, 1974) Gaston (1973)

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3 For example, Campbell *et al.* (p. 473) found that 12% of respondents reported that they denied a request for information in the past three years; 47% report one request they had made was denied in the preceding three years.

4 The Coles (1973) present empirical data to argue that being first is sometimes not enough to guarantee long-term career success in science. Instead, it is both the originality and the quality, not quantity, which makes work visible within the community and leads to recognition. It therefore becomes as important to choose a journal as carefully as the timing of it.

reported that sixty-six per cent of British high-energy physicists have been anticipated, which lead to what he described as "reticence" among that group. More recently, Campbell, *et al.'s* (2002) survey suggests that lab directors withhold data to protect the ability of graduate students and post doctoral staff to publish, as well as to protect their own ability to publish.[5]

Two recent additional conditions have heightened competition, particularly among geneticists using Grid technologies: First, research geneticists or the organizations that sponsor their work can benefit from patents of their results and, in some cases, from intermediate results, especially if, in the United States, the intermediate result happens to be a novel process. Such intellectual property pressures discourage the sharing of data that might result either in a patent's not being issued or in a competitor's wining the patent. Moreover, as Birnholtz and Bietz (2003) point out, the sponsoring organization may have negotiated a confidentiality agreement with the research lab in order to protect their interests. Thus, in addition to reputational decline, a scientist and lab can suffer tangible economic loss if a patent is not issued on scientific work; or face legal procedures if confidentiality agreements are seen to be broken. Second, the computer-supported infrastructural support that is designed to foster sharing and collaboration may unintentionally hinder it. For example, cooperating labs that are working either for a common goal (for example, understanding the genetic basis of a specific disease) or related set of goals (understanding genetics and toxicity) may both use the Grid and closely observe the work of cooperating labs with the intention of racing to be first or to be at the center of a breakthrough.

Given the intangible and tangible rewards accrued from being first, it would seem that economic theory can explain reticence among potential collaborators; many have taken this approach and have used the language of business and economics when describing behavior. For example, Franch (2002) self-consciously portrays the scientific community, "as a population of entrepreneurs who maximize attention in the same way that businessmen maximize profit…". Birnholtz & Bietz (2003) argue that laboratories may conceal data in order to obtain "monopoly rents" in the form of publications, students, grants and reputation. Writing for the National Academy of Sciences (1996), Hilgartner argues that laboratories are reluctant to share bench techniques because "the value of the technique developed in a lab—and the value of the scientist—declines. At first, a researcher might be able to do something no one else can do, and thus gain a short-term competitive advantage." Indeed, an economic approach to knowledge exchange conditions can strongly argue that an infrastructure such as a Grid in fact discourages knowledge exchange. Why? Groups of competing working scientists may use the Grid to gain intelligence from others—*under the guise of collaboration*—for their own advantage. For example, the institutional economist Oliver Williamson (1975) argues that an economic agent is guided not only by self-interest but also by "opportunism;" that is, "self interest seeking with guile; agents who are skilled at dissembling realize transactional advantages. Economic man…is thus a more subtle and devious creature than the usual self-interest seeking assumption reveals."

Institutional economists may thus view the sharing of data and know-how as abstract economic transactions initiated to maximize economic advantage in any way possible. Indeed, as we have seen, Williamson argues that transactions are conducted not only by rational economic agents, but by agents that seek *any form of opportunism that they can*. Such behavior, however, posits purely rational atomic agents minimally affected by social relations who are concerned *only* with maintaining a competitive advantage. Such a view has powerful implications and potential explanatory power. For example, it predicts that

5 Of the twelve per cent that Campbell, *et al*. found who reported denying a request for data in the previous three years, sixty-four per cent protected graduate students and post docs, and fifty-three per cent protected their own interests.

scientists will not exchange private knowledge because that knowledge may be used by a competitor to further their own advantage. It argues an exchange will occur if there is an equitable *qui pro quo*. An economic view would argue that when there is a single reward, there will be intense competition to realize it. This would imply that self-interested behavior, moreover, is likely when groups are working on common problems, using common resources—as they are in Grid environments—but who are competing for a single, or individual, reward, as in the scientific community. An economic view can model a networked collaborative environment, where agents have only weak knowledge of each other, as a marketplace of abstract transactions (Strathern, 2004)—in this case, transactions involving the transmission data and know-how. Because agents in a distributed environment have not developed trust (they have few face-to-face daily encounters) and their behavior is guided by any form of opportunism to gain advantage, they would need to establish rules and sanctions to govern behavior, as in any other market, enforced by a third party. This is to say, norms and behaviors of participants who transact in networked environments would exist purely to serve the efficient economic needs of the market (Williamsom, 1975) rather than the mutual interests of the group. (Muller, 2006) Indeed, such an economic analysis would explain the behavior of "the selfish scientist."

The weakness of this approach is that individual or group motivations explained in purely economic terms tend to militate against the notion that any scientific community, indeed any working community, can be collaborative or work for any mutual purpose beyond individual gain. Every action will be guided by a rational economic analysis—guided by a perfect or complete view of the market—that is intended to result in individual gain. Moreover, this view minimizes or ignores any form of social relationship.

Alternatively, an idealized communitarian[6] approach that maximizes social relationships and minimizes or ignores economic behavior in science is equally weak. This would imply that scientists work purely altruistically to push forward the frontiers of science with little or no regard for their own personal gain, or that the rewards that they seek are entirely intrinsic. Taking this viewpoint to an extreme, practitioners would freely share all data and knowledge with their peers.

We know from common sense that neither case exists. A powerful approach that takes into account the influence of both economic motives and social relationships was set out by Mark Granovetter (1985) who argued that actions, including economic actions, are embedded in social relations. Embeddedness refers to the fact that economic action and outcomes are affected by actors' dyadic relations and the structure of the overall network relations. Granovetter argues that by looking at choices made by individuals and groups, when the choices are made at the intersection of the economic and social worlds, we can come to a better understanding of "meaning in action." When economic and non-economic worlds are intermixed, non-economic activities affect the costs and available techniques for economic activity. This mixing is the "social embeddedness" of the economy—economic action is linked or depends on institutions that are non-economic in context, goals or processes.

Granovetter's theory of social embeddedness is a potentially powerful explanatory concept when we view knowledge exchange in electronic settings, particularly in the science community where non-economic institutions (the idealized norms of science given by

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6 I should point out that the Mertonian norms described earlier in this paper are sometimes confused with idealized communitarian norms. Merton wanted to distinguish science driven by positivist observation from science driven by ideology (in his case Stalinism and Nazism), as well to delineate an ideal social process that explains the efficient unfolding of science. See, (Mulkay, 1975).

Merton) coexist with economic considerations (the ability to gain a patent). The theory helps one to understand and evaluate the system by understanding the influence that social relations play in the selection of data to share, and the timing of sharing.

# Method

This is exploratory work to discern if there is evidence to believe that the theory of embeddedness can potentially explain scientists' decisions on sharing private knowledge with others in a network. The research consisted of ten face-to-face interviews with researchers in the fields of molecular microbiology, molecular biology and cell signaling at three research sites in the United Kingdom who participate in collaborative work with others outside of their home institutions. Our research design was intended to discern when an economic motive would overpower a social relation and vice versa. We conducted individual interviews with the following structure. First, we posed a number of data sharing scenarios and asked the respondents questions on how they would react if that scenario actually happened to them. For example, in one scenario, a researcher receives a request from a colleague from another institution for a dataset that is still under construction, and can be used to support a potentially important publication for which the requestor is not a potential author. In another, the researcher is asked for the same dataset from a perfect stranger working in a remote lab. For each scenario we asked (1) What would you do? (2) Why would you take this action rather than some other one? (3) What conditions would need to exist for you to change your actions? Finally, we asked respondents to provide examples from their own experience that would illustrate the scenarios. Each interview lasted from thirty to seventy minutes.

This limited method is intended to have only suggestive results. First, the structure of the networks was discerned from the data derived from the interview itself. We did not conduct a formal survey to ascertain the nodes and relations in the network. Second, the results would apply only to these fields in biology—there is nothing to suggest that they are applicable to biology or to other fields in science. Third, while we probed for alternative explanations, the structure of this first interview did not explicitly seek them. For example, Lamb & Davidson (2005) very convincingly discuss the relationships between data and information sharing, reputation, opportunities for networking and collaboration, and professional and project-based identities. Our work, so far, looks at identity only tangentially as an alternative explanation to the theory of embeddedness. Fourth, we have only begun an analysis to discern is those who have loosely-connected nodes are more likely to transact with nodes that have many connections—our analysis so far has centered on the strength of a relationship between to nodes. Finally, we did not conduct an on-site ethnographic study of how these researchers worked in their day-to-day lives, nor did we track documents. Although these are severe limitations, our findings, we believe, are suggestive because the patterns that emerged were clear.

# Preliminary findings

Most ethnographic studies of science communities and scientific practice (see, for example, (Latour & Woolgar, 1986) and Knorr-Cetina, 1999), as well our interview data collected would not recognize the picture depicted as a purely economic approach outlined by Williamson. Instead, the evidence from the respondents so far suggests that working scientists are motivated by a number of parallel factors, the most important of which concerns their professional reputation in their social network and their reputation in the community. We can define their social network as relations with others that are direct or through at most two intermediate nodes. Their community is defined as all members of their particular sub-discipline.

The respondents suggested that their community reputation derives from the quality of their publications. As one respondent stated, “If you do good work, everything else takes care of itself.” They tend to agree that the quality of work can be measured through citation counts and, as the Coles (1973) suggest, good work seen as important to the community will be cited irrespective of an individual’s structural relationship in the community. Community reputation was viewed as most important, and no one would take a risk with it. Therefore, no one would admit to sharing data that was used in support of a publication. As one said, “Your data are the lifeblood of your work. Why would you do all that work and just give it away?” They also tend to assert that it is their individual reputation that matters, not necessarily the reputation of their lab, when they consider their own identities in relation to the community. As one respondent said, “I don’t care if we are thought of as the best lab in the field. What matters to me is that I’m thought of as the best guy in the field. A lab gives me the opportunity to do the best work.”

The situation is more complex when respondents describe their relationship within their social networks, possibly because the network is far more connected with their day-to-day research activities than is the community as a whole. Respondents suggested that they negotiate carefully when sharing private data within their social network, and were virtually unanimous about not sharing private data or bench know-how outside of it. Some respondents were reluctant to share private data or techniques with those for which they had a weak tie because they believed that the techniques or the data had not been sufficiently tested or verified, and would thus reflect poorly on them. The responses suggest that these researchers were more willing to share unverified private datasets with colleagues with whom they had close relationships because they could have better control over the interpretation of the data, they were confident that the recipient clearly understood the limits of the data, and they trusted the receiver to give the supplier credit in any resulting publication. As one said, “I can trust *X* to phone me to ask a question.” Another said, “I don’t believe *Y* would take a chance and misinterpret the dataset.” Their emphasis on maintaining their reputation in a social network tends to support Lamb and Davidson’s (2005) observation that data placed on an open FTP server is seen risky by researchers because the dataset could be poorly interpreted and thus reflect poorly on the creator by “making a mess of it.” (p. 14). The respondents agreed that a dataset or technique would best be available for open use after it had been verified, that its usage would be unambiguous, and that there was a mechanism by which the requestor would be identified to the supplier. This tends to support Birnholtz and Bietz’s (2003) observation that open use datasets are compatible with research practices that are well established and predictable.

Respondents were unlikely to share data that were *incomplete* with anyone because such data were seen to be misleading and would have no value to the recipient; indeed, many feared that such a requestor may be “data hungry” and use the dataset as if it were verified and complete. This could potentially result not only in “bad science” but with their names being associated with bad science. If the requestor was known to the supplier, and had a good reputation with the supplier, the supplier would provide the data if both agreed that it served as an opening opportunity for joint research of mutual interest. This tends to support Lamb & Davidson’s (2005) observations on data sharing providing opportunities for research.

Most important, scientists in our sample tended to be more at ease with sharing private knowledge and data with others for whom they had developed a prior relationship, or with people with whom they had a mutual relationship than with members of the community outside their social network. In one scenario we asked about sharing private data unhindered with complete strangers, and the responses were uniformly no. They would, however, consider sharing such data or techniques if the data were not to be used by them to support a publication, the data were not likely to be misinterpreted, and if the requestor were connected to the supplier through a trusted intermediary with whom the supplier had a strong relationship.

# Conclusion

The respondents suggest that their decision what to share, with whom, and under what conditions is motivated by both parallel social and economic considerations, and that their concern with reputation within the social network and within the community is critical to understanding their sharing behavior. Reputation is socially derived, and a supplier tends to seek control over their reputation within the social network. A critical factor that helps to understand sharing behavior within the social network is the relative positions of the supplier and requestor. The stronger the connection between the supplier and requestor, the more likely that data would be shared. This is the result of the supplier's knowledge of how the data would be used, and the expectation that the requestor would not misinterpret the data. However, when data or techniques are needed in support of a publication, or series of publications, the data are typically held. Those outside the social network have almost no chance of obtaining private data from someone within it unless the requestor had a connection with a known and trusted intermediary.

Although this research is at an early stage, it provides strong evidence in support of Granovetter's theory of social embeddedness. That is, when economic and non-economic worlds are intermixed, as they are when a scientist is called upon to exchange private knowledge or data, economic action depends on the actions or institutions that are non-economic in content, goals or processes. The institutional norms of science do not alone determine actions, but nor do actions intended to effect only economic advantage. Instead, the preliminary results suggest that there is a complex interplay between openly sharing knowledge and expertise with colleagues (thus upholding a principle that knowledge is a resource to be shared within a community), and taking no risks that have the potential to tarnish a supplier's reputation within that community. This is a socially-mediated process where scientists exchange information with others with whom they have a prior structural relationship, have developed a working relationship through repeated contact, or who are closely connected with mutual relationships.

# Implications for evaluation digital systems that support science

This work suggests that social network analysis is a useful tool in understanding the dynamics of knowledge sharing, and that social embeddedness is a promising concept that helps to explain the conditions of exchange, and the patterns of exchange. The complex picture it depicts can be used to explain how and why knowledge is exchanged, by whom, and under what conditions. This has important implications for the evaluation of such digital communities involved in scientific work because it may show, for example, that scientists are neither purely altruistic nor purely selfish but often reticent and careful with sharing data, knowledge and technique. That is, applying the theory of embeddedness to design and evaluation should demonstrate that actors are neither rational agents operating in constrained economic contexts nor pure altruists upholding the communitarian norms of science. Instead, they work within relational contexts that influence what they share, how much they share, with whom, under what circumstances, and what they expect in return.

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