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The Dynamics of Communication Patterns within a Biotech Cluster: A Simple Method for Studying a Complex Relationship

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Abstract. In a study currently underway, we measure communication patterns among firms in the Cambridge/Boston Biotech Cluster. We refined tools and techniques once used to measure patterns of communication among scientists and engineers within companies, and adapted them to analyze the patterns of real-time scientific communication among the Biotech firms. The purpose of this study is to gain a better understanding of the inter-organizational dynamics through which universities, firms and other institutions come together to create vibrant and successful industrial communities. We believe that this study will enable us to follow the diffusion of knowledge by both formal and particularly informal means through this communication network and, over the time, to match specific structure of communication networks with research effectiveness and economic success – in both firm level/ industry level and national level.

Keywords: research methodology, measuring communication, networks, and technology clusters.

1. Introduction

There have many claims made for the benefits of newly formed firms in high technology, perhaps especially biotechnology firms, 'clustering' together in a limited geographic region. Some benefits are very obvious. It is easier to attract scientific to a firm if there many other job opportunities in a region; a multiplicity of new venture firms is likely to attract venture capital into region; similarly, suppliers and even customers will find attractive business in the region and so on. Beyond these benefits, there are claims of intellectual advantages in the form of scientific synergies that develop among the firms due to geographic proximity.

The importance of industrial clustering for the knowledge spillovers has been observed in many different contexts (see for example at Audretsch & Feldman , 1996; Beaudry et al 2003; DeCarolis & Deeds, 1999; Edwards & Murray, 2003; Powell et al, 1996; Klepper, 1996; Zucker 1998). The studies underlining the clustering as a mechanism to facilitate the interchange and flow of information between firms, through co-authorship of papers (Jaffe et al 1993; Murray 2002, 2004; Wallston 2001) patents (Baptista & Swann, 1998,1999; Wallsten , 2001; Rosenkopf, 2003; Furman et al, 2004) , and other innovative outputs (Baum et al , 2000; Beaudry 2003; Feldman, 1994, Auderetsch & Feldman , 1996; Jaffe, 1989). These studies found that firms located in clusters produced more innovative outputs than those who were geographically isolated. Knowledge spillovers resulting from geographic proximity are often enhanced by the use of common coffee shops, lunchrooms, etc. Such informal meeting sites provide a mechanism for increasing the innovative performance and growth of firms (Aharonson, Baum, & Feldman, 2004).

The investigation of co-authorship, while obviously uncovering inter-firm collaboration, operates at a fairly high level of screening. There could very well be a lot of communication among scientists in different firms that is significant for the firms although not reaching the level of a patent or paper submission. The purpose of the research program described in this paper is to determine whether and to what degree such communication develops within a cluster and to determine, over time, the effect this communication has on the success of the firms involved.

Figure 1. Map of the Cambridge/Boston Area Showing the Concentration of Biotechnology Firms.

To begin the study, we chose a target of convenience, viz., the biotechnology cluster that has developed adjacent to MIT in Cambridge and to the Harvard teaching hospitals in Boston, Massachusetts (Figure 1). Porter et al (2005) show how dependent the Boston biotech community is on personal relations among research scientists, strong ongoing affiliation among universities, hospitals, and firms and reciprocal flows of ideas and personnel. Their databases count such formal ties among firms as alliances, and collaborations (co-assigned patents). In our study, we want to dig below this level and measure scientific communication across firms that may not have resulted in a patent or scientific paper and was never picked up in any of the more accessible databases. In order to do this we had to find a way to measure this 'below the radar' level of communication. Fortunately, we had faced the same issue in earlier research when we were trying to determine the structure of person-to-person communication networks that develop among scientists and engineers within firms (Allen, 1984). In that case, we chose to use paper-based and later web-based listings of all the technical staff in the organization under examination, send emails linked to the web listing to all of the staff on randomly chosen days and ask respondents to merely click on the names of any individuals with whom they talked *on that day* about a *technical or scientific* subject. This exercise was repeated at intervals of about once per week for several months. Results could be then be averaged to determine what the network looked like for any chosen frequency of communication (Figure 2).

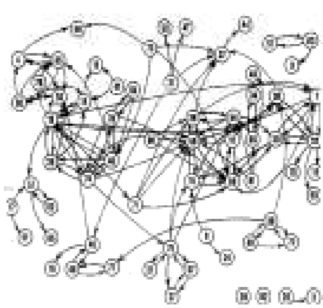

Figure 2. A Person-to-Person Scientific Communication Network
Within A Firm. Determined by the Communication Sampling Method.

Why could not this approach be adapted for the measurement of inter-firm communication? Not finding any significant obstacles to this (other than the recruitment of firms[1]), that is what we are now doing.

2. Data

In addition to firms located within the city limits of Cambridge, we include firms located in the Boston/Cambridge area more generally. We are using postal (Zip) codes as the study's geographic unit and include all biotechnology firms, pharmaceutical firms, hospitals and universities within selected postal regions.

2.1. Biotechnology Companies

We were able to create an accurate listing of firms with the kind assistance of the Massachusetts Biotechnology Council and the MIT Sloan School of Management's Entrepreneurship Center.[2] We compiled a database listing of Boston's' biotechnology firms, pharmaceuticals firms, hospitals and universities. Around 90 firms and institutes are located at the core cluster (Boston and Cambridge) while another 100 firms are located in variety "suburbs". In order to focus our attention onto those firms working on human applications of biologically-derived pharmaceuticals, we eliminated all companies that were in the agricultural, veterinary, and environmental products and services fields from the initial listings. This left us with a final sample of around 65 firms. Of these, we are currently receiving data from 40 companies. In each of these companies, we select a random listing of approximately ten percent[3] of their bench-level scientists. The chosen scientists must have at least a PhD or MD level of education and be actively engaged in research.

2.2. Big Pharma

A number of 'Big Pharma', or large broadly-based, pharmaceutical firms have recently located research operations in the Cambridge/Boston area. The goal of these larger firms presumably is to tap into the scientific communication network

1. This is not a trivial issue since it is very labor intensive and requires a considerable amount of credibility and salesmanship.
2. In the case of the Entrepreneurship Center, we must acknowledge financial support and the encouragement of its Director, Kenneth Morse, as well. Special thanks go also to Shyamala Balekuduru, who designed the Web page and helped in the preparation of the data.
3. In companies with fewer than 10 scientists, we sample all of those engaged in bench level research. Cooperation is, of course, voluntary and the overall research plan has been reviewed and approved by the MIT Committee on the Use of Human Experimental Subjects.

that may exist among the smaller, newly-formed firms. Their longer term goal is probably to acquire new technology and products through licensing from or acquisition of the firms owning the intellectual property. The large pharmaceutical firms are also included in our sample, to determine the degree to which they are successful in attaining this goal.

While the presence of the larger firms in many ways is a benefit to the startups, since they bring resources in the form of much needed money for licensing or even outright acquisition, this is not universally viewed in a positive light. One entrepreneur described the relationship of firms such as his with 'Big Pharma' as "…a bunch of monkeys playing with gorillas". He was very concerned with protecting his intellectual property or at least getting what he considered a fair price for it. The degree to which this view is shared is something that we hope to determine in follow-up interviews.

2.3. A Control Group

In addition to those firms located within our selected postal codes, we are also sampling communication from scientists in a number of firms (both small and large) located within a 100 Km range of Boston but outside of the experimental region comprising our selected postal zones. These more distant firms are a control group that will allow comparisons on the basis of geographic propinquity or separation.

2.4. Universities

There are five large research-based universities located within the selected postal codes. These are included in the study in a somewhat indirect way. We are not asking scientists in the universities to report their communications but are instead relying on the reports of those in firms. Our reasoning for this is nothing more complex than ease of data collection. The initial phase of collecting data only on communication will be followed by a web survey in which we will seek further information on the exact university laboratories with which communication took place, the origins of the contact, etc. In looking at the universities, we hope to find the degree to which firms originating from these universities retain their connection with their 'mother' organizations as well the degree that firms born elsewhere are able to develop relations with universities within the region.

2.5. The Data Collection Web Page.

The structure of the web page used for collecting the basic data of the study could not be simpler.[4] In achieving simplicity and ease of response we, of course, had to sacrifice much information that might be considered useful.[5] Following the response that we received to the pilot test of an earlier, more detailed version, we were able to simplify and reduce the length down to a version that can be completed within a maximum of 60 seconds.[6] Note that we avoided a very long listing of the 190 of organizations by providing an alphabetical search tool. Now a scientist has to merely open the web page, using the link from our email message then, if the scientist had no communication outside of the firm on that day, click on that button and submit. If there were communication with an outside organization, find that organization on the alphabetized listing, click on it, click on 'submit' and the task is completed. The data are then assembled in a data base file and are available for analysis. Such measures as frequency of communication between firms can then be computed and networks plotted. Once the networks are available a second level of analysis will begin. Such network measures as centrality can be computed for each organization. Comparisons can be made between the experimental and control firms on most of the network measures as well as the more simple measures such as mean communication levels.

3. Measuring the Structure of Communication Networks; A Web-based Research Method

As noted before, many current studies rely upon patent and publication databases and therefore are unable to detect communication that while significant may not result in such products. To capture this type of communication, we developed a tool that, in addition to being sensitive enough to capture much of this additional communication is also able to sense the dynamic aspect of the communication network as it evolves.

By refining the tools and techniques once used to quantify the strength of communication among scientists and engineers within companies, and adopting them to analyze the patterns of real-time scientific communication among the life science firms (see Allen 1971). A web page is sent each week to a scientist which lists the names of the biotech/ pharmaceutical organizations (including universities and hospitals). A scientist has to merely open the page and by mouse click indicate which organizations (if any) he or she had contact with on that

4. The reader can see a "test version", that we are using for the Boston/Cambridge cluster http://entrepreneurship.mit.edu/biostudy (Enter 'test' in the personID box).
5. Achieving a simple, high response potential questionnaire is similar to achieving an uncluttered home or office. Much of what "might be useful in the future". must be eliminated
6. Experience shows that the tradeoff between questionnaire length or complexity and response rate follows a very steep downward slope.

particular day. This simple exercise, which can be completed in one minute or less, is then repeated on randomly chosen days, approximately once per week for a period of six months. The results collected this tool can be related to measures of success. We will correlate these communication patterns to performance measurements such as: firm growth, patents, partnerships, publications profitability, etc..

The software tool we are using to analyze the network is called TeCFlow (Temporal Communication Flow Analyzer).

This tool reveals the evolution of interaction patterns in social networks. TeCFlow provides an environment for the visual identification and analysis of the dynamics of communication in social spaces. Communication patterns of a team/ firms define and indicate how that actor (team/firm etc) work together. By comparing dynamic interaction patterns with the performance of virtual actors, TeCFlow can identify typical communication patterns of different types of virtual communities and shed light on how a team collaborates. With Knowledge Flow Optimization, the insights gained through TeCFlow can be used to develop recommendations for improved team performance[7] (Gloor,2006).

4. Some Very Preliminary Results

The purpose of this paper is not to report on the actual results of the research but rather to describe the research method to make it more readily available to others. Nevertheless, we would be less convincing of the effectiveness of the method were we to fail to allow the reader a peek at some of the early data and results.

4.1. A Peek at the Emerging Structure of the Network

In Figure 3, we can see an early view of how the network might eventually look. This approximation is based on data from only the first few months of collection. So it is far from stable at this point and very likely to change before the study is completed. It is shown only to demonstrate to the reader the nature of what we are looking for in the study.

7. The framework is based on a multi-year research project on Collaborative Knowledge Networks by a global group of universities under the leadership of the MIT Center for Coordination Science and the Center for Digital Strategies at Tuck at Dartmouth (see http://www.ickn.org/ickndemo/).

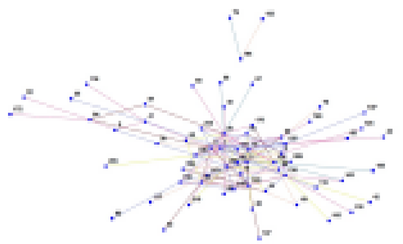

Figure 3. A Preliminary View of Communication Among Organizations in the Cambridge/Boston Biotechnology Cluster.

The TecFlow software draws the length of the connecting branches or edges inversely proportional to the amount of communication reported between any two nodes (in our case organizations). As a result of this feature, the reader will see in Figure 4 that there is a set of organizations that the software positions in the center of the network, indicating that they are all in very close communication with one another. It thus appears as though there is what might be labeled a ‘super cluster’ within the overall Cambridge/Boston Biotechnology Cluster.

Who are the members of this super-cluster and how did it form? At this point, we can answer the first of these two questions. The answer to the second must await the results of follow-up interviews with participating organizations after the initial data collection period.

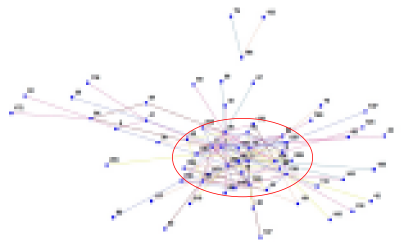

Figure 4. A 'Super-Cluster'?

4.2. The Universities

As mentioned earlier, there are five major universities[8] located within the postal zones selected for the study. Where do they appear in the network and how do they relate to the biotech firms? At this point, the data indicate that four of the five are well positioned within the super-cluster (Figure 5). The fifth university appears within the overall network but has not (yet) exhibited sufficiently strong communication links to organizations in the super-cluster. The fact that the universities are so strongly embedded in the cluster should come as no surprise since many of the biotech firms had their origins in the scientific laboratories of these same universities. It will be interesting though to see the degree to which the strength of the ties back to the mother laboratories decays with time since company formation. Unfortunately, due to our decision not to sample communication from the universities, we have no way to see the degree to which the academic scientists communicate across universities.[9]

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8. Boston University, Harvard University, Massachusetts Institute of Technology, Northeastern University and Tufts University. Three of these (Boston university, Harvard and Tufts have medical schools.
9. Nor was that a major purpose of the study.

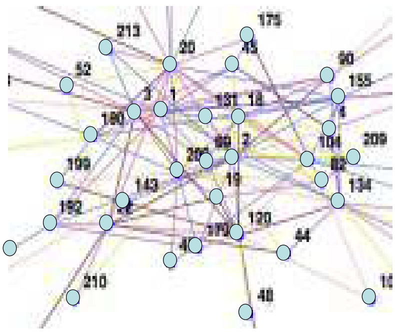

Figure 5. A Close-up View of the 'Super-Cluster'.

4.3. Big Pharma

Five major pharmaceutical firms have built substantial R&D operations in the Cambridge/Boston area in the past several years. All of these are devoting at least some of their efforts in the direction of biologically based products. Hence it doesn't require much imagination to suspect that one of their major goals is to break into any scientific communication that might form among the newly formed biotechnology firms as well as directly with the university laboratories. The purpose, of course, is technology transfer, either directly from university basic research or indirectly through the firms that spun off from the university research. In both cases the hope is for licensing opportunities as well as other formal and informal acquisition of new ideas. Of course, acquisition of the new venture firms, themselves, is often a goal and a way to acquire the technology.

Have they been successful? It is far too early to tell. Of the five large pharmaceutical companies in our network, four are located within the super-cluster. Does this mean success? We can't say. However, it does indicate attainment of what must be an intermediate goal of these companies. What about the one that is not so tightly clustered? Again it is too early to tell, but it will be interesting to see the differences in policy and strategy employed by these firms.

4.4. 'Big Bio'

There are several large (more mature) biotech firms in the region. At this point, we have developed neither criteria nor an operational definition to place firms into this category. Nevertheless, if one just guesses on the basis of size and age, there are several firms that are bound to fit under a more rigorous definition. Looking at the positioning of these firms in the network, we find that they are at about the same level as the traditional pharmaceutical firms in the cluster. Of the six firms that we would place in this category, all but one fall within the bounds of the super-cluster.

The class of large biotech firms is an interesting to study for many reasons. Many of them, for example, have been sources of spin-offs themselves. There are many 'children' of these firms in the cluster. In fact, we have found grandchildren and there are perhaps even great grandchildren in the cluster. It will be interesting to see just what effect the presence of the successful biotech firms has had on the structure of communications within the cluster.

5. Conclusions

Our principal conclusion, at this point, is that our research method works. We are still in the process of collecting data and far from analyzing it thoroughly. Nevertheless, some tantalizing results are emerging. An unexpected result of the ease designed into the data collection method is that some of the scientists feel compelled to provide further information to explain the nature or reason for communication reported on the web site. Had we asked for this additional information, in the first place, the time required might have discouraged any response at all. Interestingly, once scientists have invested a small amount of time in responding to the web page, they will sometimes feel an obligation to provide additional clarifying information. Upon completion of the phase in which we gather data on communication, we plan to return to the firms, show them where they are positioned in the network (without revealing the identities of any of the other firms) and then ask clarifying information about whether their position surprises them and an explanation of how they think they ended up in that particular position. This is all information that would have been difficult to obtain if we had not gathered the communication beforehand.

Finally, one of the motivators for participation by some firms is that an assessment of where they end up in the measured network will aid them in expansion plans. Should they remains in the high rent district or not?

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