FIRM EFFECTS VS. LOCATION EFFECTS IN THE ORGANIZATION OF PHARMACEUTICAL RESEARCH

Jeffrey L. Furman
MIT – Sloan School of Management
50 Memorial Drive, E52-507
Cambridge, MA 02142

phone: 617-588-1439
fax: 617-253-2660
email: jfurman@mit.edu

January 2001

FIRM EFFECTS VS. LOCATION EFFECTS IN THE ORGANIZATION OF PHARMACEUTICAL RESEARCH

ABSTRACT

This paper evaluates the extent to which firm effects and location effects impact the adoption of organizational practice in pharmaceutical research laboratories. Examining simultaneously the relative salience of firm versus location effects enables the paper to assess quantitatively how multiple environments shape organizational characteristics. Using a novel dataset, the results suggest that both firm-specific and location-specific effects have a significant and quantitatively important impact on the extent to which laboratories engage in *science-driven drug discovery*, a practice associated with enhanced research productivity in the 1980s and 1990s. The magnitude of firm effects exceeds that of location effects in the worldwide sample, although this finding is reversed for laboratories in the United States. Overall, the results imply that both firm-specific and location-specific characteristics drive organizational practice in pharmaceutical research laboratories and that the relative strength of each depends on context. More generally, the paper demonstrates that while organizations may be broadly homogeneous within environments, organizational heterogeneity may result if organizations are subject to multiple environments.

I. INTRODUCTION

Why do some firms look and behave in similar ways while others are different? Several theoretical perspectives address this by proposing that organizations subject to common influences will be broadly homogeneous, including institutionalization theory (DiMaggio and Powell, 1983), population ecology (Hannan and Freeman, 1977), resource dependency theory (Pfeffer and Salancik, 1978), and the "strategic fit" perspective (Learned, et. al, 1969). Consistent with this conjecture, a broad range of empirical studies document that organizations in similar environments indeed exhibit similar structures, processes, and behaviors. A fundamental insight arising from this research is that variation among organizations' environments is an important source of variation among organizations' characteristics and behaviors. However, while numerous studies examine populations of organizations within a single environment, substantially less research evaluates organizations exposed to multiple environments (Scott, 1983; Westney, 1993; Rosenzweig and Singh, 1991). As these features characterize a substantial fraction of actual organizations, unpacking the relative importance of potentially dissonant environmental pressures constitutes an important issue for the study of organizations.

This paper investigates the relative salience of multiple environmental influences on organizational practice, considering research laboratories in the global pharmaceutical industry. A key idea driving the research is that the network of laboratories within a firm and the set of organizations within a geographically local region constitute separate environments to which a focal laboratory is exposed. In drawing this distinction, I address a central concern in international management that emphasizes the competing tensions that multinational enterprises (MNEs) face between maintaining consistency across their distributed establishments and adapting features of their subsidiaries to "fit" with those prevailing in the locations in which they operate (Perlmutter, 1969; Brooke and Remmers, 1970; Hedlund, 1986). For example, when choosing how to organize, Bristol-Myers Squibb's Tokyo research laboratory faces pressures both to emulate other laboratories within its firm as well as to conform to the norms and perceived "best practices" common among laboratories in its local geographic area.

The relative strength of these firm-specific and location-specific influences is a subject of debate in strategy and international management. The existence of statistically significant firm effects on productivity and profitability (Griliches, 1986; Rumelt, 1991; McGahan and Porter, 1997) and the demonstration that firms differ systematically in their adoption of organizational practices (MacDuffie, 1995; Ichniowski, et. al., 1997) suggest a significant firm-specific component affecting how firms organize. At the same time, research emphasizing country capabilities (Kogut, 1991), regional organizing patterns (Whitley, 1991), national institutions (Soskice, 1991), network and information structures (Saxenian, 1995), and industrial clusters (Porter, 1990, 1998) implies that location-specific factors have a strong influence on organizational structures, practices, and performance. By evaluating the impact of these potentially dissonant environments on the distributed facilities of multinational enterprises, this paper both responds to organization theorists who acknowledge the promise of the MNE as forum for empirical research and addresses the empirical questions in strategy and international management regarding the importance of firm-specific and location-specific effects.

The case of drug discovery research, the earliest phase of pharmaceutical R&D, provides an interesting setting in which to evaluate these effects on organizational practice (Milgrom and Roberts, 1990). I focus on the organizational practice of "science-driven" drug discovery. This practice is characterized by a set of interrelated organizational decisions that support in-house research exploring *basic science* as well as the more applied research that is more closely linked to the identification of novel drugs (Henderson and Cockburn, 1994, 1995; Gambardella, 1995). Important for the research question in this paper, the extent of science-driven drug discovery varies across firms and over time. Qualitative evidence suggests that geographic regions may also differ in their average levels of science-driven drug discovery (Cockburn, Henderson, Stern, 2000). Further, the importance of this practice is underscored by its positive association with research productivity in the 1980s and 1990s.

Most large pharmaceutical firms maintain several drug discovery research centers, many of which co-located in geographic "clusters" of pharmaceutical research activity. Whereas related prior research area considers the *firm* as the unit of analysis, I take advantage of the fact that firms operate multiple research centers and focus on the *laboratory* as the unit of analysis. Consequently, I can observe variation in environmental conditions both within and across firms as well as within and across geographic regions. The paper's empirical analysis can therefore distinguish the separate impact of both firm and location effects on organizational practice.

Using a novel dataset describing laboratory-level publication and patenting activity for a set of thirty-four multinational pharmaceutical companies from 1984-1994,[1] I compute an output-oriented, objective measure of organizational practice. The analysis demonstrates a significant and quantitatively important impact of both firm effects and location effects on the extent to which laboratories pursue science-driven drug discovery. These findings are robust to a number of alternative specifications of functional form and to a range of modifications to the explanatory variables. Firm effects generally exceed geographic effects in magnitude; however,

---

[1] This represents the tally of firms that were independent at one point in the dataset. I treat merged firms, e.g., Bristol-Myers Squibb, as the continuation of the "senior" member of the merger.

this result varies in interesting ways across sample subgroups. Overall, the results suggest that tendencies for homogeneity in drug discovery research laboratories operate both within the firm as well as within the geographic region. More generally, the paper demonstrates that while organizations may be broadly homogeneous within environments, organizational heterogeneity may result when organizations are subject to multiple environments.

Although this paper's analytic strategy differ in important ways, its empirical exercise shares commonalities with those undertaken by Rosenzweig and Nohria (1994) and Robinson (1995). Based on ANOVA analysis of detailed, cross-sectional surveys, these authors evaluate the extent to which human resource management (HRM) practices in multinational subsidiaries in a particular country more closely resemble HRM practices of either local firms or those of their own firm's headquarters. While this survey-based approach generates rich, detailed information about organizational characteristics, the methodology pursued in this paper yields more analytic power at the level of the organizational practice by facilitating comparisons across each of a firm's facilities, across a wide range of geographic regions, and over multiple years.

The paper proceeds as follows: The next section reviews perspectives on organizational homogeneity, focusing on institutionalization theory. Section III examines firm and geographic influences on organizational practice in drug discovery. Section IV describes the study's dataset and methodology. Section V presents empirical results and Section VI concludes, discussing the analysis and exploring some implications for future research.

II. ORGANIZATIONAL HOMOGENEITY IN FIRMS & GEOGRAPHIC REGIONS

This section reviews research on organizational homogeneity. While a number of views of organizations propose theories of organizational similarity, this section focuses on institutionalization theory, as empirical research considering firm versus geographic effects most often casts itself within this literature.

Institutionalization theory conceives of organizations as social systems whose characteristics reflect those understood as appropriate within their environments (Selznick, 1958; DiMaggio and Powell, 1983; Zucker, 1987). The organization's environment is also viewed as a social phenomenon and is defined to include the set of entities with which the focal organization interacts. Within this population of relevant actors, often referred to as an "organizational field," sets of institutional pressures act upon constituent members with the effect of establishing and reinforcing standards for appropriate structures and behaviors (Zucker, 1987). DiMaggio and Powell (1983) categorize these pressures as either coercive, mimetic, or normative.[2] As a result of cognitive as well as social reinforcement mechanisms, structures and processes that may have been adopted initially for efficiency reasons become "legitimated," eventually becoming pervasive within an organizational field (Meyer and Rowan, 1977; DiMaggio and Powell, 1983; Scott, 1983).

Empirical studies provide evidence consistent with institutionalization in a number of environments, for example, within individual sectors or industries,[3] within a regional economy,[4] or within corporate functions.[5] The majority of this empirical literature treats organizations as if they were internally undifferentiated and faced isomorphic pressures within a single

---

[2] DiMaggio and Powell introduce one of the most prominent typologies of institutionalizing pressures; however, a number of others exist, including Scott (1987).

[3] See, for example, Baron, et al. (1986, 1988), Davis and Greve (1997), Haunschild (1993), Haveman (1993), and Westphal et al. (1997) for private sector examples and Tolbert and Zucker (1983) and Rowan (1982) and Tolbert (1985) for examples in the public sector.

[4] Examples include Galaskiewicz and Wasserman (1989), Galaskiewicz and Burt (1991).

[5] See, e.g., Mezias (1990) and Fligstein (1989).

environment.[6] Shifting attention to the *facility*, as the unit of analysis, rather than the entire organization, raises questions about the extent to which an organization's multiple facilities resemble each other and facilitates inquiry regarding the extent to which multiple domains may affect the organization.

This paper proposes that the distributed entities of the multinational enterprise and the local geographic regions in which they operate can be considered as separate fields of influence (Figure I). Institutionalizing pressures may arise from a number of sources within a firm, including, for example, the coercive authority of hierarchical structures or the mimetic effects of the frequent interaction. Institutionalization may also operate within geographic regions, resulting from, for example, national cultures and cultural institutions (Hofstede, 1980; Whitley, 1985) or shared "mental models" and repeated interaction among local executives (Porac and Thomas, 1990; Pouder and St. John, 1996; Sull, 1999).[7] The distinction between firm and location effects draws upon research that considers the competing effects of separate domains of influence within the context of the consistency-adaptation debate in international management (Rosenzweig and Singh, 1991; Rosenzweig and Nohria, 1994; Robinson, 1995).

This work is motivated by the observation that multinational enterprises are confronted with a tension between the need to maintain consistent operations across its distributed while

---

[6] Guillen, Guler, and MacPherson (2000) constitutes an interesting exception, which examines the process of institutionalization *across* national boundaries.

[7] Circumscribing boundaries that appropriately define a regional environment is complex and imprecise and differs greatly with the context considered. Administrative domains, such national boundaries, may be natural for some defining some environments (e.g., Meyer et. al.,1997) and are the units considered most often by international management, are often more convenient for the purposes of obtaining data. Nonetheless, particularly when critical environmental pressures operate through local networks (e.g., Galaskiewicz and Wassermann, 1989), the regional cluster may constitute the most natural unit of analysis for the study of location-specific institutionalization. Consistent with this, local geographic regions are considered as the baseline unit of geographic analysis in this paper, although future versions of this paper will evaluate administrative and physical boundaries, such as state and country designations as well.

also adapting facilities to fit the particular characteristics of their local environments. Brooke and Remmers (1970) illustrate the strength of firm-specific isomorphic tendencies, documenting a "mirror effect," according to which multinational enterprises establish subsidiaries whose qualities, whether by design or unintended outcome, reflect those of the headquarters office. Perlmutter (1969) proposes a more varied outcome, characterizing multinational firms as one of three types: MNEs are ethnocentric, polycentric, or global, depending on whether foreign subsidiaries structures and processes match those of home country, those of their host country, or those of a common worldwide standard, respectively.[8] Some recent authors propose that the MNE may be internally differentiated with respect to the consistency of its practices across facilities (Doz, Bartlett, and Prahalad, 1981; Hedlund, 1986; Prahalad and Doz, 1987; Bartlett and Ghoshal, 1989; Ghoshal and Nohria, 1989).

Addressing the need to "incorporate an international perspective into organizational theory," Rosenzweig and Singh (1991, p. 340) specifically address the relationship between the extent of "pressures for consistency" within the MNE versus "pressures for local isomorphism." Focusing on environmental differences across national boundaries, they articulate a broad set of hypotheses regarding the factors that influence the similarity of MNE subsidiaries to other firms in the host country. In related empirical research, Rosenzweig and Nohria (1994) and Robinson (1995) conduct detailed surveys of multinational enterprises' subsidiaries in order to assess the extent to which subsidiaries report similarities in their human resource management (HRM) practices with those of their parent corporations. In general, the studies find evidence of strong

[8] Although focusing principally on the relationship between an MNE's competitive position in different countries, Porter (1986) argues that the importance of local adaptation may vary across industry, with some industries requiring country-specific tailoring (multi-domestic industries) while others can be served by an organization that is consistent across countries (global industries).

local influence on subsidiaries' HRM practices, both for international subsidiaries in the United States (Rosenzweig and Nohria, 1994) as well as U.S. subsidiaries in Japan (Robinson, 1995).

By examining specific practices – such as the number of sick days allowed and the use of bonuses to compensate managers – for a cross-section of individual subsidiaries, these studies provide detailed information regarding self-reported differences and commonalities between subsidiaries and their headquarters.[9] The fine-grained level of detail at which these studies are conducted does, however, require some sacrifice with respect to analytic power. By posing exclusively dyadic comparisons (between the individual subsidiary and the parent headquarters), it is not possible to observe variation across subsidiaries within the firm or to draw conclusions with confidence about the strength of "firm effects." Similarly, by observing subsidiaries in only one geographic environment (Japanese subsidiaries of U.S. firms, in the case of Robinson, 1995, and U.S. subsidiaries of various international firms in the case of Rosenzweig and Nohria, 1994), it is not possible to draw conclusions regarding whether observed effects can be generalized or remain specific to the geographic environment in which they have been observed. Finally, the absence of time-series data eliminates the possibility of observing changes in organizational practices over time, which would also improve the power of both firm-specific and location-specific comparisons.

This paper utilizes an alternative approach, employing a proxy for a key organizational practice at a broad level of detail and measuring this practice across firms, regions, and time. By adopting this strategy, the paper provides estimates of the relative importance of different levels of influence on an output-oriented indicator of organizational practice.

---

[9] While Rosenzweig and Nohria also evaluate a battery of hypotheses regarding the factors that drive isomorphism, the principal aim of this paper is to quantify the strength of firm and location effects in an econometrically sophisticated manner.

III. ORGNIZATIONAL PRACTICE IN DRUG DISCOVERY RESEARCH

This section introduces the research setting and reviews firm-specific and location-specific influences on the organization of drug discovery. Drug discovery constitutes the first phase of pharmaceutical research, during which firms seek to identify novel compounds that alleviate the symptoms or causes of disease. This process is highly uncertain, time-consuming, and resource-intensive. Estimates from the U.S. Pharmaceutical Research and Manufacturers Association (PhRMA) suggest that drug discovery research projects in the 1990s last approximately two to three years, during which five thousand to ten thousand molecules will be screened. Of these, five will eventually enter clinical testing, only one of which ultimately will be approved for consumer marketing by the Food and Drug Administration (FDA). In 1998, pharmaceutical firms devoted more than $4.25 billion to domestic drug discovery efforts in the United States (PhRMA, 2000).

For nearly a century, major pharmaceutical firms have devoted substantial resources to the applied research efforts that are closely linked to the identification of novel, disease-fighting compounds. Firms have differed quite widely over this period, however, in the extent to which they support in-house research in basic science (Liebenau, 1985; Henderson and Cockburn, 1994; Gambardella, 1995).[10] For the majority of the industry's history, the ability of *academic*

[10] Note that even in the early years of the modern industry, some firms partnered with eminent scientists. Hoechst, for example, employed Nobel prize winners Paul Ehrlich and Emil von Behring in their search for efficacious medicines. In a famous example of the use of basic science as a guide for drug discovery research, Ehrlich built upon emerging insights in bacterial biochemistry in discovering Salvarsan, a cure of syphilis, while engaged in Hoechst's research laboratory. By contrast, other early firms, such as Sterling (which held the rights to Bayer Aspirin for the majority of the 1900s) placed little emphasis on basic research, although many were pioneers in areas of marketing and advertising.

science to contribute to drug discovery was limited by its inability to understand mechanisms of action for disease-fighting agents.[11] Beginning in the 1970s, sets of scientific advances increased the usefulness of basic scientific knowledge as a guide in the search for effective new molecules (Gambardella, 1992; Henderson and Cockburn, 1994). In the 1980s and 1990s, a number of firms sought to exploit these advances more aggressively, adopting structures to monitor research projects, organize and reward research teams, recruit and promote individual researchers, and interact with researchers in university and other laboratories outside of the firm that differed substantially from those historically prevalent in drug discovery efforts.

Research on pharmaceutical R&D contends that the interrelated sets of organizational structures and processes that characterize this *science-driven* approach to drug discovery constitute a distinct organizational practice (Milgrom and Roberts, 1990). Science-driven drug discovery demonstrates positive effects on productivity during the 1980s and early 1990s (see Gambardella, 1992, Henderson and Cockburn, 1994; 1995). Although adoption increases during this period, firms nonetheless exhibit significant variation in the extent to which they pursue science-driven drug discovery (Cockburn, Henderson, and Stern, 2000). These results suggest the presence of firm effects in drug discovery practices.

Research examining knowledge spillovers and firm location in the pharmaceutical industry suggests that location-specific factors also affect the organization of science-based drug discovery. Research knowledge, especially basic scientific knowledge, flows more quickly and extensively to geographically proximate areas than to distant locations (Jaffe, 1986, 1989; Jaffe, et. al., 1993). This observation is corroborated in the pharmaceutical industry by findings that

---

[11] For example, although aspirin was discovered by Bayer in the late 1800s, its mechanism of action has only been clarified recently.

newly founded biotechnology firms tend to locate in the area of and work in conjunction with prominent university faculty (Zucker and Darby, 1994 and Audretsch and Stephan, 1996). With respect to science-driven drug discovery, this raises the possibility that facilities with better local access to leading-edge scientific knowledge – either via local academic research centers or from nearby private laboratories – may be more likely to engage in science-driven drug discovery than those with lesser access to such knowledge. More generally, this suggests that the extent to which firms engage in science driven drug discovery research differs across location. The qualitative evidence presented by Cockburn, Henderson, and Stern (2000) suggests this as well. Using the firm as the unit of analysis, however, these authors are unable to identify significant geographic effects.

In order to separately identify firm and location effects on the organization of drug discovery research, this paper takes advantage of the fact many large pharmaceutical firms operate laboratories in multiple geographic regions. This enables comparisons *across locations within firms* as well as across firms and locations (and over time). On one hand, firm effects may predominate in determining the organization of drug discovery laboratories, perhaps as a result of a similar corporate culture across all labs or because headquarters facilities design structures and processes for all subsidiaries. On the other hand, local regulatory climates, researcher cultures, or other forces may result in predominant location effects.

At the same time, the importance of firm and location effects may vary with laboratory characteristics and across samples subgroups. For example, Frost (1997) and Kuemmerle (1999) note that laboratories differ in their propensities to generate new knowledge and assimilate knowledge from the local environment. This suggests that laboratory-specific characteristics, such as the laboratory's idiosyncratic history, the preferences of its R&D director, or whether has

-post," may also affect its choice of organizational practices.[12]

This paper's empirical exercise evaluates the "horse-race" between the relative salience of firm and location effects on the organization of drug discovery laboratories, while exploring the relevance of laboratory-specific characteristics and sample subgroups. In future work, I plan to investigate the firm-specific and location-specific factors that drive these levels of influence.

IV. METHODOLOGY, DATA, AND MEASUREMENT

Empirical Methodology

This paper quantifies the effects of multiple environments on the traits of a focal facility by, first, identifying components of each environment that influence the focal facility but do not overlap with each other and, second, measuring the similarity of those traits across environment while simultaneously controlling for traits in the other environment. For example, the strength of the firm effect on Glaxo's Greenford, England facility is reflected in its similarity with organizational practices in the remainder of Glaxo's laboratories, including its labs in England, as well as those in Verona, Italy and Durham, North Carolina, controlling for other effects. Likewise, comparing Glaxo's Greenford laboratory with other firms' laboratories in the London area, identifies the strength of homogeneity within the region.

I model organizational practice in a focal laboratory as a function of organizational practice in the remainder of its firm as well as organizational practices in laboratories

[12] Laboratories' scientific orientations may also differ systematically according to their primary disciplines of research, e.g., molecular biology, chemistry, etc.

geographically proximate to the focal laboratory (but not affiliated with the focal firm), controlling for time, and assuming randomly distributed errors. The basic empirical model takes the form:

(1) $LABSCI_{ijrt} = \beta X_{-ijt} + \gamma Y_{-jrt} + \delta Z_{ijrt} + \varepsilon_{ijrt}$,

where *LABSCI* indicates the scientific orientation of laboratory *i* in firm *j*, region *r*, and time *t*, and *X*, *Y*, and *Z*, represent firm-specific effects, location-specific effects, and time controls, respectively. (The subscripts –*i* and –*j* indicate all firm laboratories other than lab *i* and all firms other than j, respectively.) Consistent with previous research, I assume separability among the effects in the primary specification. In the empirical analysis, I then perform numerous robustness tests examining the sensitivity of the results to functional form. As specified, (1) also assumes that the impact of *X* and *Y* on *LABSCI* are contemporaneous. Models in which conditions in the influences on LABSCI are lagged are also examined in the empirical results.

I interpret the relative magnitudes of the coefficients on β and γ in (1) as indicators of the relative strength of firm and location effects. For example, the event that all firm-laboratories are perfectly isomorphic with respect to scientific orientation and completely uncorrelated with location-specific qualities yields β=1 and γ=0. Note, as well, that this empirical strategy unpacks the impact of multiple environments by measuring the qualities of those environments that do not overlap. For example, for firms that operate facilities in only one region, it is not possible to isolate firm effects from geographic effects. (Single-region firms should be included in the analysis nonetheless, because they provide information about the qualities of the regional environments faced by other firms.)

Measuring science-driven drug discovery

Careful research on organizational practices requires a detailed understanding of managerial systems and individual and group level behaviors. Developing measures to capture complex and variegated organizational practices is therefore an inherently difficult and ultimately imperfect task. Researchers can choose to either develop multiple, detailed measures of specific organizational traits (e.g., Rosenzweig and Nohria, 1994; Robinson, 1995) or develop summary measures that reflect sets of choices within the organization, and thus proxy for the sets of behaviors that characterize distinguishable organizational practices (e.g., MacDuffie, 1995; Ichniowski et al., 1997; Henderson and Cockburn, 1994). Because the empirical exercise of separately identifying firm and geographic effects requires an extensive panel dataset, limitations on time and financial resources preclude the development of measures based on multiple, detailed lab-level characteristics.[13]

The structures and processes associated with the organizational practice of science-driven drug discovery include difficult-to-quantify features, such as qualities of managerial, budgeting systems, and incentive systems.[14] Fortunately for this research, an organization's commitment to science-driven drug discovery often manifests itself in a concomitant commitment to allowing researchers to publish their results in scientific journals. Consequently, measures indicating a firm's commitments to academic publication can provide insightful measures of its orientation towards science-driven drug discovery. Using extensive interviews with R&D managers, Henderson and Cockburn (1994) develop a Likert scale measure of scientific orientation,

---

[13] Although it is possible to establish point-in-time data from a survey, it would be prohibitively difficult to obtain accurate historical information. To supplement the quantitative data, I will continue to assemble over the next few months qualitative evidence from semi-structured interviews with R&D managers and drug discovery research personnel.

"PROPUB," that reflects firms' propensity to promote researchers based on their standing in the academic community.[15] Extending their research to a larger sample of firms, Cockburn, Henderson, and Stern (2000) introduce a complementary measure, "

the fraction of a firm's patenting scientists that also publish academic articles within two years of patent application. This measure, which correlates with PROPUB, has the additional advantage that it can be computed based on observable research outputs. By taking advantage of geographic information provided in publications and patent data, I adapt PUBFRAC in this paper for use at the laboratory level.

Note that researchers who *publish but do not patent* are omitted in the construction of PUBFRAC. Operationalized in this way, PUBFRAC assumes that the essence of science-driven drug discovery is reflected by individual researcher's simultaneous participation in the applied efforts of obtaining patents as well as the enterprise of basic science reflected by academic publication. The meaning of this measure thus differs in a subtle way from PROPUB, which relies upon researchers' standing in the academic community but is silent with respect to their performance of more applied research tasks. PUBFRAC reflects the propensity of a firms' active researchers (i.e., those who patent) to also engage in the academic enterprise of scientific publication. One interpretation is that while PROPUB measures intended organizational practice, PUBFRAC may be viewed as a measure of *realized* organizational practice.

---

[14] Throughout this paragraph I draw on Gambardella (1995), Henderson and Cockburn (1994; 1995), Cockburn, Henderson, and Stern (2000), and the papers referenced therein.
[15] Alternatively, Gambardella (1992) employs a firm's number of publications as an indicator of its commitment to science.

Data sources[16]

I assemble for this project a dataset that chronicles research outputs for thirty-two global pharmaceutical firms over the time period 1984 to 1994. (A complete list appears in Appendix Table 1.) Sample firms were chosen randomly from the population of the largest multinational pharmaceutical concerns. Approximate calculations suggest that firms in the sample account for more than 55 percent of total U.S. pharmaceutical patenting.[17]

The raw dataset consists of patents granted by the U.S. Patent and Trademark Office (USPTO) and publications data recorded by the Institute for Scientific Information's Science Citation Index (SCI). The SCI catalogues publications in nearly five thousand international academic and industry journals, identifying, among other relevant characteristics, authors' names and addresses, along with institutional affiliations. Appendix Figures 1 and 2 plot the annual number of USPTO patents and inventors and SCI publications and authors in the raw dataset, respectively.[18] (Each patent may list multiple inventors and each publication may list multiple authors. The annual counts of inventors and authors are reflected on the right hand side of the y-axis in Appendix Figures 1 and 2, respectively.) The sample dataset covers approximately 70,000 patents, 250,000 inventors, and 80,000 scientific publications, with more than 445,000 authors. Firms receive 49.3 patents annually, on average, but this figure varies considerably across firms. While firms such as Amersham and Organon regularly obtain fewer than 25

---

[16] While the following sub-section describes exclusively quantitative sources, I plan to supplement these numerical data with semi-structured interviews with researchers, R&D managers, and executives from between four and six of the firms in the sample, as well as some academic researchers.

[17] In a more complete version of this paper, I will replace this statistic with a precise calculation and supplement it with a comparison between total industry R&D expenditures and sample R&D expenditures.

[18] For firms that are engaged in multiple industries, I include only patents corresponding to either USPTO patent classes 424 or 514 or the international patent classes under A61K. I include the complete set of patents for firms specializing in ethical pharmaceuticals. The results are robustness to censoring the patents for specialized pharmaceutical firms. Interestingly, however, they are substantially weakened by including non-pharmaceutical patents for diversified firms.

patents per year, Merck receives more than six times as many.[19] Firms publish more than they patent, a fact that may reflect, among other things, the relatively higher costs associated with the patenting process.[20] On average, at least one firm author appears on more than 220 SCI publications annually and the standard deviation in annual firm publications, 244, exceeds the mean.

I have identified firm laboratories via reviews of company documents (including web pages), semi-structured interviews with industry experts, and with a careful review of the address fields of the patenting and publications data. Figure 2 displays a map indicating identifiable drug discovery research laboratories in the United States and Europe for all firms in the sample.[21] Over the course of the sample period, 107 laboratories are included in the analysis. These operate in 14 different countries in North America, Europe, and Japan. Forty are located in 14 different states in the United States (of which 13 are in the Pennsylvania-New Jersey corridor). Nineteen laboratories are in the UK and seven are in Japan.

I use geographic information in the USPTO and SCI data in order to attribute patents and publications to the laboratories of their origin. Unfortunately, neither data source directly identifies source laboratories and a number of features of these data complicate the simple attribution of papers and patents to drug discovery laboratories. First, the SCI dataset is imprecise in matching authors' names to their institutional addresses.[22] Second, patent data identify inventors' home addresses rather than their institutional addresses. Institutional

---

[19] I attribute patents to the year of application rather than the year of approval. As approval may take a number of years, I censor the patent data to include those applied for by 1995.

[20] A range of research examines firms motivations for and behaviors with respect to patenting and publishing, including, Schmookler (1966), Griliches (1984, 1990), Pavitt (1988); Hicks (1995), Lim (2000), and Gittelman and Kogut (2000).

[21] A map including laboratories in Japan will be included in future versions of this paper.

[22] As a rule, SCI data list the names of each paper author; however, they do not match authors to addresses where publications contain multiple authors and address.

addresses are provided for patent assignees (the companies in which inventors work), but these often refer to company headquarters rather than the particular laboratory in which the relevant research occurred. As a result, it is necessary to infer researchers' laboratory addresses via a complex matching algorithm. A precise description for the matching algorithm is available from the author (and will be added as an Appendix in future versions of this paper). In brief, the algorithm uses mapping software to match researchers to the nearest firm-laboratory within a 50 mile radius of the inventor's home.[23]

Measures

A description of key empirical measures appears in Table 1. Table 2 reports means and standard deviations for the laboratory, firm, and regional levels. Laboratory scientific orientation, LAB PUBFRAC, is computed as the fraction of individuals associated with laboratory *i* who are listed as inventors on a USPTO patent and who are also listed as authors on a paper in the SCI within two years of the patent application.[24]

Mean LAB PUBFRAC is 0.437. Figure 3 depicts variance in PUBFRAC across laboratories. Figure 3's top panel, which includes the complete data sample, demonstrates a mass of observations for which LAB PUBFRAC equals either zero or one. LAB PUBFRAC increases generally, though not universally, as a function of time (see Figure 4). Note, however, that both the trend and the level of LAB PUBFRAC differ across geographical regions (see Figure 5).

---

[23] Note that this calculation corrects for the curvature of the earth and that the matching algorithm addresses issues associated with the spelling of inventor and city names.
[24] For the firm-level equivalent see Cockburn, Henderson, and Stern (1999, 2000).

Firm-specific influences are captured primarily by FIRM PUBFRAC and firm dummy variables. Computed as LAB $PUBFRAC_{-ijt}$, where $-i$ indicates "not laboratory i," FIRM PUBFRAC is the PUBFRAC for firm j, excluding all researchers affiliated with focal laboratory i. In (1) it is used to reflect the extent to which a focal laboratory's scientific orientation is driven by the orientation towards science in the other laboratories of its firm network.

Indicators of the orientation towards science-driven drug discovery in a geographical region are constructed in a similar fashion. A location-specific variant of LAB PUBFRAC, REGION PUBFRAC, is computed as the fraction of all patent recipients in the dataset whose address lies within a one hundred mile radius of the focal laboratory (excluding those from the focal laboratory) who are listed as inventors on USPTO patents and who also appear as authors of SCI publications within two years of patent application.[25] Under this definition, the relevant geographic region of influence is unique to each laboratory, consisting of the area within a 50 mile radius of the focal lab. This definition has the advantage that it is more precise, on average, than a definition based on administrative boundaries, such as US states or countries.

A variant of the regional measure, AREA PUBFRAC, is computed using more broadly-defined geographical areas, some of which are sub-national, while others are super-national. These regions include: US-North, US-New England, US-PA/NJ/DE, US-South, US-Midwest, US-West, Canada, the United Kingdom, Northern Europe, Eastern Europe, Central Europe, Southern Europe, Japan, and Other. Note that this regional classification scheme was chosen on the basis of programming ease for the first version of this paper. (Numerous alternative versions

---

[25] A 100 mile radius was chosen based on conversations with US-American researchers who suggest that their network of research associates is strongest within a two hour driving radius. The principal results, however, demonstrate robustness to the use of a 50 or 150 mile radius. Additional regional definitions, including perhaps BEA regions, MSAs, and other administrative boundaries, will be explored in future versions.

will be explored as the research progresses.) This variable is used to help gauge the appropriate breadth at which to define the geographic region.

V. EMPIRICAL RESULTS

Tables 3 through 7 present the paper's empirical results. Table 3 reviews the pairwise correlations among the paper's key variables. LAB PUBFRAC is positively and significantly correlated with both FIRM PUBFRAC and REGION PUBFRAC, the principal variables summarizing firm and geographic effects. The pairwise correlation between FIRM PUBFRAC and REGION PUBFRAC is also positive and significant. These unconditional correlations are consistent with the proposition that high PUBFRAC laboratories are affiliated with high PUBFRAC firms and are located in high PUBFRAC regions.

The remainder of the tables present the results of estimations based on (1). Table 4 presents exploratory models as well as the paper's core results. Equation (4-1) estimates the conditional correlation between LAB PUBFRAC and FIRM PUBFRAC, controlling for YEAR. FIRM PUBFRAC is statistically significant in this model. Its coefficient suggests that slightly nearly 26 percent of differences in FIRM PUBFRAC are reflected in LAB PUBFRAC. For example, a laboratory whose FIRM PUBFRAC is one standard deviation above the mean (0.303) is expected to obtain LAB PUBFRAC 0.078 (0.259 * 0.303 = 0.078) above that achieved by a laboratory with FIRM PUBFRAC at its mean. (4-2) estimates LAB PUBFRAC as a function of REGION PUBFRAC and YEAR. REGION PUBFRAC also enters significantly, although its coefficient is smaller than that of FIRM PUBFRAC in (4-1) and R-squared in this model is also smaller than that of (4-1).

These results suggest that both firm and geographic effects are present in the data; however, evaluating this proposition more definitively requires jointly estimating the importance of each. Equation (4-3) presents the specification in which both FIRM PUBFRAC and REGION PUBFRAC enter the model, controlling for YEAR. Both firm and geographic effects are positive and significant in this model. This result demonstrates that a focal laboratory's scientific orientation is positively and significantly related to both the scientific orientation of other laboratories within its firm and well as the scientific orientation of other laboratories within its region. Consistent with the individually estimated models, firm effects are larger than geographic effects in the joint model. This is true both with respect to the magnitude of the coefficients in (4-3) as well as their elasticities, evaluating FIRM PUBFRAC and REGION PUBFRAC at the mean. Interestingly, including both FIRM PUBFRAC and REGION PUBFRAC in the model changes neither the magnitude of either effect nor the precision with which they are estimated. This suggests that, in the particular case examined here, firm effects and geographic effects operate independently.

Consistent with Figure 5, the coefficient on YEAR is positive throughout the estimations (though not consistently significant) and the coefficients on year fixed effects generally increase over time. Equation (4-4) replaces the time trend with year fixed effects. Similar results obtain, although the coefficient of REGION PUBFRAC is slightly lowered when an intercept is estimated for each year.

Table 5 explores the robustness of the core results to alternative characterizations of firm and geographic effects. (5-1) includes firm fixed effects with REGION PUBFRAC in the analysis. Identifying based on within firm variance alone (as opposed to between-firm variation) reduces the magnitude of the coefficient on REGION PUBFRAC such that it remains significant at the 10% level but not the 5% level. This is not surprising: whereas FIRM PUBFRAC contains information only for laboratories outside of the focal laboratory's local region, firm dummies incorporate information about the entire firm, including the region proximate to the focal laboratory. This nuance justifies FIRM PUBFRAC as a more appropriate measure of firm effects. Note that because regions are defined based upon the area proximate to a focal laboratory, region fixed effects cannot be distinguished from lab fixed effects. An alternative approach to elucidate fixed as well as time-variant properties of firms and regions is to control for initial conditions on each dimension. (5-3) adds the level of FIRM PUBFRAC and REGION PUBFRAC in 1984 to the core model. At the firm level, each variable demonstrates significance. The effect of separating out initial conditions from REGION PUBFRAC, however, yields insignificant coefficients for each variable, although the sum of the coefficients resembles the magnitude of REGION PUBFRAC when included individually.

Equation (5-4) examines the sensitivity of regional effects to the precision with which regions are measured. Specifically, AREA PUBFRAC, which is based on a more geographically broad definition of regions, replaces REGION PUBFRAC. That the coefficient on AREA PUBFRAC is insignificant in the model implies that geographic effects operate at a level less aggregate than that defined by AREA PUBFRAC.[26] Equation (5-5) considers the hypothesis that the strength of firm and geographic effects is mediated by the size of the firm or region. Neither the extent of patent output by the rest of the firm, the number of patents issued to other inventors in the region, nor interactions between patenting and FIRM or REGION PUBFRAC evidence significance.

---

[26] Note that this variable is something of a "placeholder." Future versions of this paper will explore more sophisticated definitions of regions, exploring definitions based on country, US-state, and, perhaps, postal codes or other administrative divisions.

Table 6 examines the robustness of the core results to specific laboratory characteristics. Including lab fixed effects in (6-1) does not reduce the significance of firm effects, but does reduce the estimated coefficient on REGION PUBFRAC. The fact that geographic effects become insignificant when fixed effects are controlled for suggests that their significance depends more on cross-sectional variation than in changes over time. (6-2) demonstrates that the core results hold – indeed, they appear stronger – for smaller laboratories. Equation (6-3) suggests that firm effects remain important for headquarters laboratories, but that these are not subject to geographic effects. Further exploring the role of headquarters laboratories, (6-4) substitutes HEADQUARTERS PUBFRAC for FIRM PUBFRAC in the core model. This result implies that lab level scientific orientation is not simply homogeneous with respect to the headquarters laboratory, but covaries with the entire set of firm labs. Taken together, (6-2) through (6-4) suggest that headquarters and larger laboratories are less subject to location-specific influences than are smaller, subsidiary laboratories. This is consistent with the conjecture that that R&D facilities more central to the firm's operation will be relatively more homogeneous with the rest of the firm than with the environments in which they are located.

Equation (6-5) provides additional results consistent with this view. For laboratories not on the same continent as the headquarters laboratory (6-5), the coefficient on REGION PUBFRAC exceeds that of FIRM PUBFRAC. This suggests that labs distant from the headquarters – less under its control or watchfulness – are more likely to be subject to location-specific influences. Equation (6-6) also demonstrates that the relative salience of firm and geographic effects varies across location, as laboratories in the United States are also characterized by larger geographic effects than firm effects.

The final set of estimations in the analysis, reported in Table 7, examines the robustness of the results to alternative specifications of (1). (7-1) demonstrates that the core results obtain in the context of a one year lagged relationship between REGION PUBFRAC and LAB PUBFRAC. This relationship, which also holds for two and three year lags, may simply reflect cross sectional differences. (7-2) examines the possibility of interaction effects between the extent of science-driven drug discovery in firm and geographic effects, but without positive findings. Equation (7-3) estimates an alternative to (1) in which the relationship between LAB PUBFRAC, FIRM PUBFRAC, and REGION PUBFRAC is exponential. Firm and geographic effects are both significant in this model. The coefficients, which can be interpreted as elasticities, indicate a higher sensitivity to geographic effects than firm effects. Note that this result may the related to the omission of observations where LAB PUBFRAC = 0, which become undefined when logarithms are applied.

Out of concern for the possibility that the results may be driven by the set of observations where LAB PUBFRAC equals either one or zero, equation (7-4) estimates a two-sided Tobit. The results of this estimation are similar to those obtained in the preferred specification, (4-3), reinforcing confidence in these results. Similarly, imposing a functional form that models the adoption of LAB PUBFRAC over time as conforming to an S-shaped curve, (7-5) estimates the core specification using a log-odds transformation of the dependent variable. The principal results obtain under this functional form as well.

VI. DISCUSSION

This paper considers the impact of multiple environmental influences as potential drivers of heterogeneity among a population of organizations. In order to overcome the challenges that limit inquiry in this area, I argue that a focal drug discovery laboratory's network of firm laboratories and network of laboratories in its local geographic region can be regarded as separate environments that act upon the focal laboratory. Further, I propose that a methodology that employs a panel dataset of laboratory-level observations can be used to identify the separate contributions of firm-specific and location-specific effects on laboratory characteristics. In the context of drug discovery in the global pharmaceutical industry, this approach appears to bear fruit.

The paper documents significant and systematic correlation between the PUBFRAC achieved by a focal laboratory inventors and that realized both by the remainder of its firm (firm effects) as well as by the set of inventors patenting in the geographic region proximate to the focal laboratory (geographic effects). Firm effects are generally larger than geographic effects throughout the analysis. The core findings are robust to alternative assumptions about functional form as well as to alternative characterizations of firm and regional variables. The salience of each class of effects does vary somewhat, however, according to the characteristics of the laboratories included in the analysis. For example, regional effects are stronger in US laboratories and in laboratories located on continents different from the central research facility.

I interpret these econometric results as evidence of firm-specific and location-specific influences on organizational practice in drug discovery. The conclusion that each of these domains influences organizational behaviors is broadly consistent with the expectations of the consistency-adaptation literature in international management and with views in strategy emphasizing firm and regional conditions. The result that firm effects exceed geographic effects differs from prior research exploring isomorphism in human resource practices (Rosenzweig and Nohria, 1994; Robinson, 1995). This may reflect that practices in drug discovery are more closely linked to critical firm strategic decisions than are the HRM practices in the sets of industries previously studied, and thus require greater coordination across multinational enterprises.

More generally, the paper serves as a demonstration of an exercise that distinguishes and quantifies the influence of multiple environments on a set of focal organizations. Such an effort is important both because it is likely empirically true that many organizations are subject to influences from multiple environments and because it is possible that evaluating the importance of a single domain on a population of organizations influenced by numerous domains may yield biased results. Interestingly, evaluating either the influence of either just firm effects or just geographic effects would, in this case, obtain coefficient estimates for each set of effects similar to those obtained when both are evaluated together.

This paper also addresses a growing literature that attempts to systematically characterize the sources of organizational heterogeneity. By demonstrating that observed organizational behaviors are correlated both with other behaviors internal to the focal firm boundaries as well as behaviors external but geographically proximate to the focal organization, the paper underscores the usefulness of considering the firm-facility as the unit of analysis. At the same time, the paper raises a number of questions for future research. The result that both firm and geographic effects obtain – and, in particular, that the relative salience of firm and geographic effects varies across contexts – recommends extending the research effort to identify and evaluate the factors that driving these effects.

Finally, as organizational practices have been linked with productivity differentials, both in the context of drug discovery as well as with regards to high performance work practices (see MacDuffie, 1995; Ichniowski et. al., 1997) the findings of this paper raise the intriguing possibility that complementarities may exist between organizational practice and location-specific characteristics, a proposition has implications for both strategy research interested in the origins of competitive advantage as well as research in international business concerned with measuring the sources of location-specific advantage. I intend to examine this further in future research.

REFERENCES

Audretsch, David and Paula Stephan (1996) "Company-Scientist Locational Links: The Case of Biotechnology," *American Economic Review*, vol. 86, num. 3, June, pp. 64-652.

Bartlett, Christopher A. and Sumantra Ghoshal (1989) *Managing Across Borders: The Transnational Solution*. Boston, MA: Harvard Business School Press.

Brooke, Michael Z. and H. Lee Remmers (1970) *The Strategy of Multinational Enterprise: Organization and Finance*. London, UK: Longman.

Cockburn, Iain, Rebecca Henderson, and Scott Stern (2000) "Untangling the origins of *Strategic Management Journal*, 21, 1123-1145.

Davis, Gerald F. and Henrich R. Greve (1997) "Corporate elite networks and governance *American Journal of Sociology*, 103(1): 1-37.

DiMaggio, Paul J. (1983) "State expansion and organizational fields," in R.H. Hall and R.E. Quinn (Eds.) *Organization Theory and Public Policy*, p. 147-161. Beverly Hills, CA: Sage.

DiMaggio, Paul J. and Walter W. Powell (1983) "The iron cage revisited: institutional isomorphism and collective rationality in organizational fields," *American Sociological Review*, 48: 147-160.

DiMaggio, Paul J. and Walter W. Powell (1992) Introduction. In *The New Institutionalism in Organizational Analysis*, ed., DiMaggio, Paul J. and Walter W. Powell. Chicago: University of Chicago Press.

Galaskiewicz, Joseph and Ronald Burt (1991) "Interorganizational contagion in corporate *Administrative Science Quarterly*, 36: 88-105.

Galaskiewicz, Joseph and Stanley Wasserman (1989) "Mimetic processes within an interorganizational field: An empirical test," *Administrative Science Quarterly*, 34: 454-479.

Ghoshal, Sumantra and Nitin Nohria (1989) "Internal differentiation within multinational *Strategic Management Journal*, 10: 323-337.

Ghoshal, Sumantra and Eleanor Westney (1993) *Organization Theory and the Multinational Corporation*. Hong Kong: St. Martin's.

Gittelman, Michelle and Bruce Kogut (2000), "Why Do Firms Publish Their Research (By Their Own Scientists?): Co-Publication and Patenting by US Biotechnology Firms," mimeo, New York University.

Griliches, Zvi (1986) "Data problems in econometrics," in *Handbook of Econometrics*, Intriligator Michael and Zvi Griliches, eds., North-Holland: Amsterdam, 1466-1514.

Griliches, Z. (1990) “Patent Statistics as Economic Indicators: A Su Journal of Economic *Literature*, 92, 630-653.

Griliches, Z. (1994) "Productivity, R&D, and the Data Constraint," *American Economic Review*, 84, 1-23.

Guillen, Mauro, Isin Guler, and J. Muir MacPherson (2000) “Global competition, institutions, and organizational change: The international diffusion of the ISO 9000 quality standards,” Wharton School of Business, mimeo.

Hannan, Michael T. and John Freeman (1977) “The population ecology of organizations,” *American Journal of Sociology*, 82: 929-964.

Haveman, Heather (1993) “Follow the leader: Mimetic isomorphism and entry into new *Administrative Science Quarterly*, 38: 593-627.

Henderson, Rebecca and Iain Cockburn (1994) “Measuring competence? Exploring firm effects in pharmaceutical research,” *Strategic Management Journal*, Winter Special Issue, 15, 63-84.

Henderson, Rebecca and Iain Cockburn (1996) “Scale, scope, and spillovers: the determinants of research productivity in drug discovery,” *Rand Journal of Economics*, 27(1), 32-59.

Hicks, Diane (1995) “Published papers, tacit competencies, and corporate management of the public/private character of knowledge,” *Industrial and Corporate Change*, 4(2), 401-424.

Hedlund, Gunnar (1986) “The hypermodern MNC: A heterarchy,” *Human Resource Management*, 25: 9-35.

Hofstede, Geert (1980) *Culture’s Consequences: International Differences in Work-Related Values*. Beverly Hills, CA: Sage.

Ichniowski, Casey, Kathryn Shaw, and Giovanna Prennushi (1997) “The effects of human resource management on productivity: A study of steel finishing lines,” *American Economic Review*, vol. 87, num. 3, pp. 291-313.

Jaffe, Adam, Manuel Trajtenberg, and Rebecca Henderson (1993) “Geographic localization of knowledge spillovers as evidenced by patent citations,” *Quarterly Journal of Economics*, vol. 108, , pp. 577-598.

Kogut, Bruce (1991) “Country capabilities and the permeability of borders,” *Strategic Management Journal*, Special Issue on Global Strategy, 12, 33-48.

Kuemmerle, Walter (1999), “Foreign direct investment in industrial research in the pharmaceutical and electronics industries - Results from a survey of multinational firms,” *Research Policy*, 28 (2-3), 179-193.

Learned, Edmund P., C. Roland Christensen, Kenneth R. Andrews and William D. Guth. 1969. *Business Policy*. Homewood, IL: Irwin.

Lim, K. (2000) *Basic Research, Applied Research, and Innovation in the Semiconductor and Pharmaceutical Industries*, unpublished doctoral dissertation, MIT-Sloan School of Management.

MacDuffie, John Paul. (1995) "Human Resource Bundles and Manufacturing Performance: Organizational Logic and Flexible Production Systems in the World Auto Industry," *Industrial & Labor Relations Review*, 48(2), 2

Meyer, John W. and Brian Rowan (1977) "Institutionalized organizations: Formal structure as myth and ceremony," *American Journal of Sociology*, 83: 340-363.

Meyer, John W., John Boli, George M. Thomas and Francisco O. Ramirez (1997) "World society and the nation-state," *American Journal of Sociology*, 103(1): 144-181.

Mezias, S. J. (1990) "An institutional model of organizational practice: Financial reporting at *Administrative Science Quarterly*, 35(3): 431-457.

Milgrom, Paul and John Roberts (1990) "The economics of modern manufacturing: Technology, Strategy, and Organization," *American Economic Review*, pp. 511-528.

Milgrom, Paul and John Roberts (1995) "Complementarities and fit," *Journal of Accounting And Economics*, vol. 19, num. 2-3, pp. 179-208.

Nelson, Richard R. and Sidney G. Winter (1982) *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.

Pavitt, K. (1988) "Uses and abuses of patent statistics," in van Raan, A. (ed.) Handbook of Quantitative Studies of Science Policy, Amsterdam: North Holland.

Perlmutter, Howard (1969) "The tortuous evolution of the multinational corporation," *Columbia Journal of World Business*, 4: 9-18.

Pfeffer, J. and G. Salancik (1978). *The External Control of Organizations: A Resource Dependence Perspective*, New York : Harper & Row.

Pharmaceutical Research and Manufacturers Association (2000) *The Pharmaceutical Industry Profile 2000*. Washington, DC.

Porac, Joseph and Thomas, Howard (1990) "Taxonomic mental models in competitor *Academy of Management Review*, 15: 224-240.

Porac, Joseph and Thomas, Howard (1994) "Cognitive categorization and subjective rivalry among retailers in a small city," *Journal of Applied Psychology*, 69: 54-66.

Porac, Joseph, Howard Thomas, and C. Baden-Fuller (1989) "Competitive groups as cognitive communities: The case of Scottish knitwear manufacturers," *Journal of Management Studies*, 26: 397-416.

Porac, Joseph, Howard Thomas, and B. Emme (1987) "Understanding strategists' mental models of competition," in G. Johnson (Ed.) *Business Strategy and retailing*: 59-79. New York, NY: Wiley.

Porter, Michael E. (1986) "Changing patterns of international competition," *California Management Review*, 28(2): 9-40.

Porter, Michael E. (1990) *The Competitive Advantage of Nations*. New York: The Free Press.

Porter, Michael E. (1998) "Clusters and competition: New agendas for companies, governments, and institutions," in Porter, Michael E. (Ed.) *On Competition*: 197-299. Boston, MA: Harvard Business School Press.

Pouder, R. and St. John, C.H. (1996) Hot spots and blind spots: Geographical clusters of firms and innovations, *Academy of Management Review*, 21(4): 1192-1212.

Powell, Walter W. (1990) "Neither market nor hierarchy: Network forms of organization," in Staw, B. and Cummings, L. L. (Eds.) *Research in Organizational Behavior*: 12 295-336. Greenwich, CT: JAI Press.

Robinson, Patricia. (1994) *Applying Institutional Theory to the Study of the Multinational Enterprise: Parental Control and Isomorphism among Personnel Practices in American Manufacturers in Japan*. Unpublished doctoral dissertation, MIT-Sloan School of Management.

Rosenzweig, Philip (1994) "Management practices in U.S. affiliates of foreign-owned firms: Are they just like us," *The International Executive*, July-August.

Rosenzweig, Philip and Jitendra Singh (1991) "Organizational environments and the *Academy of Management Review*, 16(2): 340-361.

Rosenzweig, Philip and Nitin Nohria (1994) "Influences on human resource management practices in multinational corporations," *Journal of International Business*, 2nd quarter, 229-251.

Scott, W. R. (1983) "Health care organizations in the 1980s: The convergence of public and professional control systems," in Meyer and Scott (eds.), *Organizational Environments: Ritual and Rationality*. Beverly Hills, CA: Sage Publications, 99-113.

Scott, W. R. (1987) *Organizations: Rational, Natural, and Open Systems.* Englewood Cliffs, NJ: Prentice Hall.

Scott, W. R. (1987) "The adolescence of institutional theory, *Administrative Science Quarterly*, 32, 493-511.

Schmookler, J. (1966) *Invention and Economic Growth.* Cambridge (MA): Harvard University Press.

Selznick, P. (1965) *TVA and the Grass Roots.* New York: Harper & Row.

Soskice, David (1991) "The Institutional Infrastructure for International Competitiveness: A Comparative Analysis of the UK and Germany", in A.B.Atkinson and R.Brunetta (eds.), *The Economics of the New Europe*, International Economic Association conference volume, Macmillan.

Sull, Donald (1999) "Industrial clusters and organizational inertia: An institutional perspective," London Business School, mimeo.

Westney, D. Eleanor (1993) "Institutionalization theory and the multinational corporation," Chapter 3 in *Organization Theory and the Multinational Corporation*. Hong Kong: St. Martin's, 53-76.

Westney, D. Eleanor (1987) *Imitation and Innovation: The Transfer of Western Organizational Patterns to Meiji Japan*. Cambridge, MA: Harvard University Press.

Whitley, R. (1991) "The Social Construction of Business Systems in East Asia; Whitley, Richard D," *Organization Studies*, 12(1), 1-29.

Westphal, James D., Ranjay Gulati, and Stephen M. Shortell (1997) "Customization or conformity: An institutional and network perspective on the content and consequences of TQM adoption," *Administrative Science Quarterly*, 42: 366-394.

Zaheer, Srilata (1991) *Organizational Context and Risk-Taking in a Global Environment: A Study of Foreign-Exchange Trading Rooms in the U.S. and Japan*, unpublished doctoral dissertation, MIT Sloan School of Management.

Zucker, Lynne (1987) "Institutional theories of organization," *Annual Review of Sociology*, 13, 443-464.

Zucker, Lynne and Michael Darby (1998) "Intellectual human capital and the birth of U.S. biotechnology enterprises," *American Economic Review*, vol. 88, num. 1, pp. 290-306.

Zucker, Lynne and Michael Darby (1997) "Present at the revolution: Transformation of technical identity for a large incumbent pharmaceutical firm after the biotechnological breakthrough," *Research Policy*, vol. 26, num. 4, 5, pp. 429-447.

TABLE 1
DEFINITIONS OF KEY VARIABLES

VARIABLE NAME	DEFINITION
PUBFRAC	The fraction of a unit's inventors (individuals whose names appear on a USPTO patent in year *t*) who publish an article cataloged in the Science Citation Index within two years of patent application.
LAB $PUBFRAC_{i,j,t}$	The fraction of a **laboratory *i's*** inventors (individuals whose names appear on a USPTO patent in year *t*) who publish an article cataloged in the Science Citation Index within two years of patent application.
REST-OF-FIRM $PUBFRAC_{i,j,t}$	The fraction of **firm *j's*** inventors not affiliated with laboratory *i* who publish an article cataloged in the Science Citation Index within two years of patent application.
REST-OF-REGION $PUBFRAC_{i,j,,t}$	For laboratory *i*, the fraction of inventors *not* affiliated with firm *j* whose addresses are within a 100-mile radius of the focal laboratory who publish an article cataloged in the Science Citation Index within two years of patent application.

Sources for all data: Science Citation Index and US Patent and Trademark Office, 1984-1994.

TABLE 2
MEANS & STANDARD DEVIATIONS

VARIABLE	N	MEAN	STANDARD DEVIATION	MIN	MAX
LAB-LEVEL					
Year	704	89.387	3.191	84	94
Annual PATENTS	704	22.690	26.300	1	158
Annual INVENTORS	704	56.080	78.252	1	472
LAB PUBFRAC	704	0.437	0.303	0	1
LAB PUBFRAC 1984	558	0.359	0.295	0	1
FIRM PUBFRAC	704	0.428	0.174	0	1
FIRM PUBFRAC 1984	558	0.342	0.187	0	0.707
REGION PUBFRAC	704	0.425	0.221	0	1
REGION PUBFRAC 1984	499	0.306	0.213	0	1
AREA PUBFRAC	704	0.447	0.117	0	0.798
FIRM-LEVEL					
Number of Labs per Firm	374	3.147	1.480	1	7
Annual PATENTS	374	61.575	46.257	1	259
Annual INVENTORS	374	228.207	213.256	2	1035
REGION-LEVEL					
Annual PATENTS	704	84.516	101.659	1	422
Annual INVENTORS	704	218.756	276.140	1	1231
AREA-LEVEL					
Annual PATENTS	154	194.941	131.044	4	466
Annual INVENTORS	154	724.900	579.361	11	1986

TABLE 3
CORRELATION AMONG PRINCIPAL VARIABLES

	LAB PUBFRAC	FIRM PUBFRAC
FIRM PUBFRAC	0.153**	
REGION PUBFRAC	0.121**	0.140**

** Denotes pairwise correlations significant at the 5% level.

TABLE 4
FIRM EFFECTS AND LOCATION EFFECTS^

	Dependent Variable = LAB PUBFRAC$_{i,j,t}$			
	(4-1) Firm PubFrac and Year, only	**(4-2)** Region PubFrac and Year, only	**(4-3)** Firm Region PubFrac and Year	**(4-4)** (4-3), with Year Fixed Effects
FIRM PUBFRAC	**0. 259** **(0. 065)**		**0.260** **(0.068)**	**0.220** **(0.069)**
REGION PUBFRAC		**0.152** **(0.054)**	**0.145** **(0.054)**	**0.110** **(0.055)**
YEAR	0.007 (0.064)	**0.009** **(0.003)**	0.005 (0.004)	
YEAR FIXED EFFECTS*				F(10, 691)= 2.02 Pr>F= **0.0291**
CONSTANT	-0. 343 (0. 309)	-0.447 (0.329)	-0.174 (0.334)	
R-squared	0.0351	0.0292	0.0491	0.0697
Adjusted R-Squared	0.0326	0.0264	0.0451	0.0691
Observations	704	704	704	704

^ Throughout the tables, boldface type indicates coefficients significant at least the 5% level. Bolded and italicized text denotes coefficients significant at least the 10% level.
* Reports results of Wald test of joint restrictions.

TABLE 5
EXPLORING ROBUSTNESS OF FIRM & REGIONAL EFFECTS

	Dependent Variable =(LAB PUBFRAC)$_{i,j,t}$				
	(5-1) Firm Fixed Effects and Region PubFrac	**(5-2)** (4-3) with Firm Fixed Effects	**(5-3)** (4-3) with initial PubFrac conditions	**(5-4)** (4-3) using alternative definition of region	**(5-5)** (4-3) with Firm & Region Size Effects
FIRM EFFECTS					
FIRM PUBFRAC		**0.160 (0.070)**	**0.152 (0.084)**	**0.241 (0.067)**	**0.246 (0.068)**
FIRM FIXED EFFECTS*	F(34,667)=2.99 **Pr**>F=**0.000**	F(34,666)=2.70 **Pr>F=0.000**			
FIRM PUBFRAC 1984			***0.129 (0.074)***		
FIRM PATENTS					0.000 (0.000)
REGION EFFECTS					
REGION PUBFRAC	**0.104 (0.054)**	***0.100 (0.054)***	0.109 (0.071)		**0.136 (0.056)**
REGION PUBFRAC 1984			0.014 (0.062)		
REGION PATENTS					0.000 (0.000)
AREA PUBFRAC				0.131 (0.107)	
INTERACTIONS					
(FIRM PUBFRAC) * (FIRM PATS)					0.002 (0.002)
(REGION PUBFRAC) * (REGION PATS)					0.000 (0.001)
CONTROLS					
YEAR	**0.009 (0.004)**	**0.006 (0.004)**	**0.011 (0.004)**	0.005 (0.004)	0.006 (0.004)
CONSTANT	-0.493 (0.336)	**-0.322 (0.343)**	**-0. 752 (0. 374)**	-0.218 (0.325)	-0.206 (0.342)
R-squared	0.1576	0.1642	0.0561	0.0370	0.0551
Adjusted R-Squared	0.1122	0.1177	0.0464	0.0332	0.0456
Observations	704	704	490	704	704

* Reports results of Wald test of joint restrictions.

TABLE 6
EXPLORING ROBUSTNESS TO LABORATORY CHARACTERISTICS

	Dependent Variable = (LAB PUBFRAC)$_{i,j,t}$					
	(6-1) (4-3) with Laboratory Fixed Effects	**(6-2)** (4-3) for Small Laboratories (<10 matches) Only	**(6-3)** (4-3) for Headquarters Labs only	**(6-4)** Headquarters PubFrac, Firm	**(6-5)** (4-3) for Distant Laboratories	**(6-6)** (4-3) for US Laboratories only
FIRM EFFECTS						
FIRM PUBFRAC	**0.195 (0.068)**	**0.304 (0.108)**	**0.232 (0.082)**		***0.273 (0.155)***	**0.231 (0.105)**
REGION EFFECTS						
REGION PUBFRAC	0.085 (0.056)	**0.204 (0.087)**	0.052 (0.077)	**0.139 (0.064)**	***0.315 (0.171)***	**0.242 (0.105)**
LABORATORY CHARATERISTICS						
LABORATORY FIXED EFFECTS	F(97,603)=2.35 **Pr>F=0.000**			0.000 (0.002)		
HEADQUARTERS PUBFRAC				0.019 (0.039)		
CONTROLS						
YEAR	0.006 (0.004)	-0.004 (0.007)	***0.009 (0.005)***	**0.077 (0.004)**	0.006 (0.009)	**0.012 (0.006)**
CONSTANT	-0.261 (0.341)	-0.569 (0.597)	-0.499 (0.454)	-0.328 (0.342)	-0.395 (0.734)	***-0.912 (0.508)***
R-squared	0.3103	0.0381	0.0599	0.0318	0.0868	0.1057
Adjusted R-Squared	0.1959	0.0301	0.0493	0.0274	0.0723	0.0960
Observations	704	368	269	669	193	280

* Reports results of Wald test of joint restrictions.

TABLE 7
EXPLORING ROBUSTNESS TO FUNCTIONAL FORM

	Dependent Variable*				
	LAB PUBFRAC			**ln(LAB PUBFRAC)**	**Log-odds(LAB PUBFRAC)$_I$**
	(7-1) (4-3) using lagged Region PubFrac	**(7-2)** (4-3) with Firm and Region interaction	**(7-3)** (4-3) using 2-sided Tobit	**(7-4)** (4-3) using logged variables	**(7-5)** (4-3) on log-odds Lab PubFrac
FIRM EFFECTS					
FIRM PUBFRAC	**0.148** **(0.076)**	**0.449** **(0.144)**	**0.361** **(0.095)**		**0.577** **(0.251)**
ln(FIRM PUBFRAC)				**0.133** **(0.045)**	
REGION EFFECTS					
REGION PUBFRAC		**0.324** **(0.131)**	**0.189** **(0.074)**		**0.451** **(0.189)**
ln(REGION PUBFRAC)				**0.185** **(0.060)**	
REGION PUBFRAC in Year *t-1*	**0.113** **(0.055)**				
INTERACTION EFFECTS					
(FIRM PUBFRAC) * (REGION PUBFRAC)		-0.425 (0.286)			
CONTROLS					
YEAR	0.007 (0.004)	0.005 (0.004)	0.004 (0.005)	**0.017** (0.008)	**0.046** **0.130**
CONSTANT	-0.306 (0.391)	-0.277 (0.341)	-0.191 (0.457)	**-2.057** **(0.746)**	**-4.752** **(1.109)**
R-squared	0.0275	0.0521		0.0723	0.0830
Adjusted R-Squared	0.0227	0.0467		0.0671	0.0775
Pseudo R-square			0.0319		
Observations	604	704	704	535	507

* Note: Log-odds (LAB PUBFRAC) = ln[(LAB PUBFRAC)/(1 – LABPUBFRAC)]

FIGURE 1
PRESSURES FOR HOMOGENEITY IN MULTIPLE ENVIRONMENTS

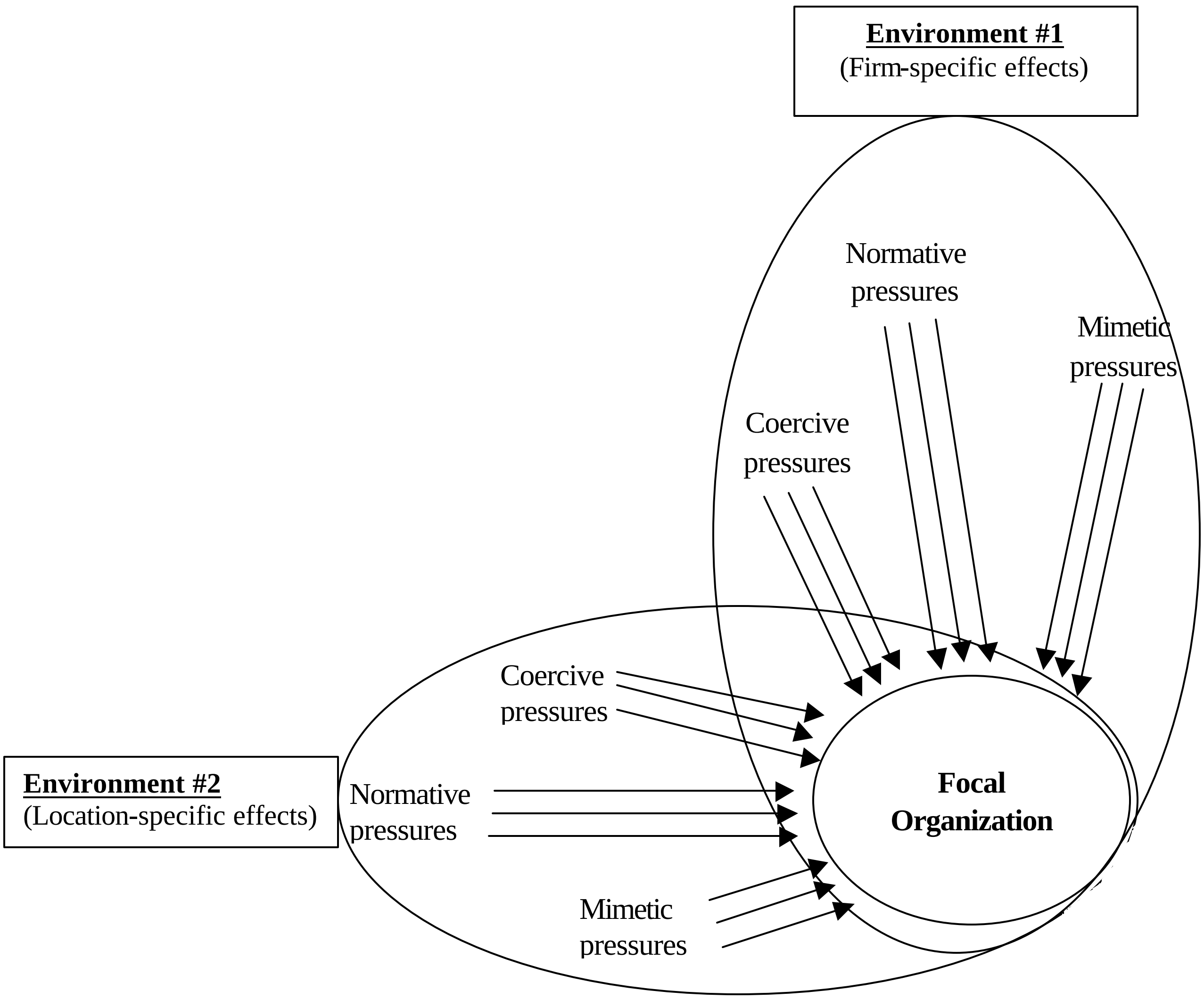
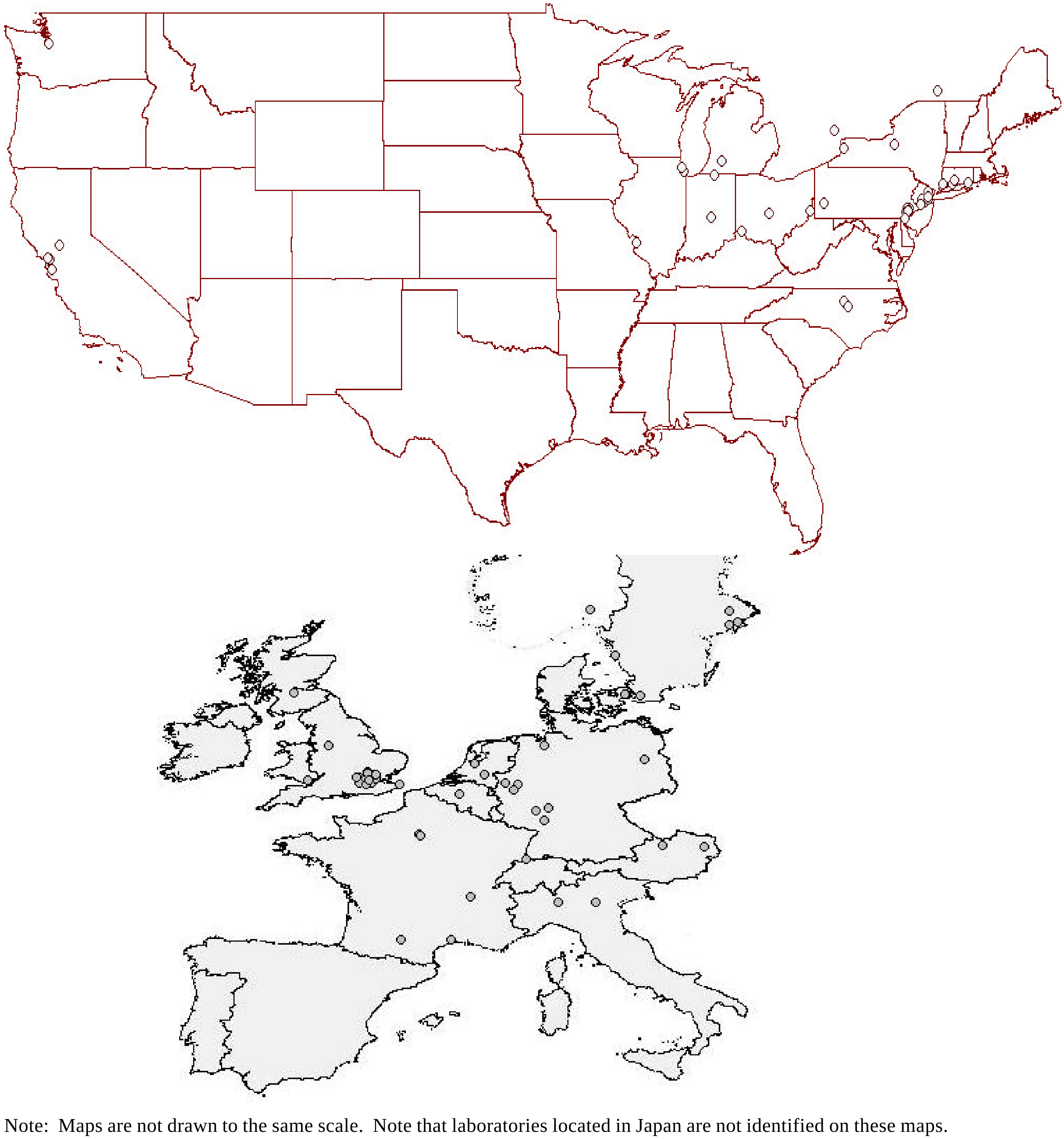


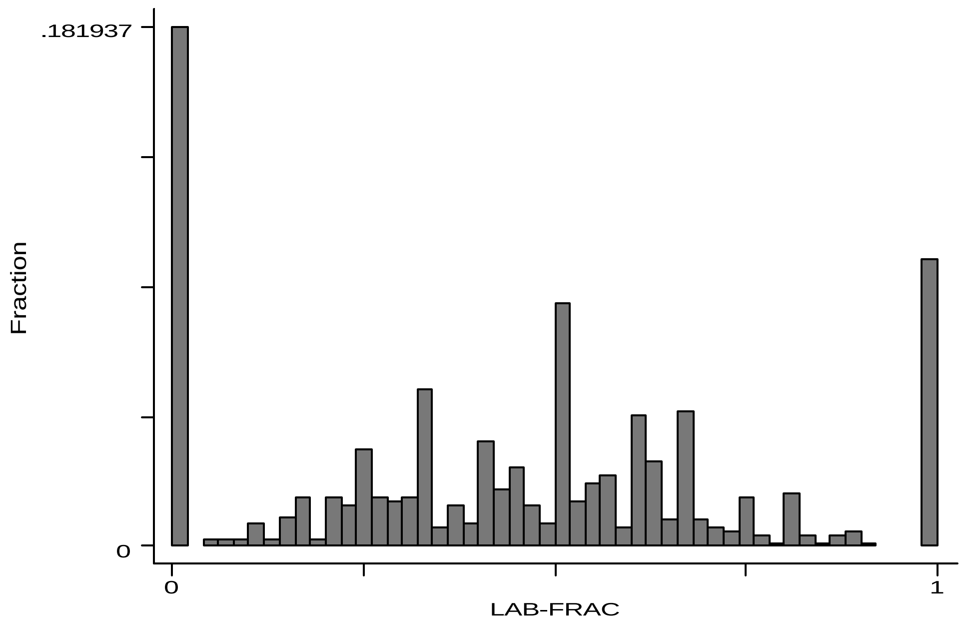
FIGURE 2
DISTRIBUTION OF DRUG DISCOVERY LABORATORIES
IN THE UNITED STATES AND EUROPE



Note: Maps are not drawn to the same scale. Note that laboratories located in Japan are not identified on these maps.

FIGURE 3
DISTRIBUTION OF LAB PUBFRAC

ALL LABORATORIES



LABORATORIES ABOVE MEDIAN SIZE

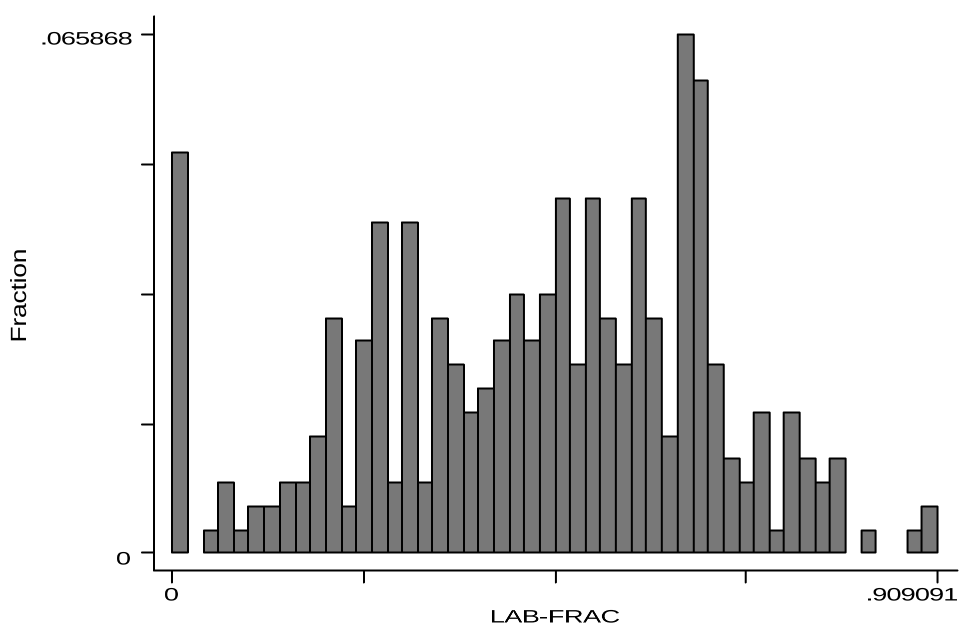


FIGURE 4
TREND IN LAB PUBFRAC OVER TIME

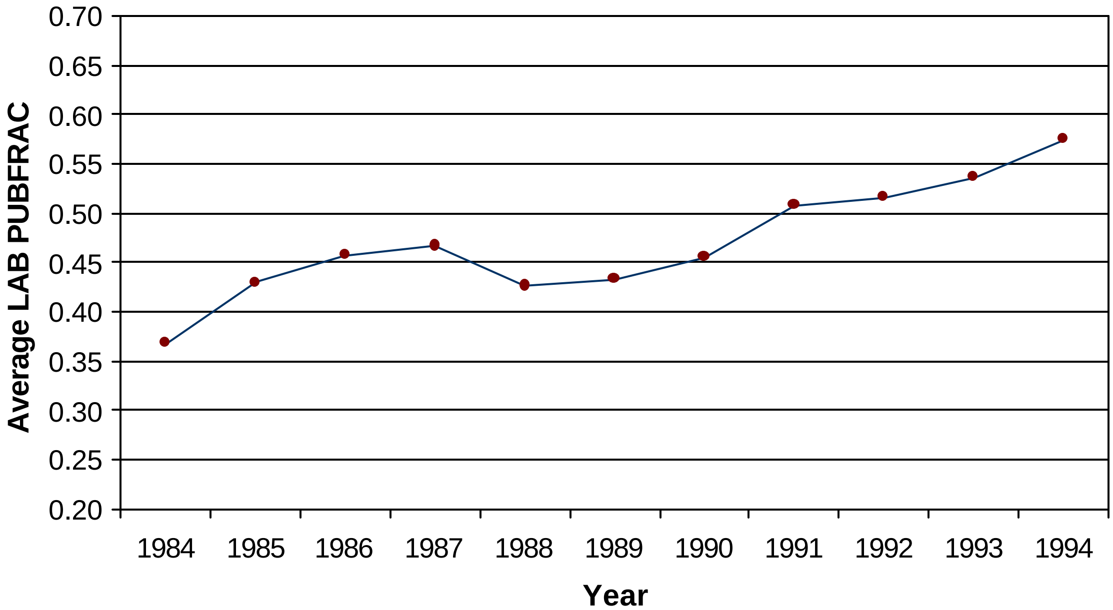
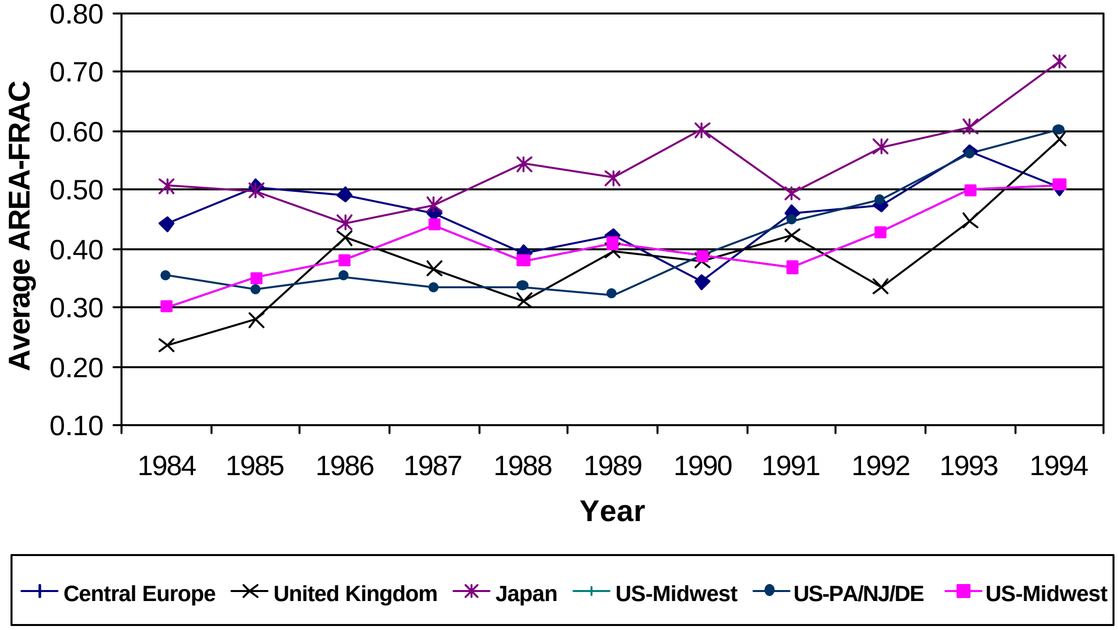


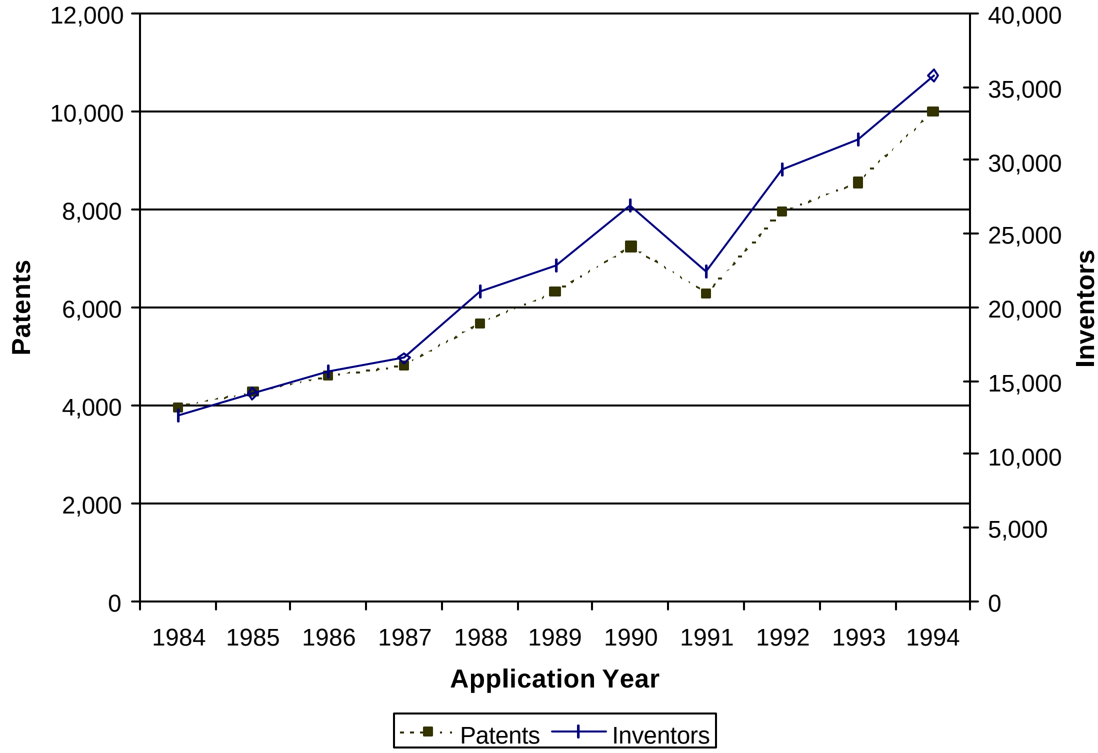
FIGURE 5
TRENDS IN LAB PUBFRAC OVER TIME, SELECTED AREAS



APPENDIX TABLE 1
FIRMS INCLUDED IN THE STUDY

Abbott	Ciba-Geigy	Nycomed	Searle
Amersham	Glaxo	Organon	SmithKline
Astra	Hoechst	Pfizer	Solvay
Bayer	Lilly	Pharmacia	Squibb
Beecham	Merck	Rhone	Takeda
Boehringer Ingelheim	Miles	Sanofi	Upjohn
Boehringer Mannheim	Nordisk	Schering	Yamanouchi
Bristol-Myers	Novo	Schering-Plough	Zeneca.

APPENDIX FIGURE 1
SAMPLE TREND IN USPTO PATENTS AND INVENTORS



APPENDIX FIGURE 2
SAMPLE TREND IN SCI PUBLICATIONS AND AUTHORS