

**Europe and the United States : The Power of Networks
Lessons from technology transfer**

PAMMOLLI Fabio ⁽¹⁾ ; RICCABONI Massimo ⁽²⁾ ; OWEN-SMITH Jason ⁽³⁾ ;
POWELL Walter W. ⁽⁴⁾

⁽¹⁾ University of Florence, DSA, Faculty of 'Economics, Via Montebello 7, Florence
50123, ITALY

⁽²⁾ University of Siena, EPRIS, Via Banchi di Sotto 55, Siena 53100, ITALY

⁽³⁾ University of Michigan, Ann Arbor, MI 48109, USA

⁽⁴⁾ 509 CERAS Building, Stanford University, Stanford, California 94305-3084, USA

Biofutur

Introduction

Over the last two decades, the development of a number of key science and technology-based industries has helped to spark economic growth on both sides of the

Atlantic. The United States has developed broad commercial leadership in a number of these areas, and commentators suggest that U.S. universities and research institutes have played a significant role in this process. In contrast, university-industry relations in Europe have been less common, in part due to some countries' legal prohibitions against faculty collaboration with business, and cultural predispositions against academic involvement with the world of commerce.

Since the late 1980s however, European attention has shifted to technology policy and academic technology transfer. In a climate of strong anxiety about European Union competitiveness in science-based industries, programs developed following the Single European Act of 1987 encourage matches between universities and firms, placing particular emphasis on quick delivery of tangible commercial results. Despite these European policy changes, the U.S. remains ahead in the biomedical industry.

The canonical explanation for differences in the rate of development of U.S. and European biomedicine is straightforward, emphasizing a first-mover advantage, in the growth of small, research-intensive U.S. biotechnology firms and dramatic differences in the scale of federal funding for R&D. Along with these features, emphasis has been placed on the role of supporting institutions – ranging from federal policy initiatives (e.g. the 1980 Bayh-Dole act) to the availability of venture capital, intellectual property law firms, and university technology transfer.

This story is accurate, but incomplete. We focus, in contrast, on the upstream division of innovative labor, highlighting the importance of the underlying science, the diversity of organizations involved in R&D, and the structure of network connections among them. Biomedicine is characterized by extensive reliance on collaboration among

many parties, including universities, research institutes, new biotechnology firms, and mature pharmaceutical and chemical corporations. These varied combinations of organizations afford us the opportunity to analyze cross-national differences in the roles these diverse organizations play in the process that moves biomedical research from academic laboratories to clinical development. While legal and financial reforms and the availability of venture capital are necessary for the development of a strong biotechnology sector, these elements along may not be sufficient to generate dense linkages between public research organizations and industry.

Different institutional terrains

The research systems in the U.S. and Europe are arranged in qualitatively different ways. The science underlying biotechnology emerged from university and government laboratories. Though the leading centers of research in molecular biology were dispersed widely through the advanced industrial nations, it was U.S. universities and academic scientists who actively worked to develop commercial applications and outlets for new findings. U.S. scientists and research organizations, then, also reaped rewards from their early involvement. Consequently, small biotechnology firms were first located in close proximity to key universities and research organizations. In time large pharmaceutical companies were attracted to the field, initially collaborating with biotechnology firms and offering a set of skills in managing the downstream aspects of commercial development that were lacking in research intensive start-ups. The early development of biotechnology firms around U.S. universities created an initial advantage for the U.S. industry.

Important trans-Atlantic differences in the character and degree of support for life science R&D also played a key role in shaping the comparative advantage enjoyed by the United States. Substantial research funds are administered through the U.S. National Institutes of Health (NIH), which support significant interactions between producers of basic life science knowledge and those involved in clinical research and drug development. The U.S. system also includes numerous alternative avenues of support, with award mechanisms and principles that complement the NIH's more academic orientation. These varied funding sources represent multiple rationales for supporting R&D and enable greater research diversity in the U.S. system.

In Europe, funding is more often administered at the national level, with individual countries pursuing distinct approaches to biomedical research and development. Without a central funding source equivalent to the NIH, competing rationales and procedures for awarding R&D funds in Europe may have hindered development. In some cases, European resources have either been spread among a large number of small laboratories or concentrated in single centers of excellence. In addition, research funds are much less likely to support integration across basic science and clinical development.

Beyond differences in rationales and levels of funding, organizational arrangements supporting biomedical research differ dramatically. European research is less integrated with teaching. The relevance of the research-teaching nexus for high quality research and integration across the development process cannot be understated. Consider the diffusion of molecular biology from specialized research organizations into general training. In many European countries this is a relatively recent phenomenon. In

the U.S., close linkages between teaching, research, and the clinic have supported faster diffusion of new biomedical knowledge across organizations and down the development path.

Traditionally, European molecular biology has been confined to highly specialized university and research institute laboratories. These organizations tend to organize in hierarchical disciplinary clusters that make it more difficult to conduct the type of interdisciplinary life science research that has been central to the development of the biotechnology industry. In contrast, similar U.S. organizations tend to be organized around multidisciplinary research teams that often include clinicians in the early phases of research. European policy changes have been targeted mainly to creating specific organizational devices to manage and coordinate technology transfer activities. Intermediary institutions, such as science and technology parks, do not effect changes in the arrangement of upstream R&D and may even increase the distance between university research and commercial development by adding an extra layer to the relationship.

Partly as a consequence of the institutional differences we sketch above, the founding of new biotechnology companies in Europe was more difficult than in the U.S. during the industry's infancy. Start-ups are strongly correlated with access to publicly funded research and the organization of academic R&D in Europe mitigated against such access. In the absence of a strong small firm sector, European pharmaceutical corporations turned to U.S. biotechs to tap new scientific competencies as they struggled to stay abreast of scientific changes in drug development. Given the head-start in firm formation and faster rates of transfer from academic to commercial science, European

inventions that might have lead to start-ups may be have been preempted by American firms. Moreover, the more dominant role that large pharmaceutical companies played in Europe has had a profound effect on the development of R&D networks as these organizations serve a ‘clearinghouse’ function for specialized innovations developed in national research clusters.

Variations in collaborative arrangements

Differences in the organizational and institutional arrangements of R&D across the U.S. and Europe have resulted in different trajectories for the development of the inter-organizational networks that support discovery and drug development efforts in the biotechnology industry. Trans-Atlantic differences in funding, relationships among research, clinical work, and teaching, and variations in the disciplinary organization of research laboratories, shape the evolutionary trajectories and structure of university-industry R&D networks in the U.S. and Europe.

At first glance, university-industry R&D networks seem very similar on both sides of the Atlantic. In each case, small firms cluster near national and regional centers of research excellence, and large pharmaceutical firms located outside those clusters appear to play an important role in connecting multiple regional networks into a coherent system. These apparent similarities seem to suggest that the major differences between U.S. and European systems for biomedical innovation are those of scale and maturity. We do not suggest that such differences are not real, instead we argue that when viewed through the lens of upstream arrangements for R&D the similarities are less than they originally seemed.

Consider the effect on public sector innovation of the different institutional arrangements we highlight above. While university-industry networks are tightly clustered in both systems, those communities differ dramatically in their organizational diversity, reach across the development path, and breadth of scientific focus. Consider the differences between the biotechnology community in the Boston metropolitan area and those in France, Germany, and the UK. **[here is where a figure could go]**

First, note the differences in the diversity of public research organizations located in each cluster. In France and Germany public sector research is dominated by the Institute Pasteur and the Max Planck and Max Delbrück centers. Their centrality is not surprising, given their important role in the history of molecular biology. The lack of important universities or research hospitals in these regions make it more difficult for new findings to diffuse and for academic knowledge to be moved into the clinic, however. In both France and Germany, then, institutional homogeneity in terms of R&D is matched by scientific specialization. When we examine the patents held by German and French research institutes, the former focus almost exclusively on hereditary cardiovascular diseases, while the latter emphasize infectious diseases and AIDS. The somewhat more institutionally diverse British system is broader in focus. But the diverse organizations, such as the Cancer Research Campaign, the Medical Research Council, and the British Technology group that anchor this national cluster still patent most heavily in the area of cancer therapeutics.

European centers of research excellence, then, tend toward organizational similarity and scientific specialization. These two features of European national R&D systems have several important consequences. First, scientific specialization within

regions makes it difficult for significant collaborative ties to form across them, hindering attempts to develop a truly European R&D network. Second, the homogeneity of these regions and their lack of direct ties between the laboratory and the clinic help insure that the work of drug development and clinical trials must occur outside each cluster. Here, the dominant clearing-house role of European pharmaceutical companies becomes apparent. Not only is it difficult for European R&D clusters to forge collaborative ties with each other, when organizations in these national centers do reach outside their borders, they are most likely to connect to large pharmaceuticals that are themselves distant from the European centers of research excellence.

Instead of fostering greater coherence within each region, or emphasizing complementary ties among them, these patterns of institutional and scientific specialization make the development of a cohesive European R&D network particularly difficult. Contrast these arrangements with those found in the Boston Area, one of the largest regional R&D networks in the U.S. national system. Where European regions tend toward scientific and institutional homogeneity, the Boston region is anchored in nineteen public research organizations including elite universities (MIT, Harvard), research institutes (the Dana Farber Cancer Center) and research hospitals (Massachusetts General, Brigham & Women's). Internal to Boston, then, we find organizational capacities in research and teaching, academic science and clinical development. Moreover, these organizations are scientific generalists, patenting broadly across all 120 therapeutic areas we have identified. The dense regional R&D network found in Boston, then, is fundamentally different than those located in the various European national clusters.

Institutional and scientific diversity has effects not only on the success of technology transfer efforts within the region, but also on the formation of a coherent national R&D network for biomedical innovation and commercialization. Such differences in scientific and institutional diversity are critical to understanding the development trajectories followed by the U.S. and European biomedical industries. We argue that greater integration within and across U.S. regions results neither from policy differences, nor wholly from differences in scale. Instead, we suggest that organizational and scientific diversity in the upstream arrangement of R&D have more to do with differences in industry success across the U.S. and Europe.

This finding also contains a cautionary tale for European policy makers engaged in efforts to increase the scale of European innovation. Absent attention to the patterns of homogeneity and specialization that make creation of a unified European R&D network difficult, policies and funding arrangements designed to increase the scale of European biomedical innovation will not make the European industry resemble its American counterpart. Instead, our findings suggest that such increases in scale may only deepen national specialization in scientific areas and heighten fragmentation among the European national systems.