International benchmarking of biotech research centers—lessons and perspectives

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Results from a European-US comparative study characterizing the centers and their performance.

What are the structural similarities and differences between European and US biotech research centers? How do they perform? What is their impact? These were the basic questions underlying a study launched by the European Commission's Directorate General for Research in 2000. A UK-German-US research team tried to provide the answers via a large survey[1].

There are many problems associated with collecting any sort of data on biotechnology. On one hand, definitions are ever changing, making it difficult for statisticians to produce consistent time series. On the other hand, there are problems providing policy makers with the indicators they need, as changes in biotech R&D are happening so rapidly that they cannot be tracked and responded to in time. For these reasons, the collection of better data and the production of improved indicators on biotech is a priority not only for Europe's policy makers, but also at the international level; this is why the Organization for Economic Cooperation and Development (OECD) is also involved in studies on this subject.

Definitions—and obstacles

The research team here used a definition of biotechnology that has been developed in a previous study and is basically a list of seven broad biotech research areas, such as 'environmental biotechnology,' that are made more specific with up to nine subareas such as 'biosafety' or 'microbial ecology.' The definition of a 'center' on the other hand proved to be much more complicated, at least for Europe. Whereas the formation of a center is seen as a typical US academic development strategy, European biotech centers were primarily created through incentives for existing research centers to move into this area, by establishing new ones or by relabeling existing ones. Several large public research centers that focused, for example, on traditional agricultural research have shifted their specialization to agricultural biotech research, and sometimes have reflected this in a name change as well.

However, not every institution containing the word 'biotechnology' in its name or doing research in biotechnology is necessarily a biotech research center. Many European public research centers pursue several research strategies, and biotechnology might well be one among others. How should one deal with this reality? The research team opted for a rather strict definition of 'biotech research center.' To qualify, a center had to have at least 50% of its research activities focusing on biotechnology, be receiving at least 50% of its funding from public sources, and have a specific mission related to biotechnology. The latter could be one or more of the following items: providing education and training, building up the knowledge base, creating a national center of research excellence or fostering commercialization.

The sample

Although the prime interest at the European Commission level focuses on its 15 member states, the geographic coverage of the study was extended to include Switzerland, a European powerhouse in pharmacy and biotechnology. Of the initial 714 centers identified—504 in Europe and 210 in the United States—324 responded to the survey (Europe, 272; United States, 52). However, owing to the definition, not all qualified as biotech research centers. Some 194 European centers and only 32 US centers remained in the sample. Within Europe, the numbers vary considerably by country. Whereas 44 German centers are included (of an initial 139 identified), there are only 3 Irish ones (of an initial 6), reflecting nonetheless the size of the countries.

Although the European sample seems to be representative, a closer analysis of the US centers shows that the ones responding are not the traditional, well-known and well-established ones. On the contrary, the US centers did not represent 'first movers and major players' or top-quality universities. Instead, they represent only 'second movers and emerging actors,' major research universities late to enter biotechnology research and universities without an established research tradition. This does not necessarily render the outcome invalid or obsolete, but raises the question of whether or not the US centers can be used as a benchmark.

Structural features

More than three-quarters of European centers and all the US centers were established during the last two decades. The remaining European centers are older, some dating back to the turn of the 19th century. They are primarily the ones that have shifted their research focus to biotechnology over time.

Whereas the majority of centers are affiliated with universities, European centers are also affiliated with other types of organizations. The majority of centers (65%) are unitary centers based on a single institution. Cooperative or 'virtual' centers in the same town or in different geographic areas were found only in Europe; however, this does not

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imply that there are no 'virtual' centers in the United States.

Most of the European and US centers have multiple missions. They differ very little in their mission to provide education and training, build up the knowledge base or create a national center of research excellence. A wider gap exists, however, when it comes to commercialization: only about half of the European centers have a mission to foster commercialization, compared with almost three-quarters of US centers.

When it comes to size, European centers are on average substantially larger than US centers in terms of the total number of research staff and in terms of budgets.

A significant difference was found concerning long-term versus short-term researchers. US centers clearly favor long-term employment, whereas in Europe more researchers were employed on a short-term basis.

There is no substantial difference in the average number of staff in single- and multi-focus centers. Among the single-focus centers, both in Europe and the United States, those specializing in human biotechnology have the highest number of staff and highest budgets per staff mem-ber. 'Basic research' and 'plant biotechnology' have the lowest budgets per research staff member.

Key personnel, defined as those who had published more than 20 publications in the period 1994–1999, were identified in 45% of European centers, but in only 22% of US centers. The average number of key personnel per center is also considerably lower in the United States than in Europe.

Process features

The majority of the centers are involved in several areas of biotechnology research. US centers allocate a very high percentage of their expenditure to basic research (50%). European centers spend over 30% of their budgets on human biotechnology, followed by basic research (17%), cell factory (15%) and plant (12%) and animal biotechnology (10%).

Although most centers are involved in several areas of research, 57% can be regarded as 'single-focus' because a substantial proportion of their budget is dedicated to one area. The remaining centers allocate their budgets more or less equally to several areas and can be regarded as 'multi-focus.'

Most marked increases in employment concerned the employment of technicians. Although 48% of the centers are not permitted to award PhDs, these centers have similar numbers of doctoral students to those permitted to award PhDs. The numbers of doctoral students per center and per research staff member are similar in Europe and the United States. European centers have double the productivity of US centers in PhDs awarded for both these measures.

Structure + process = outcome

When it comes to the question of growth or decline of a center, continuous growth characterizes the development of 70% of all centers. Only a handful of centers state a decline or a single decrease in their lifetime.

European centers account for 7.1% of all European biotech publications in the period 1994–1997, and US centers for 0.3% of all US biotech publications. European centers received an average of 10.7 citations per publication and US centers 18.2 citations per publication.

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In terms of 'prestige' activities, that is, having highly active researchers in terms of publications, scientific awards and memberships of external committees, European centers have more members of editorial and scientific committees. They also send far more researchers to transatlantic conferences than do those in the United States.

In terms of industrial activities, European centers have a higher percentage of industrial research collaborations and a higher average number of collaborations per center than do US centers.

US centers have a higher launch rate for spin-off firms than do European centers.

Performance and impact

The very low output in terms of scientific publications required further analysis. Are these centers the core biotech research centers? The clear answer is no. Although they account for almost 33% of publication output in Portugal, their average share in Europe is 6.9% and in the United States a mere 0.3%.

An analysis of how various structural features of the centers affected their performance in terms of academic functioning, prestige, industry collaboration and networking was undertaken. Whereas 72% of the centers achieved a high performance in at least one of these areas, only 2% scored highly in all four areas. This is an interesting finding that might lead to more reflective thinking about the possibly conflicting goals that public research centers in Europe and the United States are pressed to attain.

The age of the center, the number of personnel and the area of research specialization influenced high performance in the above categories. Centers that performed well in academic research had, on average, up to 25 researchers, and often specialized in human biotechnology. Those excelling in industry collaboration were about equal in size, specialized in the cell factory area and were between 12 and 20 years old. The centers excelling in networking were slightly younger and tended to have a single research focus.

To estimate the relative efficiency of the European and US centers, inputs (budgets and research staff) and outputs (PhDs and publications) relating to their missions (research excellence, research training, fostering commercialization and knowledge production) were compared. Whereas 47 centers (20%) are efficient in at least one mission, 153 centers (80%) are inefficient. Only 10 centers (4%) are highly efficient in all the missions they undertake. However, no center is efficient in all four missions; none of the 19 centers stating four missions are efficient in even one of them.

Again, these findings suggest that the set of goals might be too diverse. A further analysis to identify any relationship between efficiency in the four missions found a strong relationship between efficiency in research excellence and research training and a weak relationship between research excellence and fostering commercialization. The researcher team pointed out that the 'second movers and emerging actors' group of US centers represent a high proportion of centers efficient at knowledge production and at fostering commercialization.

One of the most important findings, at least for policy makers, is the relationship between efficiency and having a single research focus. This, again, is strongly related to efficiency in research excellence. A slightly weaker relationship also exists for efficiency in research training and knowledge production. The share of long-term research staff in total staff also has a considerable but weak influence on centers efficient at achieving research excellence. Industrial excellence, on

the other hand, was not related to funding or staff. The research focus, the age of the center, and the existence of a technology transfer office were equally unrelated. The authors concluded that this might be because efficiency in industrial commercialization is mainly influenced by intangible characteristics such as management. However, the strong orientation of US centers toward fostering commercialization and basic research indicates that it is important for basic research to be relevant to industry. Furthermore, good performance in industry-related activities is perpetuated by academic activities that lead to research excellence and prestige. This will attract industrial partners to these centers and possibly improve their level of industrial performance.

Lessons and perspectives

Despite the fact that the US first movers in biotechnology were more or less absent from the study, the findings related to the European centers and the generation of US second movers provide some clear insights and indications. Although there are notable exceptions among the European centers, the situation *grosso modo* is that the European centers do not seem focused enough to become serious players. Being an excellent knowledge provider to industry, a source of top-class education and training and an ardent publisher of scientific literature are goals often assigned to public research centers, as well as self-professed claims that might be too much for the second movers, who are clearly missing the advantages of the now well-established, large and possibly excellent first movers. The various obligations are, of course, often put forward by policy makers that want a return on scarce or even declining (public) investment. However, there is still a considerable amount of public investment in biotechnology research in Europe that is nonetheless often coupled with several goals. Centers might struggle to perform well in all of them and, if one uses the results of this benchmarking study, rarely achieve these goals. The finding that small but targeted research centers were among those that performed best leads the authors to conclude that a strategy of concentrating resources—one often put forward by European policy makers—may not be the best way to proceed. Instead, the fact that US centers at nonprestigious universities are able to achieve high performance and efficiency provides hope that this might happen in European peripheral regions as well. This outcome contrasts with the view formulated in Ernst & Young's 2001 report[2] that "…many smaller institutes that struggle to achieve critical mass populate the community." It might be necessary to analyze the complex of 'critical mass' to be able to estimate if the current number of centers is too high.

Another issue that struck the authors is the surge of technicians. An important issue to policy makers and professionals alike, one needs to ask what this surge will imply for biotechnology employment, current curricula and student enrollment.

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1. Senker, J. *et al.* An international benchmark of biotech research centers. Final report, September 2002 (http://www.cordis.lu/indicators/publications.htm).
2. Ernst & Young. Integration: Ernst & Young's eighth annual European life sciences report 2001 (Ernst & Young International, Cambridge, UK, 2001).