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Research and Research Policy**

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Biotechnology in Denmark 2005

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Note: This is a revised version of the original working paper (published in July 2006). The total number of biotech firms in the original paper included two dedicated biotech companies that, while technically still in operation, have not had any activities since 2003. The number of dedicated biotech companies has therefore been revised, from 188 to 186 for 2004, and from 186 to 184 for 2005. Figures 1, 3, 5 and 6 have been changed to reflect this.

Executive summary

This paper examines biotechnology activities in Denmark based on data from the Danish public and private sector R&D surveys and a detailed list of biotechnology firms carried out by the Danish Centre for Studies in Research and Research Policy (CFA). The paper updates results reported by CFA in 2004.

Denmark experienced strong growth in the number of biotech firms from 1997 to 2003, with total dedicated biotechnology firms numbering 188 in 2003. The number of biotech firms has since been fairly constant with 184 dedicated biotech firms at the end of 2005. The large majority of these firms are small in size, with 127 having less than ten employees.

A major part of biotech activity in Denmark is conducted in larger firms that also have activities outside of biotechnology. This group includes pharmaceutical companies located in Denmark, along with a number of other large firms. While we do not have detailed information on sales and income for these firms, it seems likely that a major share of the contribution of biotechnology to economic activity in Denmark comes from these firms. In addition, biotechnology research conducted by these firms and in universities provides a strong base for the development of smaller biotech firms.

The center of biotech activity in Denmark is in Greater Copenhagen, which forms part of the Medicon Valley region. In addition, smaller biotech clusters have emerged around universities in the cities of Aarhus and Odense, and to a smaller extent, in Aalborg.

It is estimated that private sector R&D expenditures within biotechnology amounted to DKK 6.1 billion (€ 824 million) in 2003. This amounts to 24 percent of total private sector R&D in Denmark in 2003. Of the firms included in the private R&D survey that have R&D within biotechnology, around a quarter of firms are within the Food and Beverages sector, a third in Research and Development, and 16 percent in Chemicals and Pharmaceuticals. This indicates that the two primary areas of applications for biotechnology in Denmark are the health sector and food processing.

In 2003, biotech R&D expenditures in the public sector were DKK 1.1 billion (€ 149 million), which amounted to 10 percent of total public sector R&D in Denmark in 2003. In all 115 departments and institutes, covering a broad range of areas, reported R&D in biotechnology. About two thirds of this research is conducted in the Greater Copenhagen area, with the remaining third concentrated in universities and hospitals in Aarhus, Odense and Aalborg.

1. Introduction

Main objectives

There is widespread and increasing interest in biotechnology and its socio-economic impacts. Biotechnology has potential applications in a large number of areas, among them: human health, aging, food production, the environment, energy and materials. Due to the pervasiveness of biotechnology, its potential economic impact through the development of new biotech products, their uses and applications, and related supplier goods and services, may be substantial.

Given Denmark's large and economically vital medical sector, biotechnology is of significant interest here and is a high priority for research policy. Yet, despite this interest in biotechnology, there is a lack of systematic data on biotech activities and applications in Denmark. This stands in contrast to the large and growing number of other countries that have conducted biotechnology surveys. As of 2004, 16 countries had conducted biotechnology firm surveys¹.

The objective of this paper is to examine biotech activities in Denmark based on available data from R&D surveys of the public and private sector undertaken by the Danish Centre for Studies in Research and Research Policy (CFA)². In both surveys, respondents are asked to estimate the percent of their total R&D expenditures that are devoted to biotechnology. This data is utilized both in forming an estimate of biotech R&D in Denmark, and in examining research activities for Danish biotechnology firms and public research institutions active within biotechnology. While lacking the level of detail of a specialized biotech survey, this data allows us to examine the broad characteristics of biotech R&D activities in Denmark.

In addition, a comprehensive list has been compiled of biotech firms in Denmark, by gathering information from a number of sources, among them: R&D surveys, biotechnology organizations, science parks, venture capital funds, annual reports and various news sources.

This paper is a follow up on the biotech report published by CFA in 2004 (Bloch, 2004). The paper here includes analysis of R&D data in the private and public sector through 2003 and an updated list of firms through 2005.

Classifying biotechnology firms

This paper follows as much as possible the guidelines recently formed by the OECD for biotechnology statistics (OECD, 2005). The OECD's definition of biotechnology is:

“the application of science and technology to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services”

With the following (non-exhaustive) list of included biotechnologies (the *list-based definition of biotechnology*)³:

DNA: Genomics, pharmacogenetics, gene probes, DNA sequencing/synthesis/amplification, genetic engineering, RNA.

¹ Van Beuzekom (2004). See also van Beuzekom and Arundel (2006).

² See Danish Centre for Studies in Research and Research Policy (2005a, 2005b).

³ See e.g. OECD (2005).

Proteins and other molecules: Sequencing/synthesis/engineering of proteins and peptides (including large molecule hormones); identification of cell receptors; improved delivery methods for large molecule drugs (use of glycol and lipid chemistry etc); proteomics.

Cell and tissue culture and engineering: Cell/tissue culture, tissue engineering, hybridisation, cellular fusion, vaccine/immune stimulants, embryo manipulation.

Process biotechnology techniques: Fermentation using bioreactors, bioprocessing, bioleaching, biopulping, biobleaching, biodesulphurisation, bioremediation and biofiltration.

Sub-cellular organisms: Gene therapy, viral vectors.

Bioinformatics: Construction of databases on genomes, protein sequences; modelling complex biological processes.

Nanobiotechnology: Applies the tools and processes of nano/microfabrication to build devices for studying biosystems and applications in drug delivery, diagnostics etc.

A *dedicated biotechnology firm* is defined as “a biotechnology active firm (engaged in primary biotechnology activities such as the application of at least one biotechnology technique to produce goods or services and/or the performance of biotechnology R&D) whose predominant activity involves the application of biotechnology techniques to produce goods or services and/or the performance of biotechnology R&D” (OECD, 2005).

An *innovative biotechnology firm* is defined as “a biotechnology active firm that applies biotechnology techniques for the purpose of implementing new or significantly improved products or processes (per the *Oslo Manual* (OECD/Eurostat, 2005) for the measurement of innovation). It excludes end users which innovate simply by using biotechnology products as intermediate inputs (for instance, detergent manufacturers which change their formulation to include enzymes produced by other firms via biotechnology techniques)” (OECD, 2005).

Based on the above, biotech firms can be classified into 3 groups:

1. *Dedicated biotechnology firms*
2. *Other innovative biotech firms*
3. *Biotechnology end users*

Dedicated biotech firms are equivalent to the term ‘core biotech firms’ used in the 2004 report. Other innovative biotech firms are somewhat broader than the group, ‘firms active in biotechnology’ used in the 2004 report, as this new grouping includes all firms with biotech R&D. Some of these firms with a low share of their R&D that was biotech-related were previously classified as ‘users’. Since Denmark has not yet conducted a biotechnology survey, our knowledge of end users of biotechnology is limited. This paper will focus on the first two groups.

Finally, *biotechnology R&D* is defined as “R&D into biotechnology techniques, biotechnology products or biotechnology processes, in accordance with both the biotechnology definitions presented above and the *Frascati Manual* for the measurement of R&D” (OECD, 2002 & 2005)⁴.

⁴ It should be noted here that a definition of biotechnology is not included in the Danish private and public sector R&D surveys. This may potentially result in differing interpretations among firms and PRIs on what biotechnology is or includes.

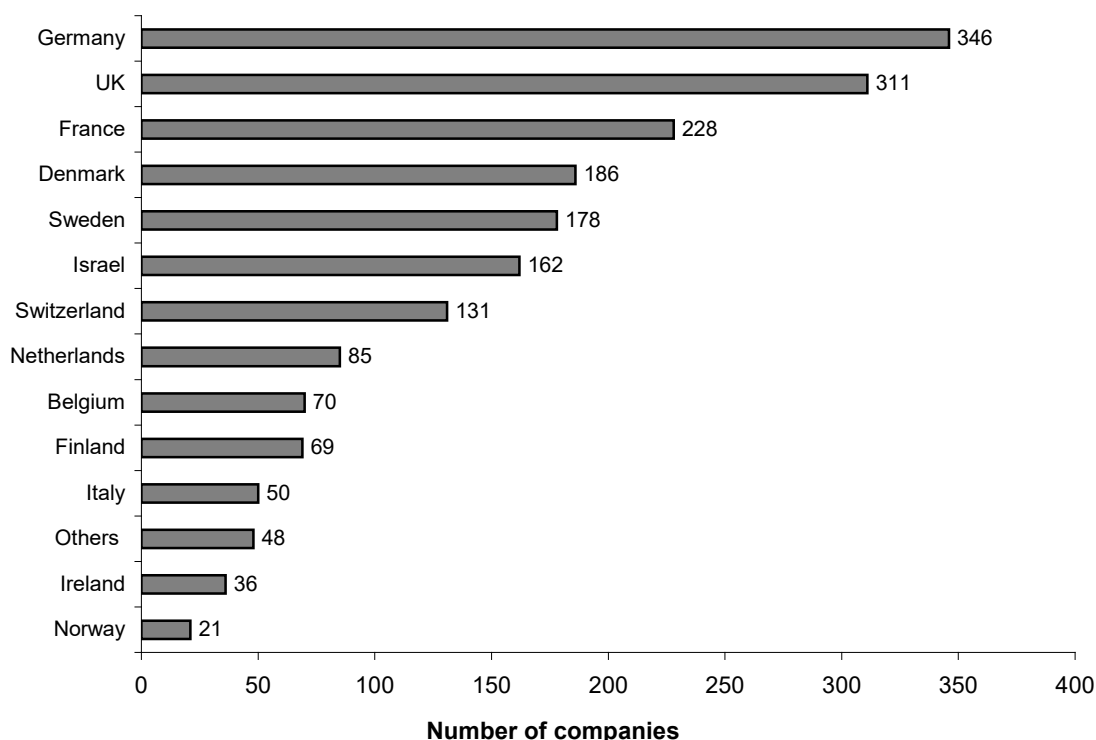
The remainder of this paper is organized as follows. Section 2 examines biotechnology firms in Denmark in terms of the number of biotech firms and employees. In addition, the chapter takes a brief look at the regions in which biotech firms are emerging. This includes the main region of Medicon Valley, which encompasses Copenhagen and the Skåne region of southern Sweden, and smaller regions that have developed around universities in the cities of Aarhus, Odense and Aalborg. Section 3 examines private and public R&D activities within biotechnology in Denmark, drawing on private and public sector R&D surveys in 2003.

2. Biotechnology firms

Biotech firms over the period 1997 - 2005

Based on preliminary examinations, there were 184 dedicated biotechnology firms in Denmark at the end of 2005, with a total of 4807 employees⁵. This is slightly less than in 2004, where there were 186 dedicated biotech firms. In addition, we identified an additional 141 innovative biotech firms in 2005. This group includes large enterprises that are active within biotechnology, and pharmaceutical companies with active research in Denmark⁶.

Figure 1. Biotech companies in Europe 2004



Source: Ernst & Young, "Beyond Borders Biotechnology Report 2005 - Gaining Momentum", though total for Denmark based on own calculations

Based on figures for other countries taken from Ernst & Young's Biotechnology Report 2005⁷, these numbers place Denmark fourth in 2004 among European countries in terms of number of biotech companies, after Germany, the UK and France⁸.

Figure 2 shows patent applications with the European Patent Office (EPO) within biotechnology, information and communication technologies (ICT) and medicine for 2001.

⁵ Employee data stems from the NewBiz Business Information Source database. For some firms, we were unable to determine whether the number of employees includes employees outside Denmark. For firms where no employee data was available (which was only the case for some smaller firms), the number of employees was estimated based on total assets. Employment was estimated for 34 firms, amounting to 3.1 % of total employees in core biotech firms.

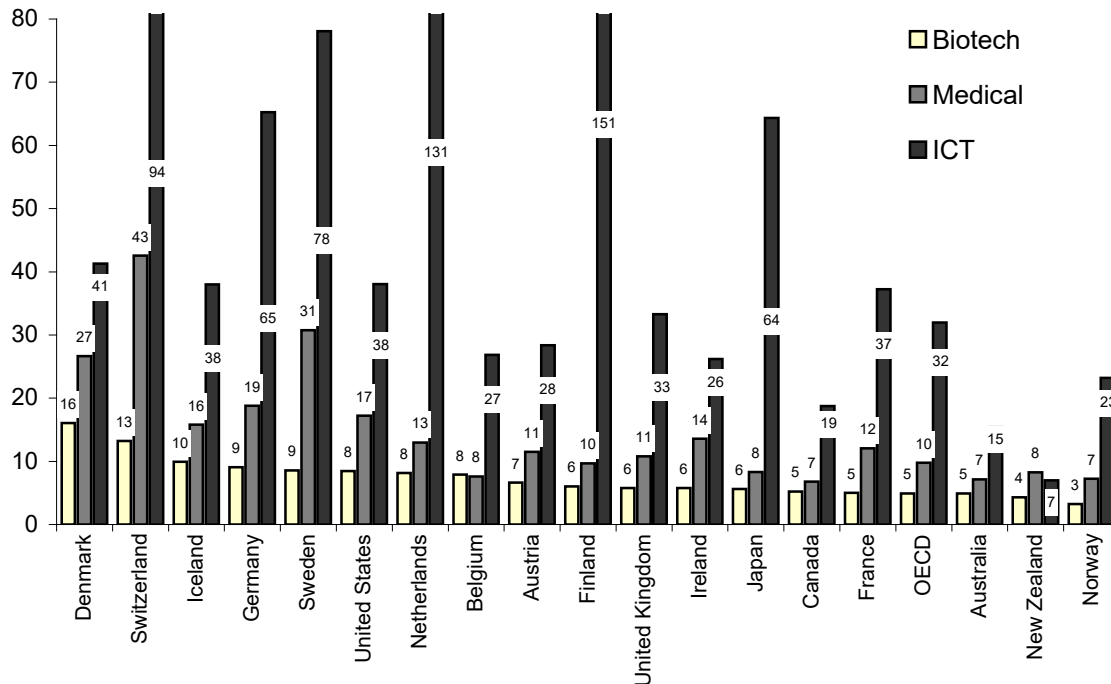
⁶ Pharmaceutical companies with only sales and distribution in Denmark were not included.

⁷ See Ernst & Young (2005).

⁸ It should be mentioned here, though, that no minimum size criteria has been used in compiling the list of Danish biotech firms. We have not confirmed if any size criteria is used for Ernst & Young's figures. See below for more details on the size distribution of Danish biotech firms.

Measured in number applications per million inhabitants, Denmark has the highest number of patent applications within biotechnology, and is third in terms of medical patents, after Switzerland and Sweden. This gives an indication of the importance of biotechnology for the Danish economy.

Figure 2. EPO patent applications per million inhabitants, by country of inventor, 2001

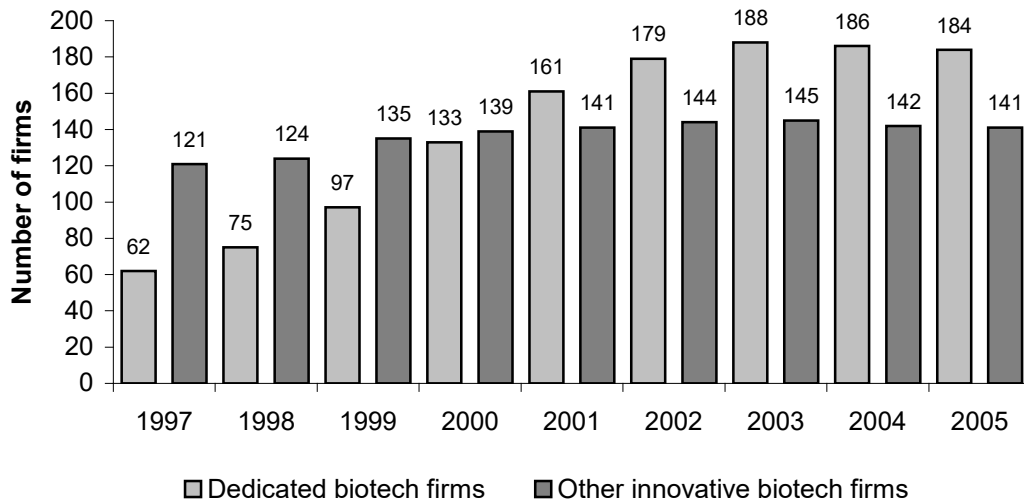


Source: OECD's Patent database. See also Mortensen (2005).

Figures 3 and 4 show the number of biotech firms in Denmark and the number of biotech firm startups for 1997-2005⁹. They indicate the rapid growth in the number of firms through 2003, with a large number of biotech start ups, particularly in 2000 and 2001. The number of biotech firms has remained fairly stable since 2003.

⁹ Note that the numbers for 2000 to 2003 have been revised upwards in relation to those reported in (Bloch, 2004). This reflects both additional biotech firms that were found in recent compilations and the availability of additional information on some firms, allowing us to confirm whether they are dedicated biotech firms.

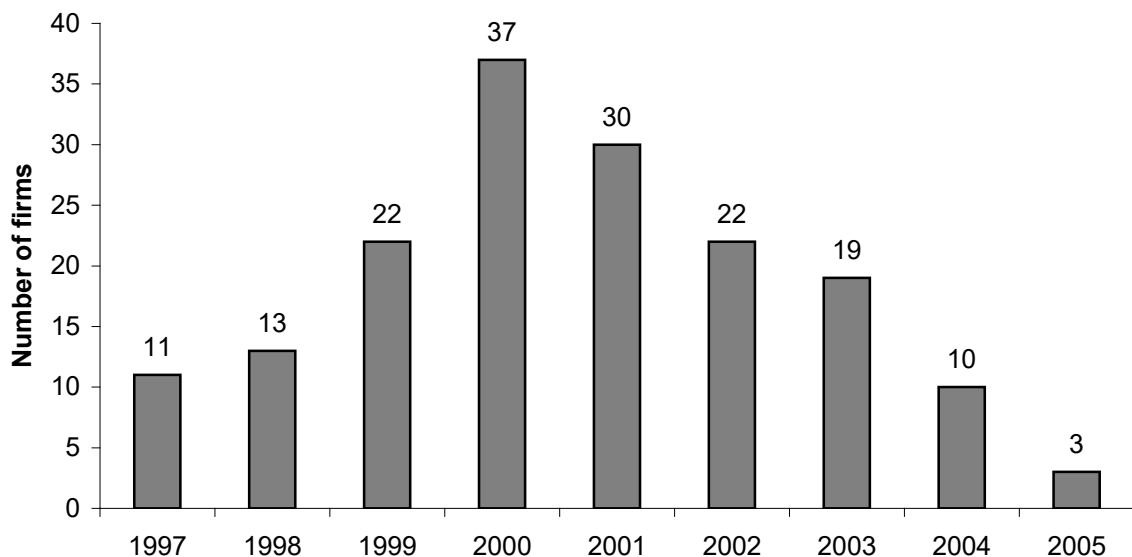
Figure 3. Number of biotech companies in Denmark, 1997-2005



Source: Own calculations based on information from several sources. Firms' start and end dates from NewBiz Business Information System.

The establishment of biotech start ups was highest in 2000, where 37 new dedicated biotech firms were created. This number has fallen steadily since 2000, and only 3 start ups were identified in 2005. This number for 2005 should, however be considered preliminary, as additional recent start ups may potentially become known over time.

Figure 4. Number of dedicated biotech start-up firms, 1997-2005

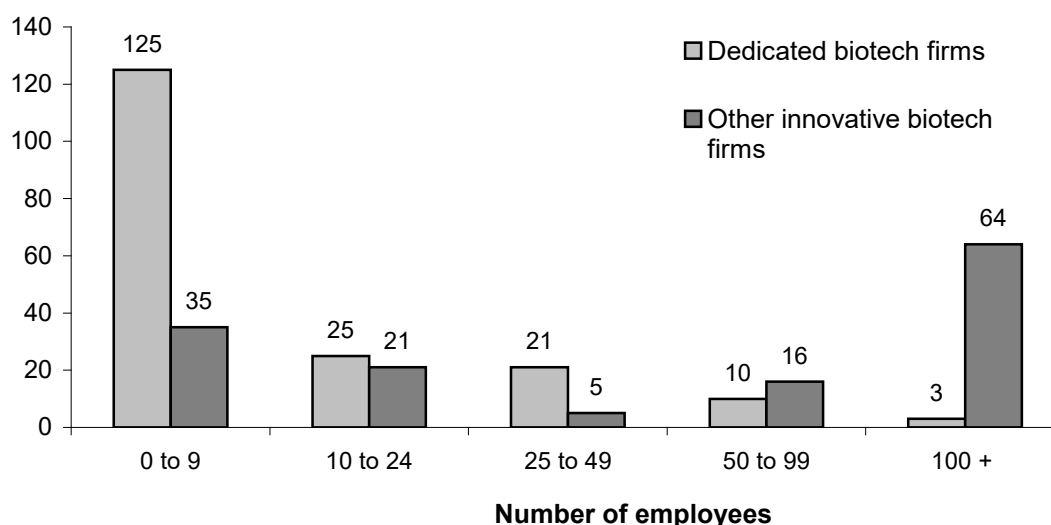


Source: Own calculations based on information from several sources. Firms' start and end dates are from NewBiz Business Information System.

Firm size

A significant number of dedicated biotech firms are small firms that have been established in the last few years, reflecting both the growth in new biotech firms and the relatively young age of the industry as a whole. Of the 184 dedicated biotech firms at the end of 2005, 13 had been established since 2004, and 106 since 2000. 7 of these 184 firms are publicly traded on the Copenhagen Stock Exchange¹⁰. Figure 5 shows the distribution of biotech firms by number of employees. It can be seen that 125 out of 184 dedicated biotech firms in 2005 had less than 10 employees, and only 13 had 50 or more employees.

Figure 5. Biotech firms by size, 2005



Source: Own calculations based on employee data from NewBiz Information Source. See footnote 3.

Also of interest is the stage of development of these firms, for example whether firms have introduced any products on the market or are generating revenue, or at what stage of development their research is. However, financial data from business registers (which are based on firms' annual reports) do not contain sales and other financial figures for many of the smaller biotech firms. A general impression based on the data shown here is that the large number of startups in recent years reflects the strength of biotech research in Denmark, with basic research generating a number of new firms. However, it also indicates both the very young age of a large part of the biotech industry in Denmark, and the small average size of Danish biotech firms.

Biotech regions

The large majority of biotech firms in Denmark are located in Greater Copenhagen, which along with the Skåne region in southern Sweden forms the Medicon Valley region. Medicon Valley is among the largest biotech clusters in Europe¹¹. There are several public research institutions conducting biotech research in Copenhagen, among them the University of Copenhagen and the Technical University of Denmark. In addition, Medicon Valley is also

¹⁰ Bavarian Nordic, Bio Porto (through its ownership of Antibody), Genmab, Neurosearch, Novozymes, Pharmexa and Topo Target.

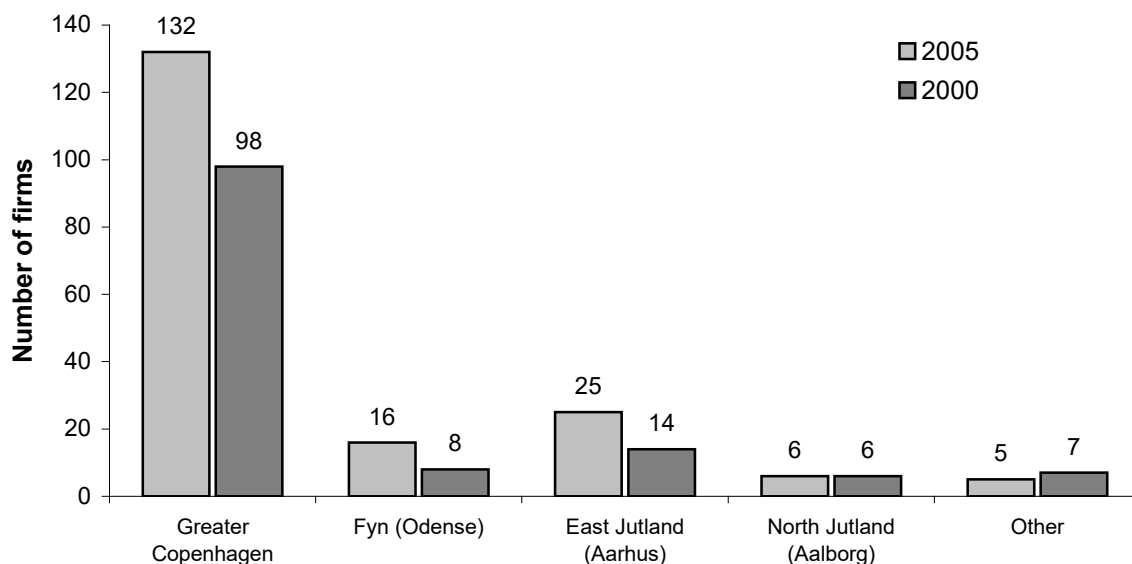
¹¹ See Boston Consulting Group (2002).

home to a number of pharmaceutical companies, such as Novo Nordisk, H. Lundbeck, Leo Pharma, and Astra Zeneca¹².

The presence of these pharmaceutical companies has influenced biotech research in the area, with emphasis on research in neuroscience, cancer, diabetes and inflammatory diseases.

Figure 6 shows the distribution of dedicated biotech firms by region in Denmark for 2000 and 2005. Over 70 percent of dedicated biotech firms in Denmark were located in the Greater Copenhagen area in 2005. It can be seen that, in addition to Medicon Valley, biotech clusters have also begun to emerge around the other main universities and hospitals in Denmark, in the cities of Aarhus, Odense, and to a smaller extent, in Aalborg.

Figure 6. Dedicated biotech firms by region, 2000 and 2005



Source: Own calculations.

Overall, the number of dedicated biotech firms has increased by 40 percent over 2000-2005, from 133 to 184. This increase in firms has been particularly strong in the regions around Odense and Aarhus. The emergence of a biotech cluster in Aarhus has its base in the University of Aarhus with 30,000 students (over 7,000 in life sciences), venture capital firms located in the area, and structural initiatives such as science parks. Growth in biotechnology in Odense has been driven primarily by research in the area of proteomics, which has resulted in the establishment of a number of biotech firms.

¹² Note that Astra Zeneca is predominantly located in the 'Swedish' part of Medicon Valley.

3. Research and development in biotechnology

Overview

Biotechnology research in Denmark spans dedicated biotech firms, universities and hospitals, and a number of large enterprises active in biotechnology. Most notable for the latter group are pharmaceutical companies with research bases in Denmark.

We estimate that private sector R&D in biotechnology amounted to DKK 6.1 billion (€ 824 million) in 2003¹³. This comprises 24 percent of total private sector R&D in Denmark in 2003¹⁴. For this same year (2003), we estimate biotech R&D in the public sector to be DKK 1.1 billion (€ 149 million), which amounted to 10 percent of total public sector R&D in Denmark in 2003.

Table 1 shows the developments in private and public sector biotech R&D over the period 1997-2003¹⁵. These biotech R&D estimates are based primarily on responses of firms and public research institutions where they have estimated the share of their total R&D that is within biotechnology. In addition, for firms in the R&D database that did not answer this research area question though were identified as dedicated biotech firms, we estimated that all R&D for these firms was within biotechnology. Detailed information on the approximation methods used is included in the Annex.

Table 1. Total biotech R&D, 1997-2003, mio. DKK

Sector	1997	1998	1999	2000	2001	2002	2003
Private	3078	4034	3938	4445	4953	5638	6103
Public	752	808	865	1056	1054	1100	1101
Total	3830	4843	4803	5502	6007	6738	7204

Source: Own calculations based on Danish Centre for Studies in Research and Research Policy's R&D database, firm annual reports. 1€ = 7.4 DKK.

For private sector, year 2000 estimated based on average of 1999 and 2001. For public sector, 1998 estimated, based on averages of 1997 and 1999.

To avoid double counting and exclude R&D conducted outside Denmark, extramural R&D are not included in estimates of aggregate levels of biotech R&D given in Table 1.

There has been fairly steady growth in private sector R&D within biotechnology, with average annual growth rates of 12.1 percent over 1997-2003. This is somewhat higher than growth rates of total private sector R&D in Denmark¹⁶. Public sector biotech R&D increased from 752 million to 1.05 billion from 1997 to 2000, but has been stagnant since 2000.

Table 2 shows developments in the number of full time employee equivalents (FTE) engaged in biotech R&D in Denmark. In 2003, an estimated 6,188 FTE's were utilized in biotech R&D. This amounts to around 15 percent of aggregate totals for Denmark in 2003.

¹³ This figure is based on data for biotech firms for which we have or were able to obtain R&D figures. Total R&D figures are unweighted. More details can be found in section 4 and in the Annex.

¹⁴ Total private sector R&D in Denmark was 24.9 billion DKK for 2003. See Danish Centre for Studies in Research and Research Policy (2005a) and the updated tables in Danish Centre for Studies in Research and Research Policy (2006).

¹⁵ Note that private sector biotech R&D has been revised upwards for 2000 and 2001 in relation to that reported in (Bloch, 2004), based on new data.

¹⁶ Average growth rates for total private sector R&D were 8.8 percent for 1997-2003. See Danish Centre for Studies in Research and Research Policy (2005a).

Table 2. Total R&D FTE, 1997-2003

Sector	1997	1998	1999	2000	2001	2002	2003
Private	3528	3648	3742	3950	4157	4528	4781
Public	1373	1551	1729	1466	1518	1439	1406
Total	4902	5199	5471	5416	5675	5967	6188

Source: Own calculations based on Danish Centre for Studies in Research and Research Policy's R&D database, firm annual reports. An FTE, or full time equivalent, is equal to a year of total working time for one employee. For the private sector, the year 2000 was estimated based on average of 1999 and 2001. For the public sector, 1998 was estimated, based on averages of 1997 and 1999.

Private sector biotechnology R&D

The 2003 R&D survey contains data on 83 biotech firms. This sample of firms is described in greater detail in the annex. It includes both dedicated biotech firms and a number of other innovative biotech firms that develop and apply biotechnologies in a variety of areas. In order to gain as comprehensive a sample on biotech R&D as possible, annual reports were examined for all dedicated biotech firms with ten employees or greater that were not in the R&D sample. Nineteen of these firms reported R&D expenditures in their annual reports for 2003¹⁷. This then gives a total 102 biotech firms, comprising 74 percent of dedicated biotech firms in Denmark with at least 25 employees¹⁸. Table 3 shows the distribution of these 102 biotech firms by industry.

Table 3. Industrial classification of biotech firms in R&D sample, 2003

Sector	NACE	%
Food Processing	15	24
Chemicals (minus Pharmaceuticals)	(24 minus 24.4)	9
Pharmaceuticals	24.4	9
Medical instruments	33	3
Other manufacturing		5
Wholesale trade	51	5
Research & Development	73.1	32
Other business services	74	13
Total		100

Source: Own calculations based on data from NewBiz Business Information Source and the Danish R&D statistics.

The largest share of biotech firms are within the classification, Research and Development (NACE 73.1). There are also a significant number of firms in Chemicals (NACE 24) and Pharmaceuticals (24.4) and in Architectural and Engineering Activities and Technical Consultancy (NACE 74.2). What is also noteworthy is the large share of firms in Foods and Beverages (NACE 15), with almost a quarter of biotech firms in this industry. The data thus

¹⁷ We then estimated the shares of their reported R&D that comprised intra- and extramural R&D based on core biotech firms of a similar size in the R&D sample.

¹⁸ And 61 percent of all dedicated biotech firms with 10 or more employees.

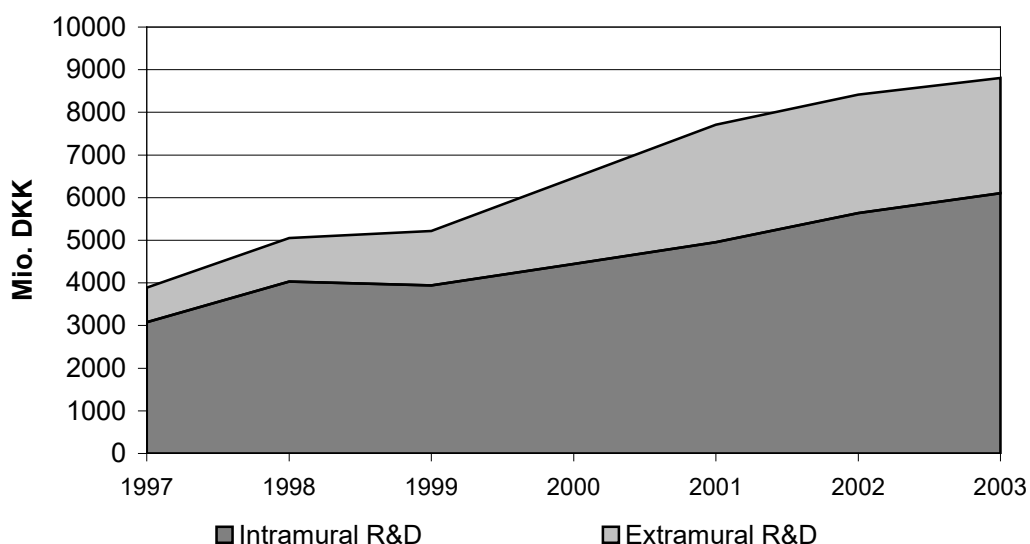
points to two areas where biotechnology is being applied in Denmark: the health sector and food processing.

For a large number of this sample of 102 biotech firms, all or close to all of their R&D is biotech related. Other biotech firms are mainly active as users and appliers of biotechnologies, and a lesser share of R&D is within biotechnology. 52 percent have more than three quarters of their R&D within biotechnology, while 34 percent have less than one quarter within biotechnology.

Intra- and extramural biotech R&D

Figure 7 shows the developments in firms' intramural and extramural biotech R&D. Extramural R&D in biotechnology has increased from DKK 812 million (€ 110 million) in 1997 to DKK 2.7 billion (€ 365 million) in 2003, with extramural R&D comprising 31 percent of firms' total biotech R&D expenditures in 2003¹⁹.

Figure 7. Intra- and extramural biotech R&D in the private sector 2003



Source: Danish Centre for Studies in Research and Research Policy (2005a), firm annual reports.

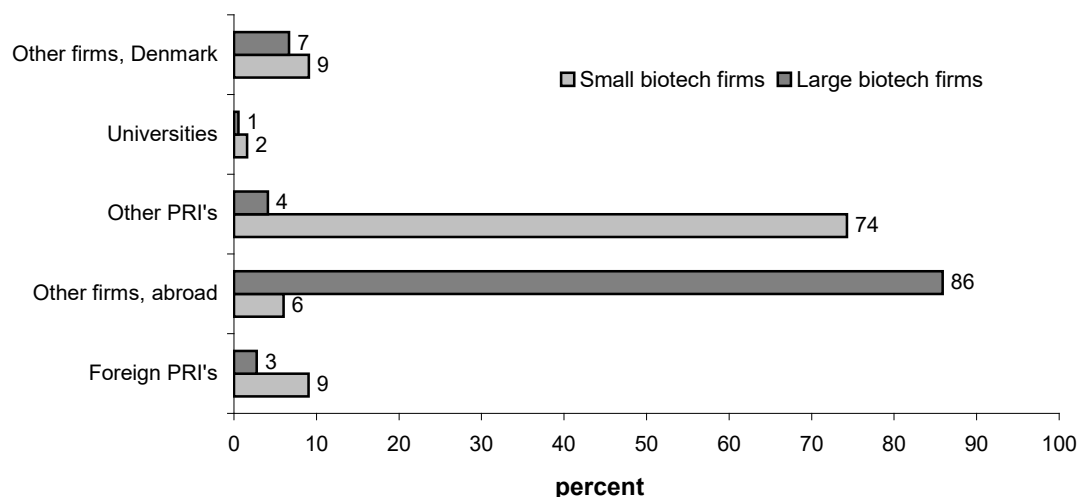
Figure 8 shows the distribution of purchased R&D according to sources, both for medium and large firms (50 or greater employees) with biotech R&D²⁰ and for small biotech firms (under 50 employees). For medium and large biotech firms in the R&D sample, 86 percent of extramural R&D was purchased from other firms outside Denmark, with a small reliance on R&D from universities and other public research institutions (PRI). The picture is very different for smaller biotech firms, with over 75 percent of extramural R&D stemming from

¹⁹ Note: extramural R&D includes intramural R&D that is conducted outside Denmark. To avoid double counting and exclude R&D conducted outside Denmark, extramural R&D are not included in estimates of aggregate levels of biotech R&D given in table 1.

²⁰ Figures are for total extramural R&D for each firm. In order to focus on biotechnology R&D, only firms with at least 20 % of their R&D focused on biotechnology are included here.

universities and other PRI's in Denmark and an additional 10 percent from PRI's abroad. This pattern is very similar to that for 2001 (see Bloch, 2004).

Figure 8. Extramural R&D by source, 2003

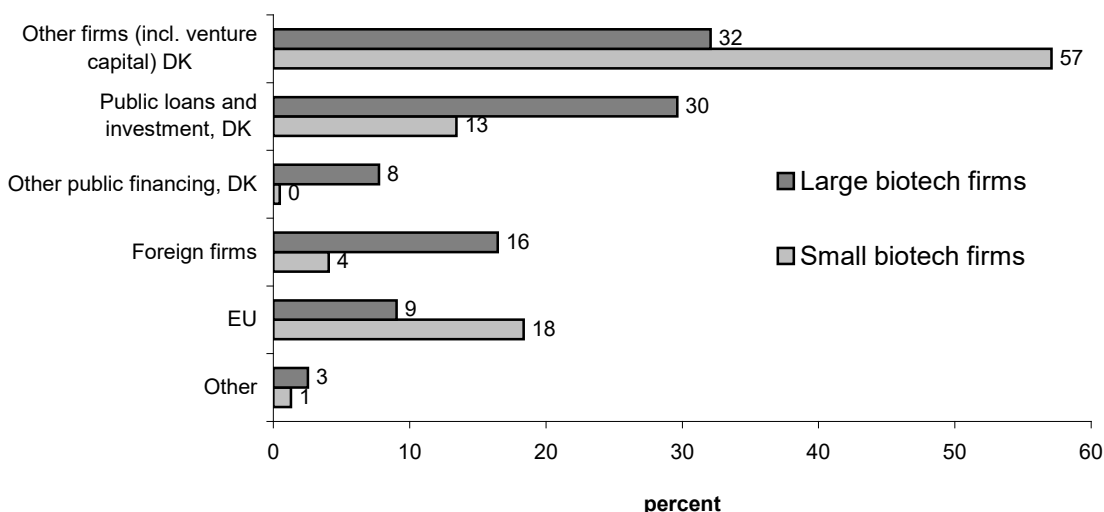


Source: Own calculations based on 2003 R&D statistics.

External financing

On average, biotech firms in this sample relied on external financing for 11 percent of their R&D expenditures. Use of external financing was significantly higher for smaller firms, at an average of 41 percent of R&D expenditures for firms with 50 employees or less. Figure 9 below shows the distribution of external financing by source, for medium and large biotech firms (50 employees or greater) and small biotech firms.

Figure 9. External financing of R&D by source, 2003



Source: Own calculations based on data from the 2003 R&D statistics.

Considering first large biotech firms in the R&D sample, the largest source of external funding is other firms in Denmark, which account for over half of external funds to R&D

activities, followed by public investment funding via the Danish Growth Fund (Vaekstfonden), and the National Agency for Enterprise and Housing (Erhvervs- Boligstyrelsen). Small biotech firms rely more heavily on other Danish firms and on funding from the EU. The 2003 R&D survey does not separate between business enterprises and venture capital funds, though results from 2001 (Bloch, 2004) suggest that this large share for 'Other firms DK' reflects a significant reliance on venture capital for external funding.

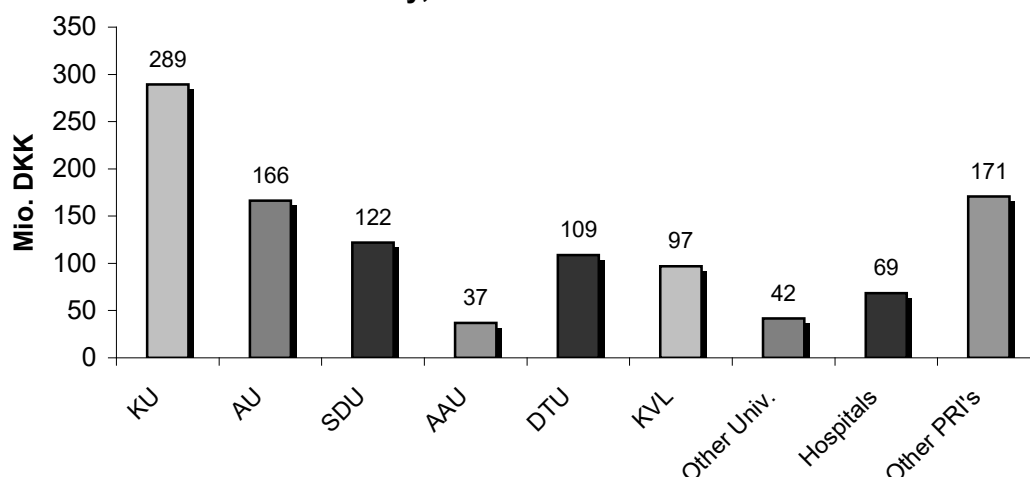
Public sector biotechnology R&D

In 2003, biotech R&D in the public sector amounted to DKK 1.1 billion (€ 149 million). In all 115 units²¹, covering a broad range of areas, reported R&D in biotechnology²². About two thirds of this research is conducted in the Greater Copenhagen area, with the remaining third concentrated in universities and hospitals in Aarhus, Odense and Aalborg.

Institutions

Figure 10 shows the distribution of public sector biotech R&D among universities, hospitals and other research institutions. The majority of public biotech R&D is conducted at six universities, three of which²³ are located in Greater Copenhagen.

Figure 10. Public biotech R&D expenditures by sector and university, 2003



KU = University of Copenhagen; AU = University of Aarhus; SDU = University of Southern Denmark; AAU = Aalborg University; DTU = Technical University of Denmark; KVL = Royal Veterinary and Agricultural University.

Source: Own calculations based on 2003 R&D statistics.

Among public institutions, the largest share of biotech R&D is conducted at the University of Copenhagen, followed by the University of Aarhus and the University of Southern Denmark. In all, over 78 percent of biotech R&D in the public sector was conducted at universities, 6 percent in hospitals, and the remaining 16 percent in other research institutions and non-profit organizations.

²¹ Units are the smallest administrative units in public research institutions, for example a department or center at a university or hospital. See Danish Centre for Studies in Research and Research Policy (2005b).

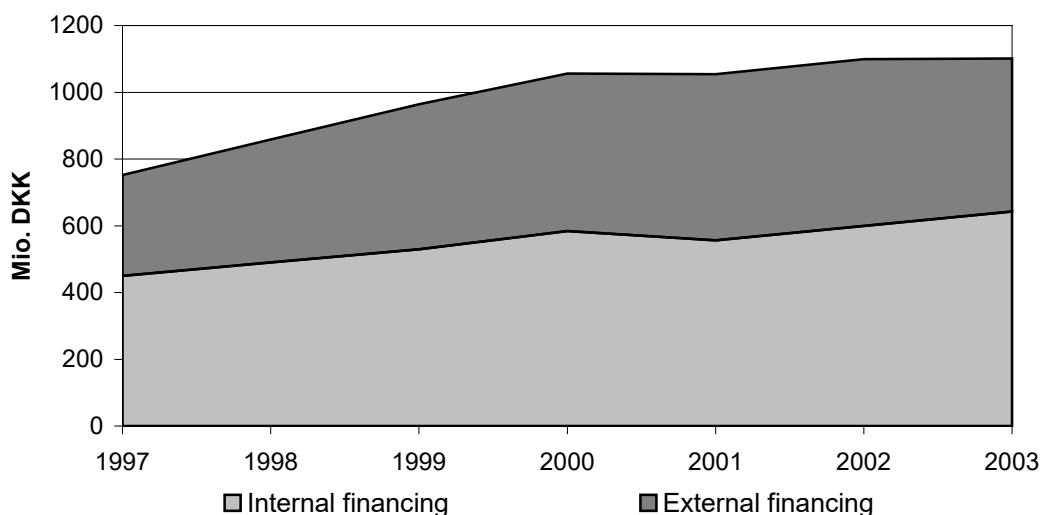
²² In addition to those that reported biotechnology research in 2003, 12 of the 115 units were estimated to conduct R&D in biotechnology based on responses in earlier years (these units had not answered the question on research areas in 2003). See the Annex for more details.

²³ University of Copenhagen, Technical University of Denmark, Royal Veterinary and Agricultural University.

Sources of finance for biotech R&D in the public sector

Figure 11 shows the development over time of the financing of public biotech R&D. The share of biotech R&D financed outside of regular budgets increased from 40 percent in 1997 to 50 percent in 1999, though it has since declined to 42 percent in 2003. This is slightly higher than the share of external financing for overall public sector R&D, which was 38 percent in 2003²⁴.

Figure 11. Internal and external financing of public biotech R&D, 2003

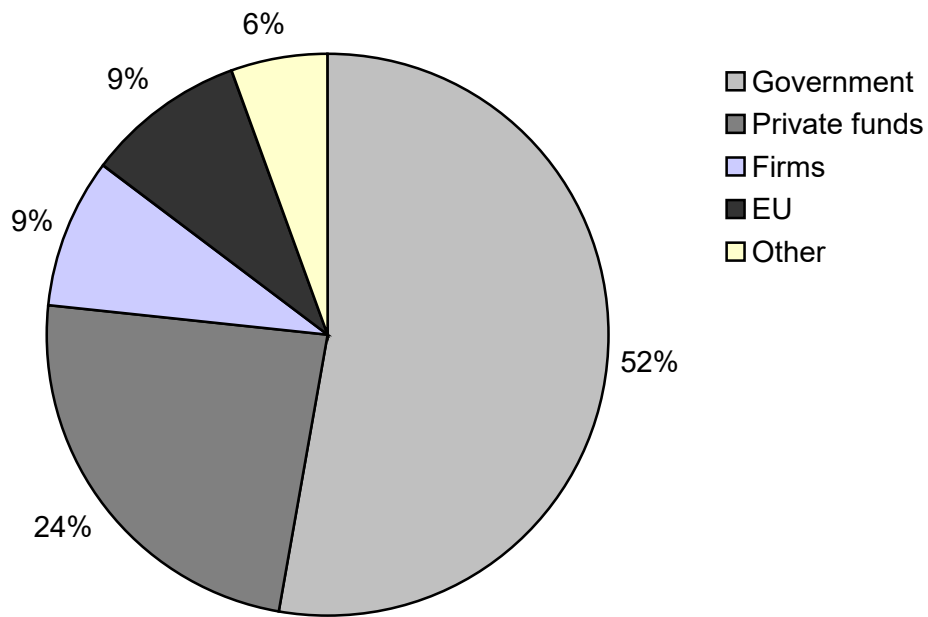


Source: Own calculations based on 2003 R&D statistics.

Figure 12 shows external financing of public biotech R&D by source. The distribution of funding is very similar to that for 2002 (Bloch, 2004). The majority of external funding (52 percent) comes from government sources (research councils and other national sources, amts and municipalities), 24 percent stems from funds and organizations in Denmark, and 9 percent from the EU.

²⁴ See Danish Centre for Studies in Research and Research Policy (2005b).

**Figure 12. Sources of external financing:
public biotech R&D, 2003**



Source: Own calculations based on 2003 R&D statistics.

Annex. Calculating biotech R&D for firms and public research institutions

This section discusses the methods used to estimate biotech R&D for firms and PRI's. In Danish R&D surveys, firms and PRIs are asked to estimate the percentage of R&D expenditures within a number of research areas, among them biotechnology. Biotech R&D for each firm or PRI is then calculated as the biotech percentage times the firm's total R&D. In order to make the set of firms and PRIs covered here as comprehensive as possible, we utilize the following conventions.

- For firms that did not answer the research area question in a given year, but reported biotech R&D in at least two out of the six surveys over 1995-2003 (1995, 1997, 1998, 1999, 2001 and 2003), biotech percentages were estimated based on data from other years. Estimates were made in the same way for public research institutions active within biotechnology (for the public sector: 1997, 1999, 2000, 2001, 2002 and 2003).
- Sampling procedures imply that small and medium sized firms may not be included in the survey sample each period. If biotech firms were not included in a given year, then data was estimated based on data from the previous period.
- We have also identified (based on other sources: firm websites, biotech organizations, etc.) a number of dedicated biotech firms in the R&D sample that have not answered the 'focus area' question (or have responded, for example, that research was within the area of health, as opposed to biotechnology). These firms were included in the biotech R&D sample and biotech percentages were estimated to be 100%.
- A few large firms in terms of biotech R&D have substantially changed the share of their R&D that is biotech related in recent years. Correspondences with these firms indicates that the changes reflect changes in the interpretation of the question (and what biotechnology includes; for example whether biotech R&D can include the application of biotechnologies to create new uses or only the development of new biotech techniques) and not a change in the character of their R&D activities. Based on this, biotech shares for these firms are assumed to be equal to shares reported in earlier years. This ensures a much greater degree of continuity and comparability over time.
- Finally, we have examined annual reports for all core biotech firms with ten or more employees. For those firms that report R&D expenditures in their annual reports, these R&D figures were used, and shares of total R&D that were intramural and extramural (which includes intramural R&D conducted outside Denmark) were estimated based on similar biotech firms in the R&D sample.

This approach allows us to form a rough estimate of biotech R&D in Denmark. Based on the information at our disposal, we believe this estimate both to be a reasonable and helpful measure of biotechnological activity in Denmark.

For the 2003 R&D survey for the private sector, we identified 83 firms in the sample that had R&D within biotechnology. Of these 83 firms, there were 26 dedicated biotechnology firms and 57 other innovative biotech firms.

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