

1. Methodology

This report provides statistics on biotechnology activities for 22 OECD countries and four non-member countries. The main methodological challenges concern the production of comparable statistics across countries that have used different survey designs. Table 1.1. summarises the main methodological characteristics of the studies of biotechnology in each country.

This methodological section applies to the data presented in Chapters two through six. The indicators and analyses presented in these Chapters are based on biotechnology data collected by the OECD from national representatives. The chapter on biotechnology patents is based on OECD patent data. The other data presented in the report, including biotechnology in agriculture, biotechnology in health, biotechnology alliances and biotechnology venture capital, are based on external data sources.

In an effort to harmonise data collection and improve international comparability, the OECD developed a data collection questionnaire in 2008 that each national producer of biotechnology statistics could complete and return to the OECD.¹ The data compiled through the OECD biotechnology questionnaire was used in this report. The use of this questionnaire helped to obtain consistent results, providing a major improvement over the data collection for the 2006 edition of *OECD Biotechnology Statistics*, which relied on national reports.

Twenty-one OECD countries and two non-member countries returned the completed questionnaire. Most of these countries provided data for the latest available year; however, 11 countries provided data covering several years. Only Japan, Brazil and South Africa were not able to complete the OECD biotechnology questionnaire. Data for these countries was extracted from national reports.²

The OECD biotechnology questionnaire focused on biotechnology activities in the business enterprise sector (firms). This reflects the focus of the OECD *Framework for Biotechnology Statistics*, published in 2005, which proposes definitions, standards and a conceptual framework for collecting internationally comparable data on biotechnology. However, the questionnaire also included one question on biotechnology R&D by sector of performance, in order to capture the public sector. This is part of the OECD's ongoing effort to establish guidelines for the collection of public sector data.

Most of the data presented in this report are for firms active in biotechnology. Data availability depends on how each country collects biotechnology statistics. Biotechnology activities can be measured in three ways:

- *Dedicated surveys* of firms active in biotechnology;
- Adding questions on biotechnology to the national *R&D survey* of firms;
- Constructing *databases* with information on biotechnology firms from diverse secondary sources, and/or data linking exercises.

Several countries conduct more than one collection exercise.

Fourteen countries collect data on biotechnology firm activity via their R&D firm surveys. As a result, these data may underestimate the number of biotechnology firms, as firms that use biotechnology but do not perform biotechnology R&D are excluded. Twelve countries run dedicated biotechnology surveys. Four countries constructed databases: Austria, Belgium, the Netherlands and Sweden. Austria and Belgium obtained information on the biotechnology activities of firms by linking data from secondary sources with the results of existing surveys.

The diverse types of biotechnologies and the range of possible applications create two main challenges for developing comparable biotechnology statistics: how to define biotechnology and how to define a biotechnology firm.

¹ Not all countries collect biotechnology data on a regular basis, therefore 2004 was established as the data cut-off point for this report. For data before 2004, see *OECD Biotechnology Statistics 2006*.

² In some cases, the data in this report may not be comparable with the data presented in the *OECD Biotechnology Statistics 2006* report. In Germany, for example, the survey is now conducted by BIOCOM on behalf of the German government. Previously the survey was conducted by the German Federal Statistical office.

Definition of biotechnology

In 2002, the OECD developed both a single definition of biotechnology and a list-based definition (see Box below) of different types of biotechnology techniques. The list-based definition of biotechnology was revised in 2005. The OECD recommends that statistical agencies provide both of these definitions to survey respondents when collecting data on biotechnology activities.

The single definition defines biotechnology as:

"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."

The single definition covers all modern biotechnology but also many traditional or borderline activities. For this reason, the OECD recommends that the single definition always be accompanied by the list-based definition, which operationalises the definition for measurement purposes.

The list of biotechnology techniques functions as an interpretative guideline to the single definition. The list is indicative rather than exhaustive and is expected to change over time as data collection and biotechnology activities evolve. In 2008, OECD member countries decided to begin work on revising and updating the list-based definition.

OECD list-based definition of biotechnology techniques

DNA/RNA: Genomics, pharmacogenomics, gene probes, genetic engineering, DNA/RNA sequencing/synthesis/amplification, gene expression profiling, and use of antisense technology.

Proteins and other molecules: Sequencing/synthesis/engineering of proteins and peptides (including large molecule hormones); improved delivery methods for large molecule drugs; proteomics, protein isolation and purification, signaling, identification of cell receptors.

Cell and tissue culture and engineering: Cell/tissue culture, tissue engineering (including tissue scaffolds and biomedical engineering), cellular fusion, vaccine/immune stimulants, embryo manipulation.

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

Gene and RNA vectors: Gene therapy, viral vectors.

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

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

Source: OECD (2005), *A Framework for Biotechnology Statistics*, OECD, Paris.

Eighteen OECD countries and two non-member countries used the OECD definitions in their surveys. Korea limits biotechnology to 'modern' or third-generation biotechnologies that are similar to the OECD list-based definition. Austria is a particular case, in that the biotechnology data were not directly collected by means of a survey but rather by data linking. Japan and Brazil used biotechnology definitions that include traditional biotechnologies. Portugal and Slovenia did not include a definition of biotechnology in their surveys (see Table 1.1).

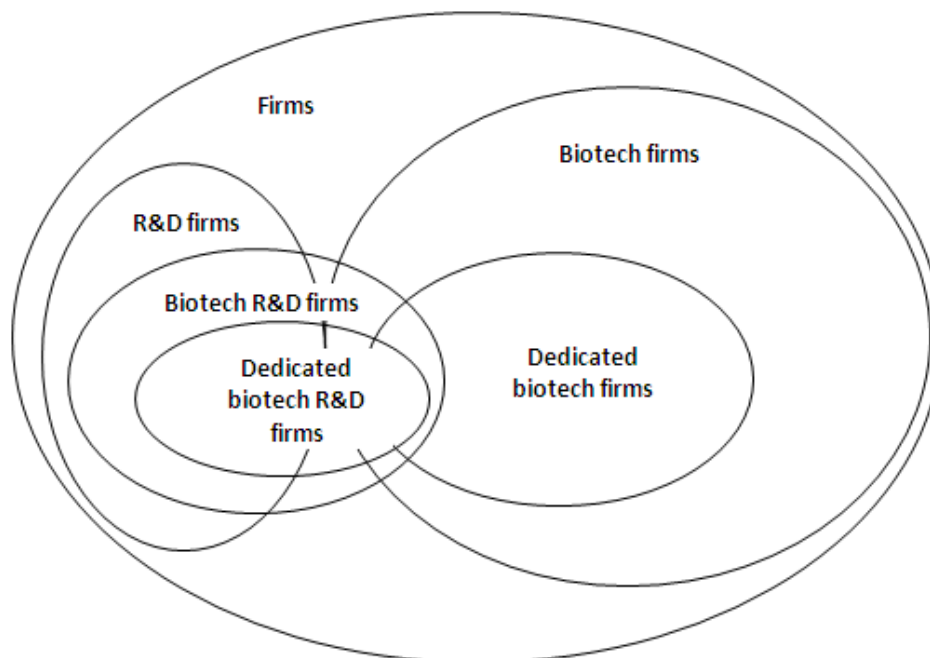
Definition of a biotechnology firm

A biotechnology firm can be defined as a firm that is engaged in biotechnology by using at least one biotechnology technique (as defined in the OECD list-based definition of biotechnology techniques) to produce goods or services and/or to perform biotechnology R&D. Some of these firms may be large, with only a small share of total economic activity attributable to biotechnology.³

There are two subgroups of biotechnology firms.

1. Dedicated biotechnology firm: defined as a biotechnology firm whose predominant activity involves the application of biotechnology techniques to produce goods or services and/or to perform biotechnology R&D.
2. Biotechnology R&D firm: defined as a firm that performs biotechnology R&D. Dedicated biotechnology R&D firms, a subset of this group, are defined as firms that devote 75% or more of their total R&D to biotechnology R&D. All of these firms are captured by R&D surveys.

The data available on firm type depends on how each country collects biotechnology data. Not all countries will have data for all types of biotechnology firms.



Sampling frame

Two main methods are used for identifying biotechnology firms. Fifteen surveys use the national R&D sampling frame. Fourteen surveys use secondary sources to identify biotechnology firms. These include industry association membership lists, participants in government programmes to support biotechnology, stock market listings, patent records, information provided by venture capital firms, and any other relevant source. Some countries used several sampling frames as they conducted several surveys (see Table 1.1).

³ Biotechnology firms in this report are equivalent to the group of ‘biotechnology active firms’ in the 2006 *OECD Biotechnology Statistics*.

Accuracy of the results

All data, with the exception of data for Brazil and the Philippines, are from official government sources. Twenty-nine of the 31 surveys were conducted by government agencies or by organisations acting at the request of a government agency. The principal advantage of government surveys is that information on the survey methodology is available. The Brazilian survey was undertaken by Biominas, a private foundation. The Philippines survey was undertaken by the Biotechnology Coalition of the Philippines, a non-profit organisation. Note, the Philippines survey methodology was based on the recommendations put forth in the OECD *Framework for Biotechnology Statistics*.

There are three other characteristics that can influence the accuracy of biotechnology statistics: the response rate (RR); whether or not results were imputed to account for non-respondents or extrapolated to the total population (Extrapolation); and whether or not the survey was mandatory (see Table 1.1).

Data accuracy is strongly dependent on a high response rate, which will reduce possible biases due to differences in the types of biotechnology firms that choose or do not choose to respond to a survey. Low response rates could result in underestimates of the number of biotechnology firms or biotechnology activities such as R&D.

The average response rate for the 21 surveys carried out by OECD countries is 76%. Thirteen surveys had above average response rates, of which 12 countries had response rates above 80%. Only three countries had response rates below 50%.

For non-member countries, the average response rate is 63%. This lower figure is due to the response rate for the Philippines (33%) – a first-time survey – and a lack of information for Brazil. The response rate was 75% for Slovenia and 81% for South Africa.

The combination of response rates and no extrapolation may have led three countries to underestimate biotechnology activity by firms: Italy, Poland and the Philippines. Data for Australia may also have been underestimated.

Countries that collect biotechnology statistics through their R&D surveys may also underestimate biotechnology activity by firms, as firms that use biotechnology but do not perform biotechnology R&D are excluded.

Measuring public biotechnology R&D

The OECD biotechnology questionnaire also included one question on biotechnology R&D by sector of performance, in order to capture the public sector. This is part of the OECD's ongoing effort to establish guidelines for the collection of public sector data.

Six OECD countries and one non-member country collected data on public biotechnology R&D expenditure. Table 1.2. summarises the main methodological characteristics of these surveys.

Conclusions

Although every effort has been made to maximise comparability across countries, caution must be used in comparing biotechnology activities among countries when the data are obtained from studies with very different methodologies. Factors, such as differences in the definition of biotechnology, whether or not all firms innovate, low response rates, whether or not results were imputed to account for non-respondents or extrapolated to the total population, will also reduce comparability.

In general, the results in this report for the number of biotechnology firms, employment, R&D and sales are more likely to underestimate the true values than to overestimate them. This is primarily caused by the reliance in several countries on studies limited to dedicated biotechnology firms and below average response rates in several studies.

Table 1.1. Characteristics of biotechnology data sources

	Year	Biotech definition	Biotech firms	Only Innovative firms	Sample frame used	Mandatory	Conducted survey	RR	Extra-polation	Type of survey
Australia	2006	OECD	All	Yes	Secondary	No	GOV	27%	Yes	Dedicated
Austria (1)	2006	NR	All	No	Secondary	NR	GOV	NR	No	Database
	2006	NR	NR	Yes	R&D	Yes	GOV	97%	No	R&D survey
Belgium (1)	2006	OECD	All	NR	NR	NR	Federal govt., Regions & Communities	44%	Partial	R&D survey
	2006	OECD	All	No	Secondary	No	GOV	54%	Yes	Database
	2006	OECD	All	No	Secondary	No	GOV	16%	Yes	Dedicated
	March 2008 version	OECD	All	NR	Census	NR	BvDEP: BEL-FIRST database	NR	Partial	NR
Belgium (Flanders)	2007	OECD	All	No	Secondary	Yes	Technopolis-GOV	80%	No	Dedicated
Canada	1999	OECD	R&D	Yes	Secondary	Yes	GOV	80%	Yes	Dedicated
	2001	OECD	R&D	Yes	Secondary	Yes	GOV	84%	Yes	
	2003	OECD	R&D	Yes	Secondary	Yes	GOV	80%	Yes	
	2005	OECD	R&D	Yes	Secondary	Yes	GOV	70%	Yes	
Czech Republic	2007	OECD	R&D	Yes	R&D	Yes	GOV	87%	Partial	R&D survey
Finland	2007	OECD	R&D	Yes	R&D	Yes	GOV	81%	Yes	R&D survey
France	2003	OECD	R&D	Yes	R&D	Yes	GOV	72%	Yes	R&D survey
	2004	OECD	R&D	Yes	R&D	Yes	GOV	75%	Yes	R&D survey
	2005	OECD	R&D	Yes	R&D	Yes	GOV	73%	Yes	R&D survey
	2006	OECD	R&D	Yes	R&D	Yes	GOV	73%	Yes	R&D survey
Germany	2005	OECD	Dedicated	Yes	Secondary	No	BIOCOM-GOV	91%	Partial	Dedicated
	2006	OECD	Dedicated	Yes	Secondary	No	BIOCOM-GOV	89%	Partial	
	2007	OECD	Dedicated	Yes	Secondary	No	BIOCOM-GOV	88%	Partial	
Ireland	2005	OECD	R&D	Yes	R&D	No	GOV	56%	Yes	R&D survey
Italy	2002	OECD	R&D	Yes	R&D	Yes	GOV	58%	No	R&D survey
	2003	OECD	R&D	Yes	R&D	Yes	GOV	50%	No	
	2004	OECD	R&D	Yes	R&D	Yes	GOV	43%	No	
	2005	OECD	R&D	Yes	R&D	Yes	GOV	36%	No	
	2006	OECD	R&D	Yes	R&D	Yes	GOV	42%	No	
Japan	2005	All	All	No	Secondary	No	GOV	55%	No	Dedicated
Korea	2002-2006	Modern	All	Yes	Secondary	No	GOV	100%	No	Dedicated
	2006	All	Yes	Yes	R&D	No	GOV	85%	No	R&D survey
Netherlands	2005	OECD	R&D	Yes	Secondary	No	GOV	NR	Partial	Database
New Zealand	2005	OECD	All	No	Secondary	Yes	GOV	93%	No	Dedicated
	2007	OECD	All	No	Secondary	Yes	GOV	96%	No	
Norway	2005	OECD	R&D	Yes	R&D	Yes	GOV	95%	Yes	R&D survey
Poland	2005-2007	OECD	All	Yes	Secondary	Yes	GOV	62%	No	Dedicated
Portugal	2005	None	R&D	Yes	R&D	Yes	GOV	74%	No	R&D survey
Slovak Republic	2005	OECD	R&D	Yes	R&D	Yes	GOV	87%	No	R&D survey
	2006	OECD	R&D	Yes	R&D	Yes	GOV	88%	No	
Spain	2004	OECD	R&D	Yes	R&D	Yes	GOV	80%	Yes	Dedicated (with Innovation survey)
	2005	OECD	R&D	Yes	R&D	Yes	GOV	86%	Yes	
	2006	OECD	R&D	Yes	R&D	Yes	GOV	86%	Yes	
Sweden	1997-2006	Modern	Dedicated	Yes	Secondary	NR	VINNOVA-GOV	NR	NR	Database
	2007	OECD	R&D	Yes	R&D	Yes	GOV	92%	Yes	R&D survey
Switzerland	2004	OECD	R&D	Yes	R&D	No	GOV	81%	Yes	R&D survey
	2004	OECD	R&D	Yes	R&D	No	GOV	81%	No	
United States	2005	OECD	R&D	Yes	R&D	No	GOV	79%	No	R&D survey
	2006	OECD	R&D	Yes	R&D	No	GOV	77%	No	
Brazil (2)	2007	All	Dedicated	..	Secondary	..	BIOMINAS	Dedicated
Philippines	2006-2007	OECD	All	Yes	Secondary	No	BPC	33%	No	Dedicated
Slovenia	2006	None	R&D	Yes	R&D	No	GOV	75%	No	R&D survey
South Africa	2006	OECD	All	Yes	Secondary	No	GOV	81%	No	Dedicated

Table 1.2. Characteristics of biotechnology data sources for public biotechnology R&D

	Year	Biotech definition	Sample frame used	Extent of coverage	Mandatory	Who conducted the survey?	RR	Extra-polation
Canada	2005/2006	OECD	Census	Federal Government departments and agencies either performing Science & Technology (S&T) activities or have a budgetary allocation to fund S&T.	Yes	GOV	100%	Yes
Czech Republic	2007	OECD	R&D survey	All	Yes	GOV	88%	Partial
Korea	2006	All	R&D survey	All	No	GOV	85%	No
Norway	2005	OECD	Census	Total HES and the Norwegian Institute sector	No	NIFU STEP	90%	No
Poland	2005	OECD	Secondary sources	Selected for S&T	Yes	GOV	100%	No
Spain	2006	OECD	Census	Only government institutions with Science & Technology (S&T) activities or S&T budgets are included.	Yes	GOV	86%	No
Slovenia	2005	OECD	Secondary sources	Selected for S&T	Yes	GOV	100%	No

→ RR = Response rate; NR = Not Relevant; .. = Information not available, HES = Higher education sector.

Source: OECD, Biotechnology statistics database, January 2009.