THE PORTUGUESE BIOTECHNOLOGY INDUSTRY: FIRMS, LABOUR MARKET AND INNOVATION INDICATORS

#01
REPORT

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"Portuguese Biotechnology industry is a high-priority sector: its ability to innovate and to promote innovation diffusion to other sectors makes it a key driver to the competitiveness of the Portuguese economy."

#01. Biotechnology industry is a high-priority sector, a key driver to the competitiveness of the Portuguese economy. Its high capacity to innovate and to promote innovation diffusion to other sectors are on the basis of its contribution to the economic growth.

#02. The present study aims at characterizing the Portuguese Biotechnology sector, based on firm-level information. Its objectives are threefold: to gauge the size of the sector by means of financial and economic indicators (turnover, employment, added value, returns on equity, among others), to characterize the labour market, and to characterize the innovation performance.

"A growing sector in a recessive context."

#03. In 2014, there were 65 firms in Portugal, which employed 478 workers, with an average size of 7.4 workers per firm, about a third of the European average (24.5 workers per firm). From 2006 to 2014, total employment experienced a strong increase, about 240%, above the average increase observed in European countries (157%).

#04 At the European level, five countries concentrate 79% of the employment and 56% of the number of firms: the United Kingdom, Germany, France, Switzerland and The Netherlands. In 23 European countries with available comparable data, Portugal ranks 14 regarding total employment (0,9% of the total) and ranks 10 in the total number of firms (2,9% of the total).

"Firm size below the European average and in need of strengthening their equity ratios."

#05. In 2014, in Portugal, the sector turnover was 30.5 million euros, corresponding to 0.25% of the total of the sector at the European level. It represents a fourfold increase compared to the turnover in 2006. The average turnover by firm was 436 thousand euros, much lower that the European average of 5.166 million euros. The average turnover by worker was 28.1% of the European average.

#06. The equity ratio of Portuguese firms has been about 30%, whereas in other European countries the indicator is about 50%.

#01

#07. About 85% of the sector workforce has at least a Bachelor's diploma. Namely, 14% of the workers have a PhD, 18% completed a Master's degree, 48% have Licenciate's diplomas and 5% have a Bachelor's degree.

#08. In 2013, the average gross wage (base wage plus overpayments) was 1558 euros, about 400 euros above the national private sector average. Half of the workers earned a wage below 1267 euros, and about 10% of them earned more than 2483 euros. The average hourly wage was 9.2 euros.

"Knowledge intensive sector, creating highly skilled jobs and paying above-average wages."

#09. The average workers' age is 34 and 61% of the workers are women.

#10. About 89% of the workers are employees, of which 64% have a permanent contract. Almost all people work full-time.

"Human resources ageing on average 6 years less than the national average and the sector employs proportionally more women than men."

#11. Patent publication in Portugal more than doubled from 2006 and 2014.

#12. From 2006 to 2014, there were 407 publications in biotechnology (0.5% of the total for the UE-28). In the same period there were 87 grants. Those patent publications represent 5.7% of the total publications in Portugal, and puts Biotechnology in fourth place among the 35 areas of the patent classification. The Portuguese Biotechnology sector has a relevant position in the European context, as its patent publication represented about 2.6% of the total number of patent publications in the EU-28, from 2006 to 2014.

"The number of patents (publication and grants) more than double over the last 8 years. In Portugal, the biotechnology ranks 4 in the 35 technological classifications regarding patent publication."

#02

The current context

Global trends in the biotechnology business

Biotechnology is considered internationally as a critical contributor to economic and employment growth, (Carlson, 2016). Although placing a greater focus on the biopharma business, the Ernst & Young's *Beyond Borders - Biotechnology Report 2016* shows that the area has been growing rapidly at two digits' rate over the past 15 years, faster than the economy as a whole, setting successive records in terms of financial performance. According to the same report, in 2015 the growth of the area started slowing down, however, signalling that it is entering a more mature phase, which presents new challenges to the companies. Nevertheless, the R&D expenses are growing faster than revenues, suggesting a willingness to continue investing in the area. In fact, Ernst & Young's report shows that biotech companies have a remarkably high capacity to raise capital. In particular, early-stage venture investment has peaked in 2015.

In the future, biotechnology is believed to be able to offer technological solutions for many existing and emerging health and resource-based problems that are expected over the next two decades, resulting in an emerging "bioeconomy" (OECD, 2009). According to OECD's forecast for the bioeconomy in 2030, it is possible that within the OECD region, biotechnology can contribute to 2.7% of GDP, being the largest economic contribution expected in industry and primary production. The major drivers for such development will be the increasing population and per capita income, particularly in developing countries, increase in energy demands, combined with measures to reduce greenhouse gases and increase in elderly population. These trends call for more sustainable and effective solutions to produce food, consumer goods, energy and improve health, which can be offered by biotechnology, suggesting that wider opportunities can be expected for the businesses in this area in the future.

Particularly in Europe, there is an explicit intention to develop the bioeconomy. For this purpose, in 2012, the European Commission has set a *Bioeconomy Strategy* and an action plan to develop technologies and processes for the bioeconomy; markets and competitiveness for the companies operating in the area and; to bring together policymakers and stakeholders (European Commission, 2016). The bioeconomy is also approached through different programs and instruments including the Horizon 2020.

The European Union acknowledges the importance of the bioeconomy, both due to its contribution for the sustainable production and exploitation of biological resources, and due to its impact on the European economic growth and job creation. According to European Commission's document *Innovating for Sustainable Growth: A Bioeconomy for Europe* (2012), with an annual turnover around two trillion Euros and employing around 22 million people, this constitutes one of the Union's biggest and most important areas, encompassing agriculture, forestry, fisheries food and chemicals. Within this broader context, biotechnology plays an important role to sustain innovation and competitiveness. The analysis of the global trends and the existing studies of the business activity within the area points to a promising future, full of growth opportunities for biotechnology companies, from which the emerging Portuguese biotechnology cluster can also benefit.

#03

Measuring the biotechnology sector in Portugal

methodological options

The first step to define a future path for the area is to establish a clear picture of the extant potential, particularly referring to characterization of the current business players. Setting the basis to apply measurement indicators present two main challenges, though: i) a definition of biotechnology must be agreed upon in order to coherently delimit the area; ii) it is necessary to determine the relevant key indicators to describe the companies. The options made in the context of the current report are presented and justified below.

3.1 The biotechnology definition

Defining biotechnology is not straightforward, and for that reason different studies may use different criteria to select the companies considered biotechnology players, hindering the comparability of the data. When presenting a report on the biotechnology research and commercialization in the US in 2002, Joseph Cortright and Heike Mayer included an appendix dedicated to the definitions of the biotechnology industry. They searched for biotechnology definitions in 11 publications, both from industry and academia. They all used different terminology and lacked operability, some publications differentiated between pharmaceutical and biotechnology firms and some others omitted the definition altogether. The understanding of the biotechnology sector remains hampered by inconsistencies in usage of the term until today (Carlson, 2016). The difficulty in defining biotechnology results from the fact that it constitutes a diverse set of activities across different sectors of the economy instead of configuring a single industry.

Nowadays, one commonly accepted definition is the one proposed by OECD, developed by its Ad hoc Biotechnology Statistics Group, and it is composed of a single definition and a list based definition of biotechnology techniques (Table 3.1).

Table 3.1 - OECD's Definition of biotechnology

The single definition	
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 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, p. 9).

#03

Any company applying the listed technologies in their activities could be considered a biotechnology firm. The identification of the companies that correspond to this definition requires a nationwide survey in which every company should declare whether or not they apply any of the listed technologies and in what extent, as recommended by OECD (OECD, 2005). The current statistical information released by OECD about the Portuguese biotechnology activity is based on the data gathered through the R&D survey conducted by the Direcção Geral de Estatísticas da Educação e da Ciência (*Inquérito ao Potencial Científico e Tecnológico Nacional*). However, according to the methodological note of the OECD's Key Biotechnology Indicators, in Portugal, the survey does not use the OECD's biotechnology definition (OECD, 2015). Additionally, it does not offer detailed information about all economic and financial indicators of performance of the firms, which are relevant to characterize the business area, being its main purpose the inventory of human and financial resources allocated to R&D activities. To undertake a nationwide new survey would be time consuming, costly and it would be expected a low response rate.

Therefore, for the purpose of the current report, the biotechnology firms are defined as those that are classified, under the classification of economic activities (CAE Rev.3 / NACE Rev.2), as performing **Research and experimental development on biotechnology (Class 7211)**. Thus, the Class 7211, as primary code, was used to construct the population list.

Although the OECD's *Framework for Biotechnology Statistics* (OECD, 2005) warns that the industrial classification has limitations in the study of biotechnology firms, since biotechnology is not an activity in itself, but a collection of techniques that are applied in several sectors, we believe that this criterion offers two main advantages: i) it is an objective method to select the firms, allowing to make proper comparisons, both at the national and international level; ii) it is a key to retrieve information from several different databases, enhancing the description of the biotechnology firms.

The main disadvantages of using industrial classification are: i) there may be some companies that perform biotechnology activities but that are not classified under the 7211 code; b) there may be some companies that are classified under this code but that are not currently active in this area. It is worth to note that OECD considers dedicated firms those that devote at least 75% of their production of goods and services or R&D to biotechnology (OECD, 2015). These possibilities could lead to the selection of some false negatives and false positives. We believe that these cases are unlikely to occur, however.

To mitigate the identified problems, the list of companies selected using the industrial classification criterion was submitted to the scrutiny of the P-Bio – Portugal Biotechnology Industry Organization, in order to minimize the number of wrongly identified cases.

3.2 Relevant key sector indicators

The second important option made in the scope of the present report concerns the indicators to characterize the biotechnology area. Taking into account the recommendation provided by the OECD's *Framework for Biotechnology Statistics* (OECD, 2005), and the past experience in sectorial characterization, the following indicators were considered as relevant (Table 3.2):

Table 3.2 - Indicators of business performance of biotechnology firms

Theme	Indicators	Relevance	Source of data
Demography and performance	Number of firms Employment Average size Turnover Added value Return on equity Financial autonomy.	It provides a statistical picture of the demographics of companies performing biotechnology activities and their economic and financial performance, shows trends in recent years and compares with the performance of the sector at European level.	**Amadeus (microdata)** Database with detailed company information, including financial reports. The database consists of a large number of listed and unlisted companies in Europe.
Human resources	Qualifications Average age Men / women ratio Wages Labour contracts.	It characterizes human resources with biotechnology activities, presents their evolution over the last years and compares with the employment data of other sectors at national level.	**Quadros de pessoal** Data about the company and their employees submitted to the Authority for Working Conditions (ACT). Data at the individual level.
Innovation	Number of biotechnology patents Patents of biotechnology vs. other areas Patents of biotechnology of Portuguese companies vs. Europe.	It assesses the evolution of inventive activity of biotechnology companies in recent years, as well as the relative importance of the sector to innovation.	**WIPO - World Intellectual Property Organization** Data on intellectual property worldwide collected from several sources.

#04
Firms characterization
Demography, financial and economic indicators

4.1 Number of firms, average size and employment

The Amadeus dataset (Bureau Van Dijk) provides information for the characterization of the firms in the biotech sector regarding its number, size and employment. As explained earlier, firms in the sector "Sector 7211 Research and Development in Biotechnology" are considered. For Portugal, in addition to the firms declaring the 7211 as its main industry, all the firms associated of P-Bio have been included.

In 2014, there were 65 firms in Portugal, employing 478 workers, which results on an average size of 7.4 workers/firm, about a third of the European average of 24.5 workers (see Table 4.1).

Table 4.1 - Number of firms, average size and employment

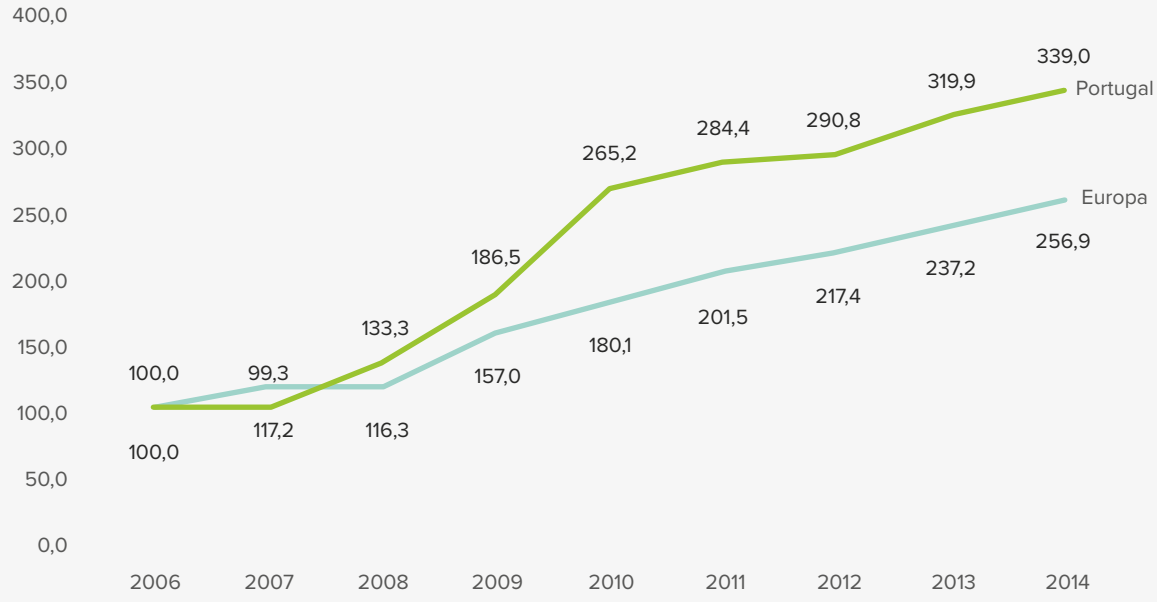
	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of firms employing at least one employee									
Europe (23)	448	608	551	962	1,182	1,464	1,877	2,038	2,213
Portugal	20	22	25	38	47	53	59	66	65
Total employment									
Europe (23)	21,065	24,696	24,496	33,070	37,932	42,438	45,795	49,962	54,123
Portugal	141	140	188	263	374	401	410	451	478
Average size									
Europe (23)	47.0	40.6	44.5	34.4	32.1	29.0	24.4	24.5	24.5
Portugal	7.1	6.4	7.5	6.9	8.0	7.6	6.9	6.8	7.4

Source: Computations made by the authors based on Amadeus dataset (Bureau Van Dijk), Sector 7211 Research and Development in Biotechnology.

In Portugal, a strong employment growth is evident in Figure 4.1, as the sector total employment has increased 240% from 2006 to 2014 (2006 is the base year). During the same period of time, the total employment increase has been 157% for the European countries.

At European level, 79% of the total employment and 56% of the number of firms were concentrated in five countries: The United kingdom, Germany, France, Switzerland and The Netherlands. Portugal ranks 14th and 10th in a total of 23 countries, regarding total employment and number of firms, respectively (Figures 2 and 3), taking 0.9% of the total employment and 2.9% of the number of firms.

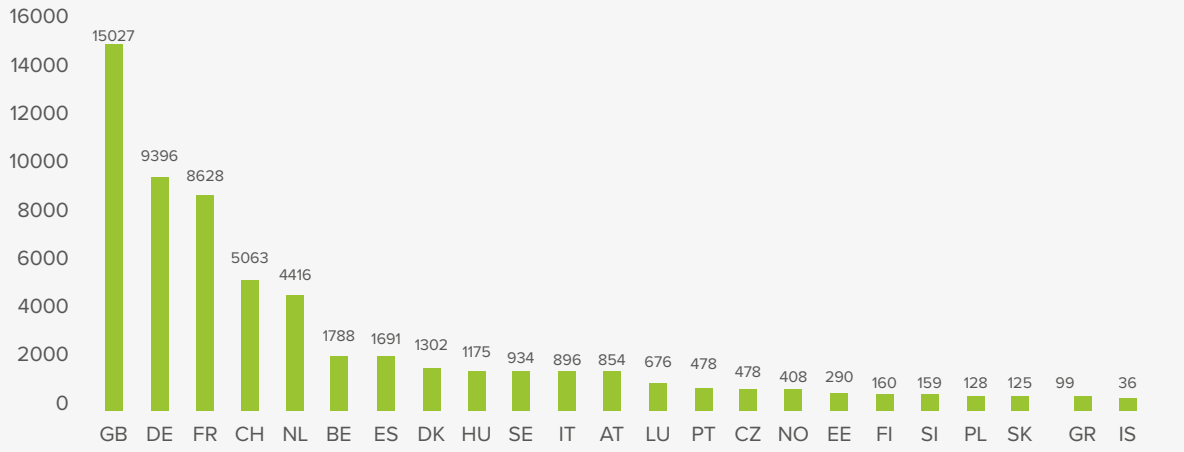
Figure 4.1 – Employment trends (2006=100)



Source: Computations made by the authors based on Amadeus dataset (Bureau Van Dijk), Sector 7211 Research and Development in Biotechnology

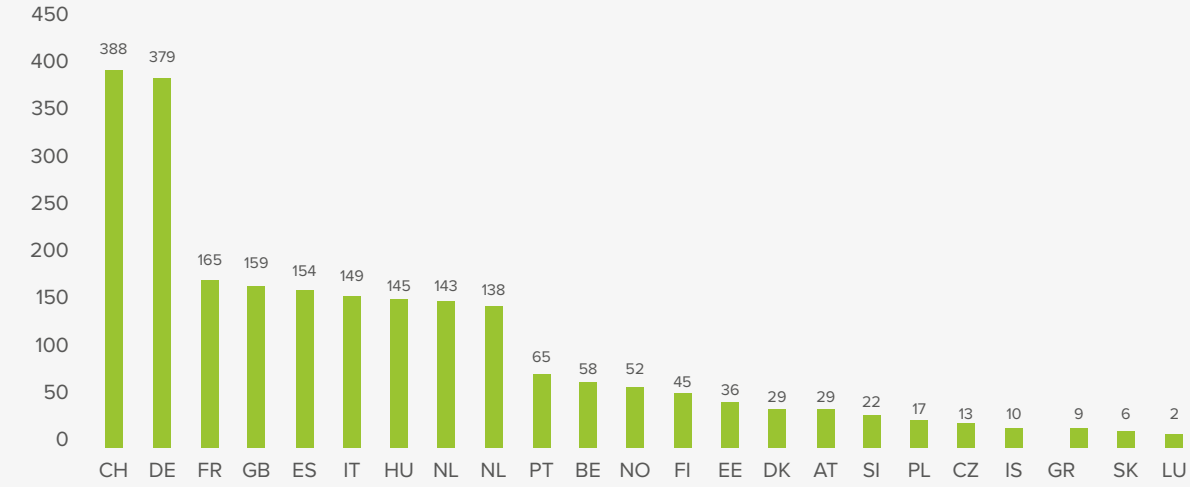
#04

Figure 4.2 – Total employment by country, 2014



Source: Computations made by the authors based on Amadeus dataset (Bureau Van Dijk), Sector 7211 Research and Development in Biotechnology.

Figure 4.3 – Number of firms by country, 2014



Source: Computations made by the authors based on Amadeus dataset (Bureau Van Dijk), Sector 7211 Research and Development in Biotechnology.

4.2 Number of firms and employment by geographical location

Most of the biotechnology companies are located along the coastal line, from Braga to Setúbal. In 2014, about 25% of both firms and employment were in municipalities in the North Portuguese littoral (Braga, Porto and Aveiro). About one third of firms and 27% of employment are in the Coimbra district; it is noteworthy the high concentration of firms in the Cantanhede municipality (13 firms), which cannot be dissociated from the Biocant location. About 30% of the firms were located in the Lisboa – Setúbal metropolitan area, as well as 42% of the sector total employment, which reflects that the firms' average size was above the national average (Table 4.2).

Table 4.2 – Firms and employment by district (2014)

District	Nr firms	% Firms	Employment	% Employment
Braga	9	13.8%	38	7.9%
Oporto	4	6.2%	69	14.4%
Aveiro	3	4.6%	18	3.8%
Coimbra	22	33.8%	129	27.0%
Lisbon	19	29.2%	194	40.6%
Setubal	1	1.5%	7	1.5%
Évora	2	3.1%	2	0.4%
Faro	1	1.5%	4	0.8%
Madeira	2	3.1%	11	2.3%
Azores	2	3.1%	6	1.3%
Total	65	100.0%	478	100.0%

Source: Computations made by the authors based on Amadeus dataset (Bureau Van Dijk), Sector 7211 Research and Development in Biotechnology.

4.3 Turnover

In 2014, in Portugal, the sector turnover was 30.5 million Euros, equal to 0.25% of the total of the sector in Europe, which was about four times the turnover in 2006. The average turnover by firm was 436 thousand Euros, much lower than the European average (5.166 million Euros). In the same line, the average turnover by employee was 28.1% of the European average (Table 4.3).

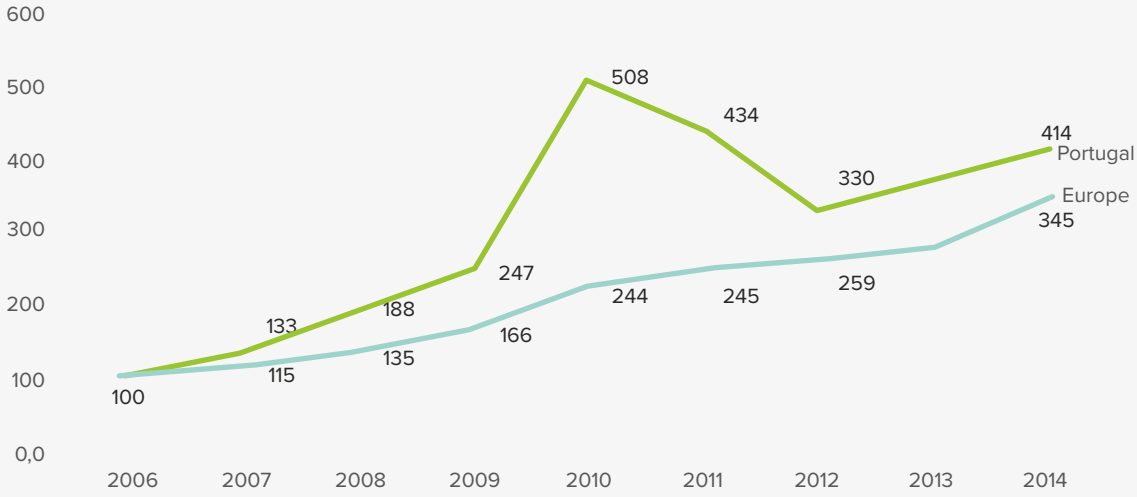
Table 4.3 – Turnover by firm and by employee

	2006	2007	2008	2009	2010	2011	2012	2013	2014
Turnover (million Euros)									
Europe (23) (A)	3,567.1	4,085.9	4,826.5	5,921.2	7,990.8	8,747.7	9,238.3	9,973.0	12,316.3
Portugal (B)	7.4	9.8	13.9	18.2	37.4	32.0	24.3	27.8	30.5
(B)/(A) X 100	0.21%	0.24%	0.29%	0.31%	0.47%	0.37%	0.26%	0.28%	0.25%
Average turnover by firm (thousand Euros)									
Europe (23) (A)	4,975.0	4,509.8	4,506.6	4,226.4	4,424.6	4,418.0	4,187.8	4,136.5	5,166.3
Portugal (23)	388.0	445.7	477.9	520.5	891.2	680.1	412.0	421.2	436.2
(B)/(A) X 100	7.8%	9.9%	10.6%	12.3%	20.1%	15.4%	9.8%	10.2%	8.4%
Average turnover by employee (thousand Euros)									
Europe (23) (A)	169.3	165.4	197.0	179.0	210.7	206.1	201.7	199.6	227.6
Portugal (B)	52.3	70.0	73.7	69.3	100.1	79.7	59.3	61.6	63.9
(B)/(A) X 100	30.9%	42.3%	37.4%	38.7%	47.5%	38.7%	29.4%	30.9%	28.1%

Source: Computations made by the authors based on Amadeus dataset (Bureau Van Dijk), Sector 7211 Research and Development in Biotechnology.

#04

Figure 4.4 – Trends in industry sales (2006=100)



Source: Computations made by the authors based on Amadeus dataset (Bureau Van Dijk), Sector 7211 Research and Development in Biotechnology.

4.4 Added value, returns on equity and equity ratio

The median added value by firm was 62 thousand Euros, in 2014, corresponding to 21,6% of the European median.

The median returns on equity, before taxes, for Portugal has been smaller than the one for Europe. The positive return of 5.5% in 2014 is noteworthy.

The firms' equity ratio has been about 30% for Portugal, much lower than the 50% observed in the other European countries (Table 4.4).

Table 4.4 - Added value, returns on equity and equity ratio

	2006	2007	2008	2009	2010	2011	2012	2013	2014
Added value by firm (median) (thousand euros)									
Europe (23) (A)	313.1	330.9	298.8	258.7	309.8	323.0	280.0	275.3	288.7
Portugal (B)	31.9	53.2	74.1	102.7	227.00	103.6	87.3	119.8	62.3
(B)/(A) X 100	10.2%	16.1%	24.8%	39.7%	73.3%	32.1%	31.2%	43.5%	21.6%
Returns on equity (ROE), before taxes (median) (%)									
Europe (23) (A)	12.4%	17.1%	13.0%	13.4%	12.7%	11.2%	10.0%	9.9%	10.0%
Portugal (23)	6.8%	-0.2%	-5.9%	0.1%	3.5%	0.0%	-0.3%	-2.2%	5.5%
Equity ratio (Equity / Assets) (median)									
Europe (23) (A))	41.9%	51.5%	52.2%	53.0%	51.4%	51.6%	53.4%	52.4%	54.3%
Portugal (B)	30.6%	38.5%	27.2%	27.8%	26.8%	35.2%	33.9%	28.4%	34.4%

Source: Computations made by the authors based on Amadeus dataset (Bureau Van Dijk), Sector 7211 Research and Development in Biotechnology.

#05

Employment:
volume, qualifications,
wages and types of contract

By aiming at characterizing the employment in the sector regarding qualifications and wages, a set of indicators is presented for two groups of firms, separately. Combining the Amadeus database with the information available in the **Quadros de Pessoal** dataset, there have been identified 49 firms in 2013 whose main activity sector is biotechnology. The number of firms increases to 74, when firms whose second sector of activity is the biotechnology are included as well. The indicators will be compared between the two groups, as well as, will be compared to the global economy.

The 49 firms, whose 7211 is the main activity with available information differs from the extended group. Its share capital is, on average, 460 thousand Euros, and only 5 firms have a share capital above 1 million Euros. The workers' average age is 34 and about 61% of them are female.

As shown by Table 5.1, the share of workers with higher education diplomas (Bachelor's or above) is 20 percentage points higher than the observed share for the extended group. The share is about 85% (that is, 5% own a Bachelor's degree, de 48% a Licentiate's degree, 18% have a Master's diploma and 14% have a PhD).

About 45% of the workers are in expert occupations, as well as in scientific and intellectual occupations; whereas 27% are intermediate level technicians .

Employees represent 89% of the workers. About 64% of them have a permanent contract. The majority works full time (about 98%, very close to 97%, the observed proportion for the extended group of firms).

The analysis of the gross wage distribution (Table 5.2) shows up an average monthly wage of 1558 euros. Half of the workers earn no more than 1267 euros, and only 10% of the workers earn more than 2483 euros. The average hourly wage is 9.2 euros. About half of the workers earn more than 7.3 euros per hour.

Table 5.1 – Employees distribution by education level (%), 2013

	Sector 7211	Extended Bio Sector	National private sector
Below primary education	0.0%	0.3%	0.7%
Lower secondary education	3.0%	22.1%	56.1%
Upper secondary education	10.9%	12.3%	24.4%
Tertiary no higher education	1.2%	0.7%	0.5%
Bachelor	4.7%	3.9%	1.9%
Licentiate	47.9%	37.9%	14.9%
Master	18.0%	13.5%	1.3%
Ph.D.	14.3%	9.3%	0.2%

Source: Computations made by the authors based on Quadros de Pessoal dataset.

There are 679 of workers in the extended group of firms, which employ 9 workers, on average. The small firm size is evident, as 50% of the firms employ at most 3 workers and only in 10% of them there are more than 25 workers. The share capital of the firms in this group is, on average, 357 thousand Euros, although half of them have a share capital below 50 thousand Euros. The sales of those firms are about 590 thousand Euros; only 10% show up sales above 900 thousand Euros. The workers' average age is 36 years old and 90% of them are blow the age of 50. Female workers represent 56% of the workforce, and men are on average 2 years older than women.

About 65% of the workers have at least the Bachelor's degree (see Table 5.1, column 1). Namely, 9% of them have a Ph.D., 14% holds a Master diploma, 38% have a Licentiate's degree and 4% completed a Master's programme.

An important share of workers has expert occupations (about 34%) and intellectual and scientific occupations. Furthermore, 22% of them are intermediate level technicians.

The majority of workers are employees (92%) and two third of which have a permanent contract.

On average, the workers have been for 5 years in the firm, and 25% have been in the same firm for at least 6 years.

#05

Workers earn an average net wage of 1422 Euros (base wage plus regular and non-regular payments). It is noteworthy that about 50% of the workers earn less than 1192 Euros, whereas the share of those earning more than 2400 Euros is 10%. The hourly gross wage is, on average, 8.4 Euros/hour, which hides differences along the distribution. Namely, 50% of the workers earn at most 6.9 Euros/hour and only 10% earn a hourly wage above 14 Euros. The wage distribution for permanent contract workers is similar: half of them receive more than 1198 Euros, and about 6.9 Euros/hour.

Table 5.2 – Gross wage distribution (€), 2013

	Sector 7211		Extended Bio Sector		National private sector	
	Monthly wage	Hourly wage	Monthly wage	Hourly wage	Monthly wage	Hourly wage
Average	1558.2	9.2	1421.7	8.4	1157.3	7.1
Standard-error	959.7	6.3	1072.0	6.6	1558.9	9.7
10th percentile	822.2	4.8	662.6	4.0	520.0	3.2
50th percentile	1266.7	7.3	1191.5	6.9	813.9	4.9
90th percentile	2483.1	14.5	2408.0	14.1	2110.1	13.1
95th percentile	3141.9	18.8	2955.2	17.1	2902.3	18.1

Source: Computations made by the authors based on Quadros de Pessoal dataset.

When looking at the Portuguese aggregate private sector, some interesting indicators emerge. On average, workers are 40 years old; and only 10% are 56 or above. Women represent 53% of the labour force, which should be compared to the 56% in the biotechnology sector. About 72% of the employees have permanent contracts, a proportion that is higher than the one found in the biotechnology sector (65%).

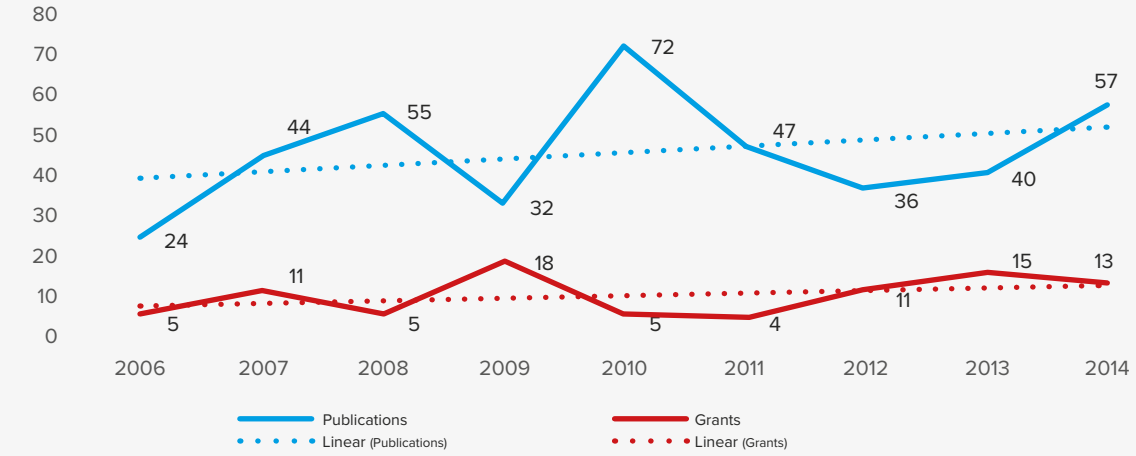
The sector 7211 has better position regarding the workers education, when compared to the aggregate private sector, in which only 18% of the working force has higher education diplomas (Bachelor's or higher degree diplomas). Almost all of these hold a Licentiate's degree, workers with a Master's or a Ph.D. diploma are in very small number (almost zero).

Regarding gross wages, the average of 1157 Euros, observed in the aggregate private sector, is clearly below its equivalent for the biotechnology sector. Half of the workers earn a monthly wage of, at most, 814 Euros, and only 10% of the workers earn wages above 2110 Euros. Such differences show up in the hourly wage as well. The hourly wage is, on average, 7.1 Euros, more than 2 Euros less that the average hourly wage in the biotechnology sector. Such difference is possibly related with the already referred differences in the average education, which is a main determinant of the wage level.

#06
Patents in biotechnology

According to the data provided by WIPO, the patent publications in the biotechnology area, filled by Portuguese applicants, more than doubled in 2014 relative to 2006. The last three years show a growth trend. The patent grants also show this increasing trend within the reference period, although in 2014 the number was lower than the previous year (Figure 6.1).

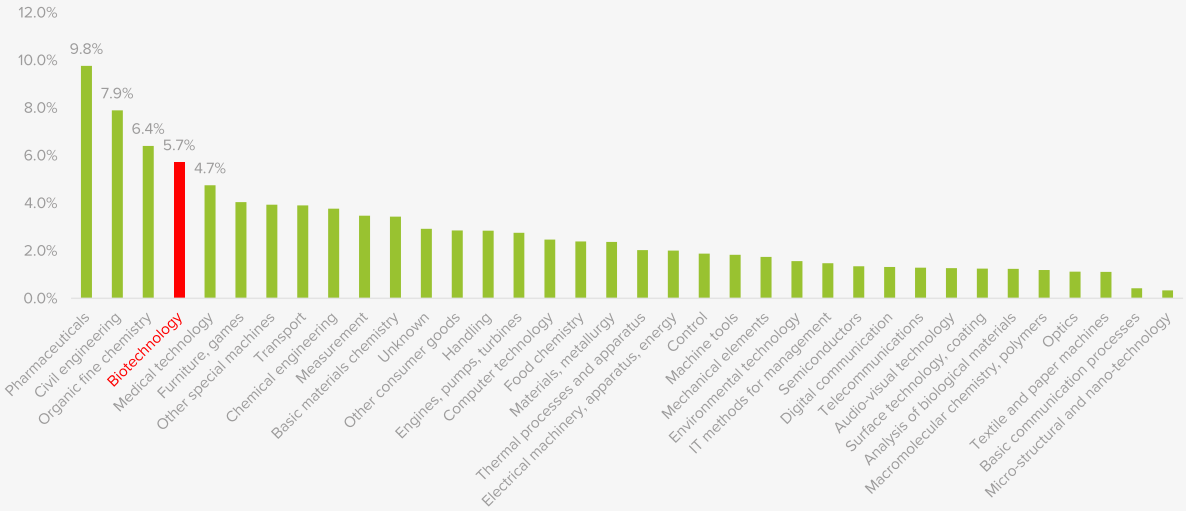
Figure 6.1. Portuguese biotechnology patent publications and grants (2006-2014)



In Portugal, the total number of patent publications pertaining to the 35 existing technology domains, within the reference period of 2006 - 2014, was of 7,125. The biotechnology accounts for 407, representing 5.7% of the total publications. This value puts biotechnology in the fourth place among 35 technology classifications, i.e., in the top third of the distribution (Figure 6.2).

In 2014 the share of biotechnology patents in the total Portuguese patents publications was higher than the average of the period (6.5%) and higher than the three previous years. This was the third highest value in an eight-year timespan.

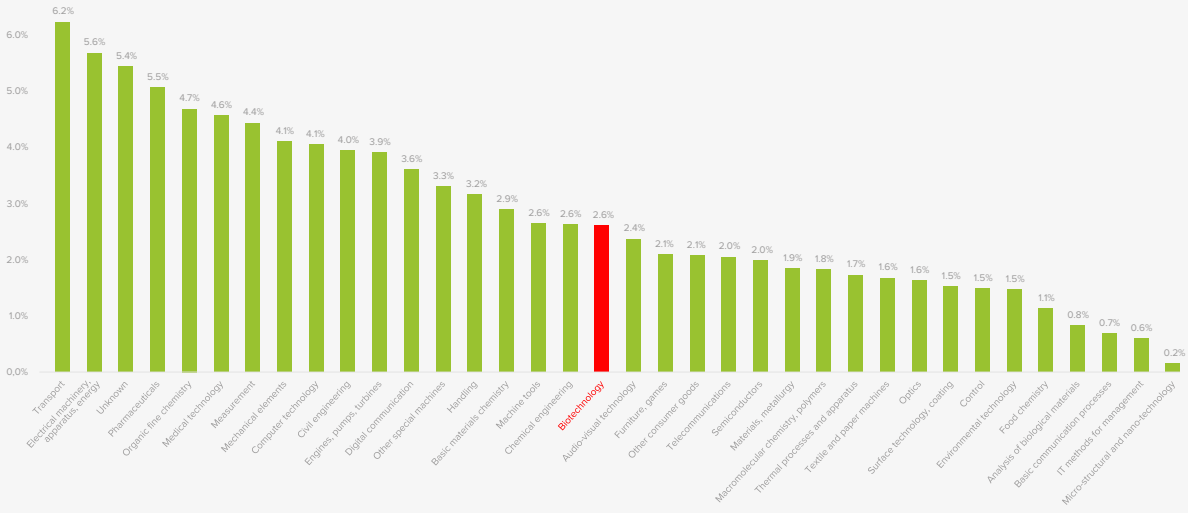
Figure 6,2, Relative distribution of the total Portuguese patent publications in the period 2006-2014 by technology



The relative weight of biotechnology patents has a greater expression in Portugal than in the European Union. The total number of patent publications in the UE28 in the 2006-2014 period was of 4,026,198. Biotechnology contributes with 105,148 for the total number, representing 2.6% and ranks 18th in the list (Figure 6.3).

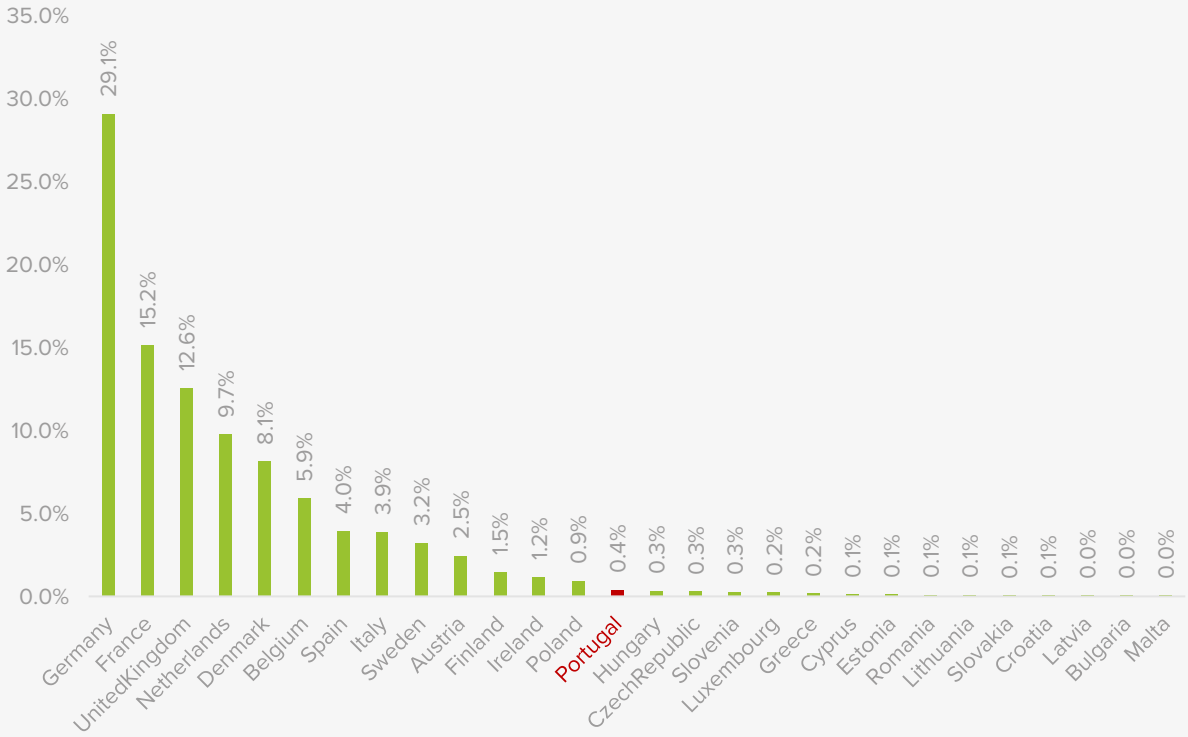
#06

Figure 6.3. Relative distribution of the total UE28 patent publications in the period 2006-2014 by technology



Germany, France and the United Kingdom are the top three countries regarding biotechnology patent publications, summing together more than half (56.8%) of the total biotechnology patents in 28 European countries. Portugal stands in the 14th position of the list, contributing with 0.39% of the total biotechnology patent publications in the European Union (Figure 6.4.).

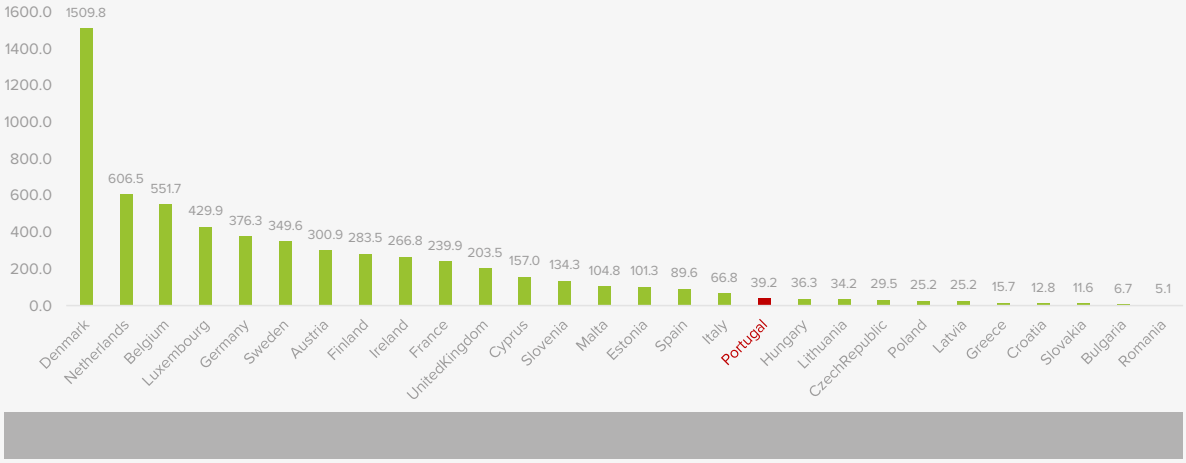
Figure 6.4. Percentage of biotechnology patent publications by UE28 country



Fonte: Cálculos próprios a partir da base de dados WIPO

When we take into account the country dimension, dividing the total number of patent publications by population size, although Portugal lowers its position to the 18th place, other small countries such as Denmark, Netherlands, Belgium and Luxembourg get ahead the leaders in absolute numbers (Figure 6.5).

Figure 6.5. Biotechnology patent publications by country in the period 2006-2014 per million inhabitants (2015 population)



#07
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#08

Appendix

Database selection as source for patents statistics

Statistics on patents reflect the country inventive capacity in different areas, providing a good measure of technology output (Haščič, Silva and Johnstone, 2015). However, due to legal rules in the patent application process, the information on patent activity is often outdated. Some specific publications both from OECD (Dernis, 2007) and the European Commission (2010) address this concern, noting that information on patents is generally publicly disclosed only 18 months after the priority date. This delay can be longer for certain patent offices and in the case of international filings. The European patents filled under the PCT procedure (Patent Cooperation Treaty) at the international phase are not included in the count, being only counted as applications to EPO (European Patent Office) when they enter the regional/national phase which can take from 19 to 31 months. Such delay weakens the timeliness of the patent indicators. Additionally, different databases can use different criteria to count the patents and present the data. The reference date, alone, can lead to differences in the indicators results. For instance, different dates can be used to determine the yearly count: the priority date refers to the first date of filing of a patent application, anywhere in the world; the application date is the date of filing of the application at the patent office, which can occur within a minimum of 12 months after the priority; the publication date is when the patent information is disclosed to the public and can distance about 18 months from the priority; the date of grant, depending on the patent office, can take 3 to 10 years (Dernis, 2007). Because priority date is the closest to the invention date, it is generally used to measure technology outputs. However, not every database offers this information, in which case, the application date or the date of grant must be used.

For the present report, three databases were explored: PATSTAT (EPO's Worldwide Patent Statistical Database); OECD and WIPO (World Intellectual Property Organization).

PATSTAT is a worldwide biannually updated database, created by the EPO that offers patent data from leading industrialised and developing countries, covering nearly 100 million patent documents from more than 90 authorities worldwide. PATSTAT is one of the most widely used and is becoming a standard among patent databases (Kang & Tarasconi, 2016).

PATSTAT was created upon request by the Patent Statistics Task Force, leaded by OECD and having WIPO; EPO; JPO (Japanese Patent Office); KIPO (Korean Intellectual Property Office); USPTO (United States Patent and Trademark Office); USNSF (United States National Science Foundation) and the European Commission as members.

OECD database covers data on patents applied to the EPO, the USPTO (US Patent and Trademark Office), patent applications under the PCT and Triadic patent families (Patents filled together at EPO; USPTO and JPO). According to the online site for the OECD patent databases, data derives mainly from the latest version of the PATSTAT.

WIPO IP database grants access to WIPO's statistical data on intellectual property (IP) activity worldwide. The data derives from: a set of questionnaires sent each year to all IP offices worldwide; a compilation made by WIPO during the application process of international filings through the PCT, the Madrid System and The Hague System; and from the PATSTAT database.

Due to PATSTAT public access restrictions, and given the fact that both OECD and WIPO databases include data from PATSTAT, these two sources were considered. The number of patents granted to Portuguese inventors with the biotechnology classifications was compared between the two databases for the reference period of 2006 – latest year available, showing discrepancies related to the lack of harmonization of data collection and presentation, as previously discussed (Table 8.1).

Table 8.1. Number of Portuguese biotechnology patents grants according to OECD and WIPO databases

Data Base	Search Criteria	2006	2007	2008	2009	2010	2011	2012	2013	2014
OECD	Patents grants by the USPTO; EPO and triadic patent family by technology by applicant(s)' country of residence (PT)*	7.7	10.1	6.6	5	5.9	6.8	2.2		
WIPO	Patent grants by technology by applicant(s) origin (PT)	5	11	5	18	5	4	11	15	13

*Fractional counts applied for patents with multiple inventors/applicants

#08

The **WIPO** database was selected to collect the data, due to two main reasons: a) first, it collects information from different data sources, including the main source used by OECD, increasing the odds of the data being validated; b) offers more recent data. In the case of OECD, as data derives mainly from PATSTAT database, which is only biannually updated, it can lead in delays in data availability.

The main indicator used was **patent publications**, which refers to the number of patent applications in the moment they are publically disclosed. This date can distance up to 18 months from the application date/priority date. Patent publications are not patent grants. The total count by applicant's origin was used, considering the concept of equivalent count.

Taking into account that the data can show substantial discrepancies between sources, due to different data processing approaches, **the most important information to retain from the data presented in this report should not be the absolute numbers, but both the temporal trends and the relative comparisons.**

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