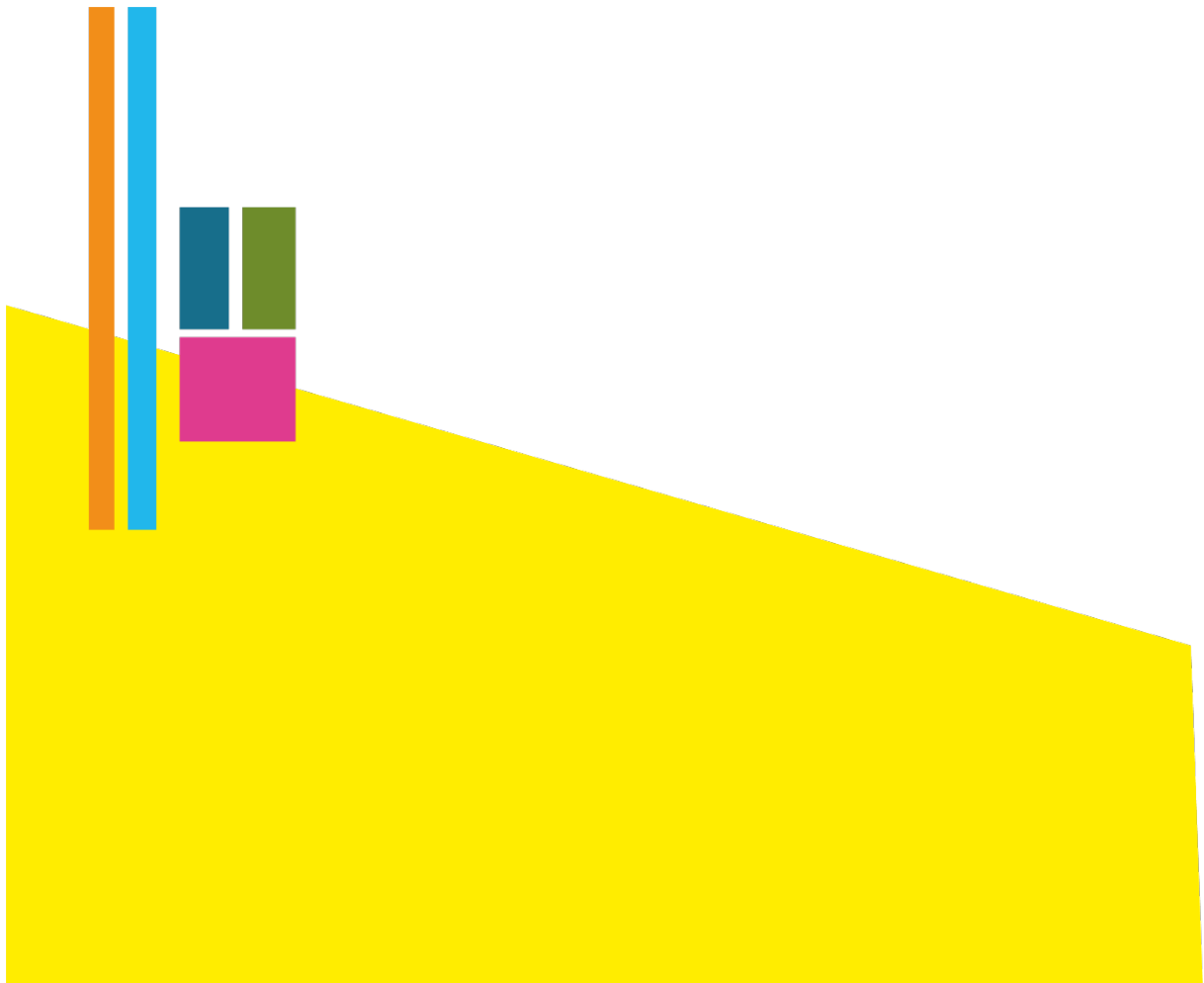


Chapter 5 STI productivity or STI output?



1 – Introduction

Patent statistics and publication statistics provide important indicators for measuring R&D output. Long time series are available and the data allow cross-country comparison. This section looks more closely at the role of publications and patents (applications and grants) as an output of R&D expenditure.

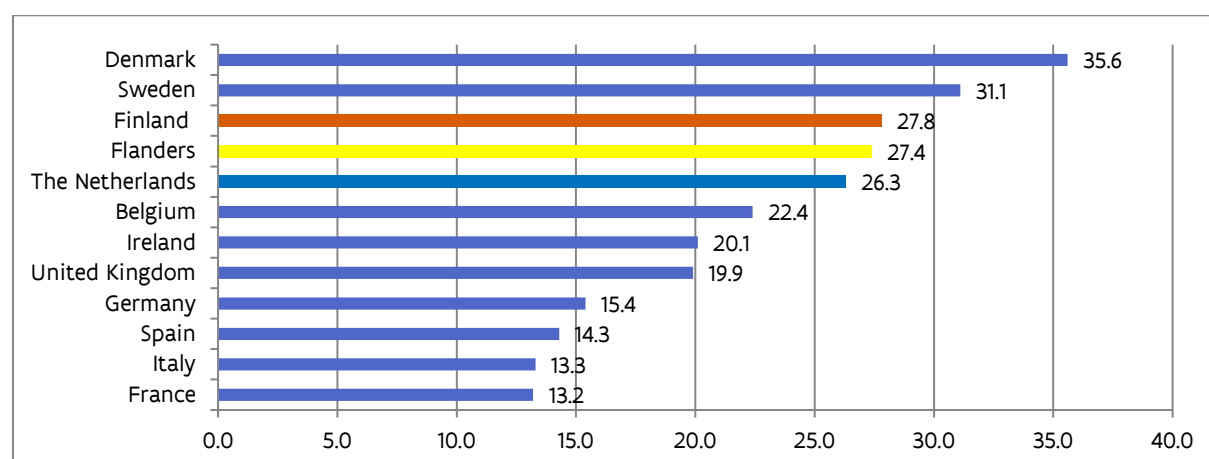
2 – Scientific publications

Scientific publications are an important instrument for measuring the visibility of research output. This analysis is based on the major bibliographic information of ISI-Thomson Scientific; namely, the Science Citation Index (scientific journals) and the Proceeding Database (conference proceedings). The Flemish output of scientific publications has increased significantly in recent years. In 2015, there were 27.4 publications per 10,000 inhabitants, whereas there were only 18.0 publications per 10,000 inhabitants in 2007. Flanders now ranks in fourth position in Europe after Denmark, Sweden and Finland.

Table 10: Evolution of the publication output per 10,000 inhabitants for Flanders (2007-2015)

	2007	2008	2009	2010	2011	2012	2013	2014	2015
only scientific journals	15.7	18.0	18.2	18.6	20.1	21.9	22.4	24.1	24.7
scientific journals and proceedings	18.0	20.7	20.0	20.7	22.0	24.4	25.3	26.0	27.4

Figure 30: International comparison of the publication output per 10,000 inhabitants (2015)



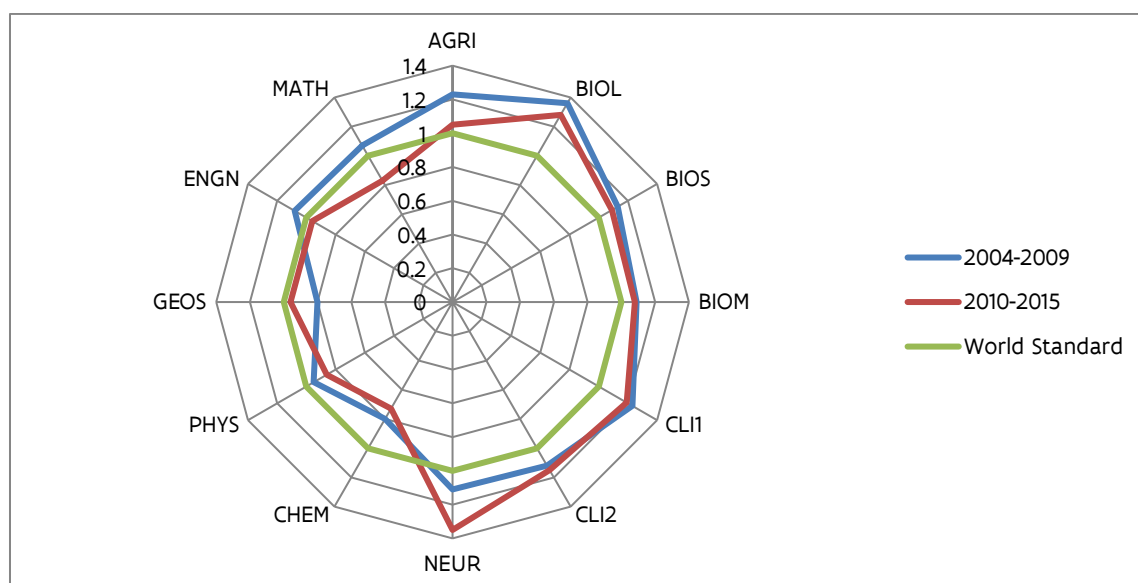
The share of Flemish publications in the total figure for Belgium showed since 2000 an upward trend and now fluctuates about 73% for the most recent years. The Flemish share (journal articles only, all S&T fields) of the world total of scientific publications increased from 0.93% in 2006 to 1.05% in 2015 (an increase of about 13%). In the past ten years, the share for France, Germany and the UK in the global amount of publications started to decline and the share for Finland and Sweden rather stayed stable. Belgium, the Netherlands, Ireland, Denmark, Italy and Spain increased their share. However, the most important new player is China. In 2002, China's share of world publication output was roughly equivalent to that of Italy (about 5%). China passed France in 2004 and Germany and Great Britain in 2006. By 2015, the Chinese share had already risen to 18.3%.

All publication output for the period 2010 to 2015 can be broken down into publications by different types of organizations. The share of higher education (universities and university colleges) in the total number of Flemish scientific publications amounted to more than 88%. Over 12% of all Flemish SCIE documents were

published by employees from public research institutes or civil servants. Private institutions and hospitals (apart from university hospitals) were responsible respectively for 6.5% and about 4% of the total. The share of the research institutes has continued to increase slightly in recent years.

The scientific specialization profile for Flanders for the period 2004 to 2015 is a typical example of the classic “Western” pattern, with life sciences and medical sciences as the dominant publications areas. Nevertheless, some other evolutions within this overall pattern are worth noting. For example, there was a sharp growth in Flanders between 2010 and 2015 in the fields of neuroscience (NEUR) and earth and space sciences (GEOS). The Flemish publication profile also shows that Flemish output is significantly above the world standard in terms of biology (BIOL), biomedical research (BIOM), life sciences (BIOS), clinical and experimental medicine I (CLI1), experimental medicine ii (non-internal) (CLI2) and neurosciences (NEUR); and below the world standard in chemistry (CHEM), physics (PHYS) and mathematics (MATH) for the second period (2010-2015).

Figure 31: The scientific publication profile of Flanders in 2004-2009 and 2010-2015 based on the Activity Index (AI)



AGRI = Agronomy and Environmental Sciences
 BIOL = Biology (at the organism and the supra-organism level)
 BIOS = Life Sciences (general, cellular and subcellular biology, genetics)
 BIOM = Biomedical Research
 CLI1 = Clinical and Experimental Medicine (general and internal medicine)
 CLI2 = Experimental Medicine II (non-internal)
 NEURO = Neurosciences
 CHEM = Chemistry
 PHYS = Physics
 GEOS = Earth and Space Sciences
 ENGN = Engineering
 MATH = Mathematics

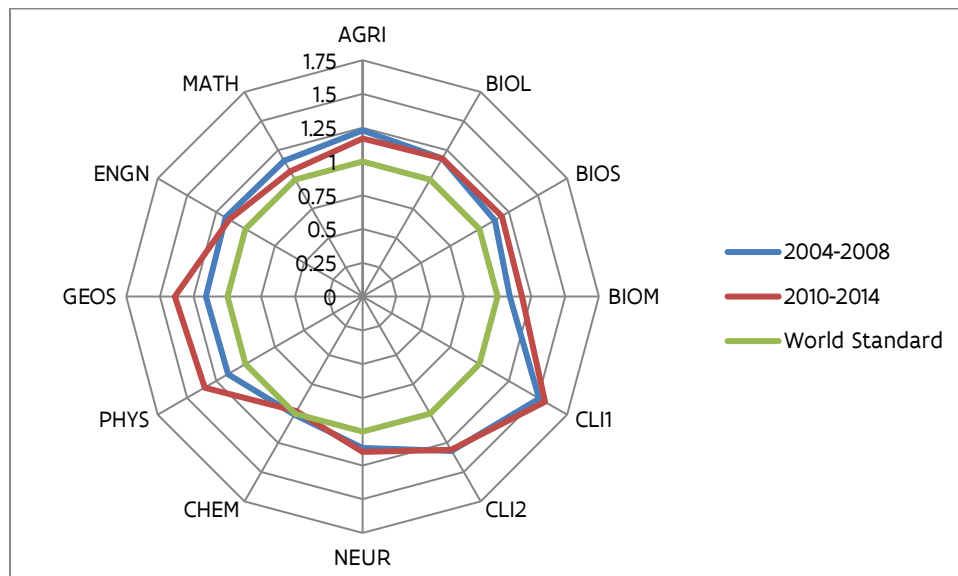
3 - Citations

Citations analysis reflects the impact made by the research output of the scientific community and can also be used for measuring the quality of that output. Compared to other European countries and based on the results for the different periods covered in the citation map (2004-2008 and 2010-2014), Flanders is part of the leading group with Sweden, Denmark, the United Kingdom and the Netherlands.

The results of the two periods show that, in terms of relative citation frequency, Flanders is above or at least equal to the world standard in all fields of science. In particular, a very high score can be noted for the life sciences. The indicator value for chemistry (CHEM) is the lowest, but still almost represents the

neutral value of 1.0 in comparison with the world standard. The relative citation scores for clinical research (CLI1 and CLI2) are higher than for the natural sciences. Also noteworthy is the increased impact in physics (PHYS) and earth and space sciences (GEOS) and the decreased impact in agriculture (AGRI) and mathematics (MATH).

Figure 32: The scientific citation profile of Flanders from 2004–2008 and 2010–2014 based on the Activity Index (AI)



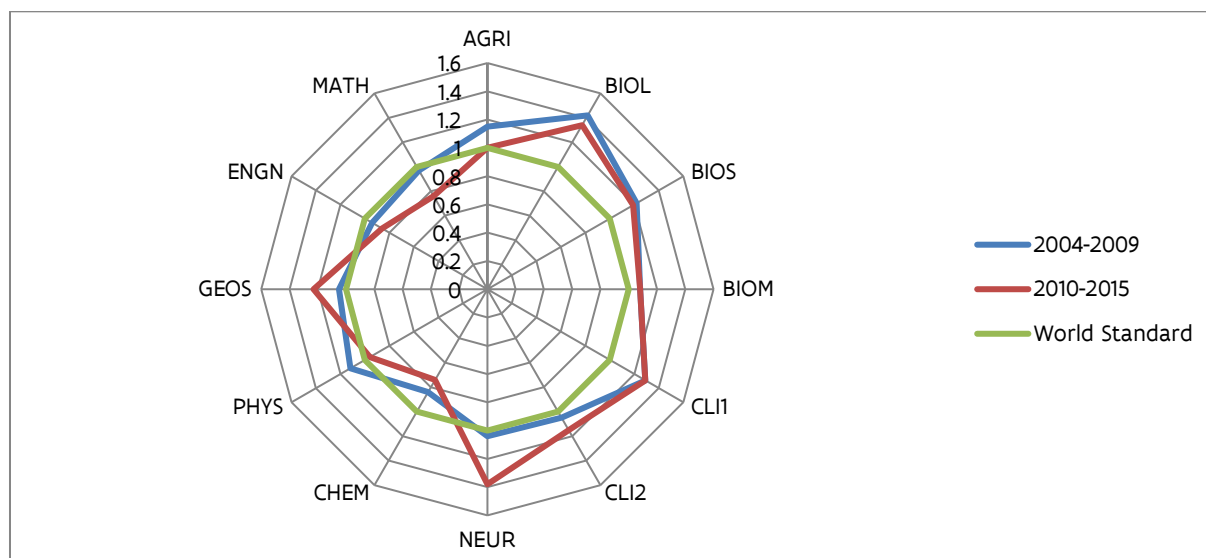
4 – Co-publications

Flemish scientific publications are increasingly the result of close international cooperation. In 2015, almost 66.5% of the publications were written with at least one foreign co-author. Flanders occupies a leading position with Sweden (64.4%) and Denmark (64.1%) in the ranking of countries involved in co-authorship (2015). An analysis of the major co-publication links for Flanders for the period 2010–2015 reveal strong cooperation links with the Netherlands and medium co-publication links with Germany, UK, France, Denmark, Austria, Italy, Greece, Switzerland, Hungary, Sweden, Spain and the United States. Other (but weaker) co-publication links can be found for most of the other EU-28 countries and other countries like Norway, Russia, Turkey, Canada, Australia, New Zealand, Brazil, Mexico,

The relatively important link with some African countries (for example, the Democratic Republic of Congo) can partly be explained on historical grounds, but also other important cooperation with Africa (Kenya, Tanzania, Egypt, South Africa) can also be noticed.

A comparison between the profile of the international co-publications of Flanders with the profile of all publications shows a clear polarization in favour of the biosciences (BIOL and BIOS) and CLI1. In the second period (2010–2015), the profile for Flanders for co-publications moved slightly over the world standard in the neuro- and behavioural sciences (NEUR), non-internal medicine (CLI2) and the earth and space sciences (GEOS). On the other hand, the co-publication activity in chemistry, physics, technical sciences and mathematics decreased.

Figure 33: The scientific co-publication profile of Flanders from 2004-2009 and 2010-2015 based on the Activity Index (AI)



5 – Social sciences & humanities

The growing importance of publications in the innovation chain and in the distribution of research funds to universities has become evident in recent years. Studies also show that the Web of Science (WoS) does not fully represent the research efforts being made in the social sciences and the humanities. The Flemish Government also wants to map the publications that are not included in the WoS. Consequently, a group of experts was charged to collect both groups in a database, called the “Vlaams Academisch Bibliografisch bestand” (VABB) for the socio-economic sciences and humanities (SSH).

At the present time, VABB-SSH lists 78,647 publications published between 2000 and 2015, of which just 34,414 were found in the WoS (under the categorizations SCIE, SSCI, AHCI and the proceedings for CPCI-S & CPCI-SSH). The other 44,233 contained 27,796 articles in journals, 1,200 books (author), 2,058 books (editor), 11,799 chapters in books and 1,380 proceedings. Analysed by discipline (period 2000-2015), economics has the greatest share (14.5%), followed by law (14.4%), social health sciences (14.2%) and psychology (10.6%).

6 – Patents

Patents are intended to grant innovators a temporary monopoly to exploit their innovative efforts. Patent information also helps to map technological progress and assess the degree of innovation within a particular organization or region. The total number of patents for Flanders, as well as for the other reference countries, has increased in recent years.

Between 1980 and 2012, 46,775 EPO patent applications with a Belgian inventor and/or applicant were made and, at the moment when the analysis was made, 22,471 or 48% had been effectively assigned. For Flanders, 31,640 patents applications were filed during the same period and 15,471 (51%) were assigned 49%. These proportions are roughly equal to those for the following reference countries: Germany, UK, USA, the Netherlands, France, Sweden and Finland.

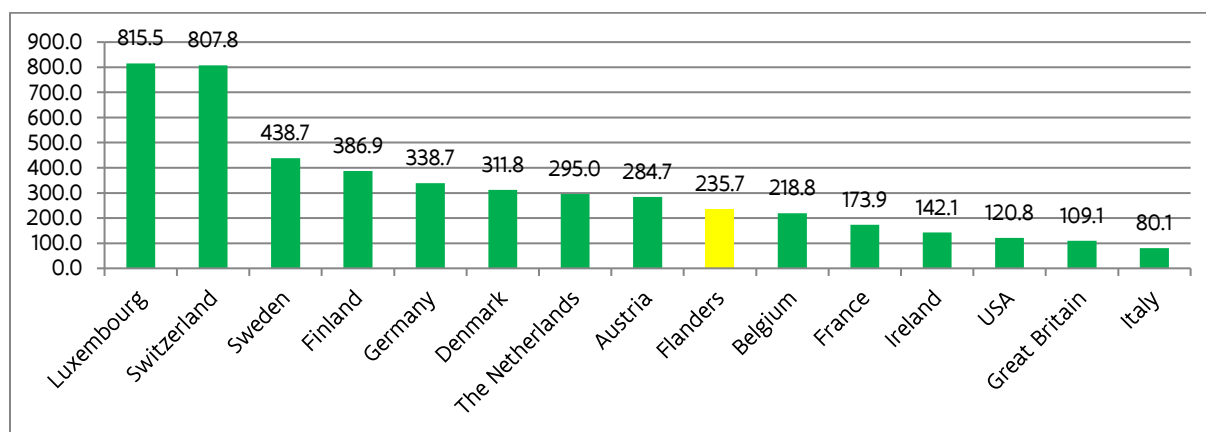
An international comparison (2012) of the number of patents by origin (EPO applications) indicates that Flanders is located in the group of followers (ninth position), with 235.7 patents per million of population,

(origin based on inventor and/or applicant address). This ranking is led by Luxembourg¹, Switzerland Sweden and Finland. Flanders is ranked after Austria (eighth) and before Belgium (tenth). From an international perspective, this is quite a good result for Flanders and Belgium, bearing in mind that all the reference countries together represent about 95% of total patent activities.

Table 11: Evolution of EPO patent applications for Flanders per million of population by origin, inventor and/or applicant (2005-2013)

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Flanders	272.7	275.7	279.4	270.2	233.5	230.3	236.3	235.7	223.9

Figure 34: nternational comparison of EPO patent applications per million of population by origin, inventor and/or applicant (2012)



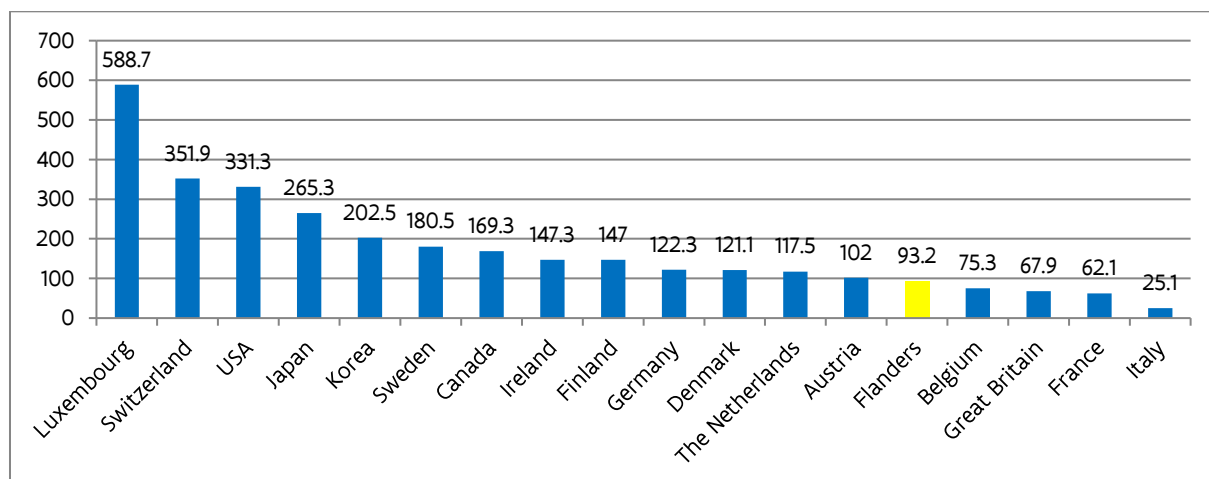
Based on patents granted under the USPTO system, Belgium and Flanders occupy respectively fifteenth and fourteenth place. The leaders here are Luxembourg¹, Switzerland, the USA, and Japan.

Table 12: Evolution of USPTO patent grants for Flanders per million of population by origin, inventor and/or applicant (2005-2012)

	2005	2006	2007	2008	2009	2010	2011	2012
Flanders	185.3	176.8	157.9	156.3	143.7	136.9	119.7	93.2

¹ It should be noted that Luxembourg is characterised by a population of less than 0.5 million inhabitants. The indicator patents / million inhabitants hence implies a multiplication of the absolute volumes with a factor approximating 2, which is not the case for any of the other reference countries. In absolute terms therefore, the numbers for Luxembourg are lower than what the figure suggests.

Figure 35: International comparison of USPTO patent grants per million of population by origin, inventor and/or applicant (2012)

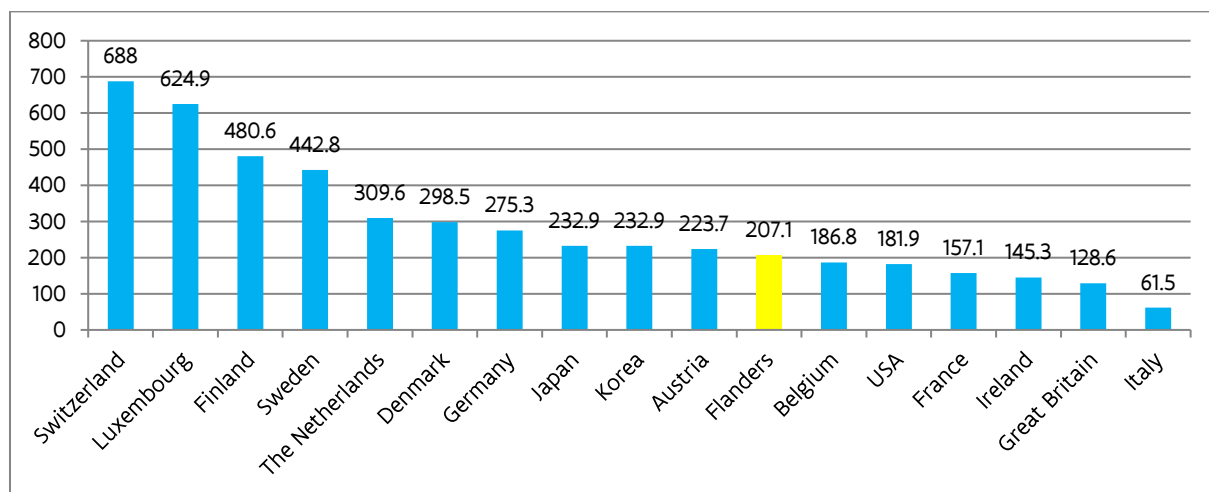


Flanders occupies the eleventh place in the ranking of PCT applications, with Belgium in twelfth position. This list is headed by Switzerland, Luxembourg¹, Finland, Sweden and the Netherlands.

Table 13: Evolution of PCT patent applications for Flanders per million of population by origin, inventor and/or applicant (2005-2012)

	2005	2006	2007	2008	2009	2010	2011	2012
Flanders	179.9	192.5	205.8	214.9	189.1	192.9	197.6	207.1

Figure 36: International comparison of PCT patent applications per million of population by origin, inventor and/or applicant (2012)



A breakdown in organisational types reveals that companies are particularly active in applying for patents (84% of patents are held by companies). The most important applicants (companies) for Flanders are Agfa-Gevaert, Total Petrochemicals/Total Research & Technology (Feluy), Janssen Pharmaceutica, Electrolux Home Products Corporation, CNH (Case New Holland) Belgium and Solvay. In addition, public research centres (Imec, VIB,...) and universities are increasingly active as patent applicants (owning 10% of patents). An international comparison shows that this 10% rate is very high.

In 35% of all EPO-patent applications with a Flemish inventor, foreign applicants are involved (measured over the last ten years). It concerns mainly applicants from the United States (34%), Germany and France (both 17%). International inventor collaboration can further be illustrated by considering patents with at least one Flemish inventor and one foreign inventor (international co-inventions). This is the case for 43%

of Flemish patents. International co-applicants (at least one Flemish applicant and at least one foreign applicant) represent 57% of all Flemish patents.

A regional European patent map (version 2017) divided 276 European regions at the NUTS2 level. The European top-five (based on applicants addresses) are: Nordwestschweiz (CH), Oberbayern (DE), Inner London – West (UK), Helsinki-Uusimaa (FI) and Stuttgart (DE) . For Flanders, Vlaams-Brabant occupies position 42 in this ranking, with West-Vlaanderen at 49, Oost-Vlaanderen at 76, Antwerpen at 79 and Limburg at 96. When considering inventor addresses, the top-five are Nordwestschweiz (CH), Voralberg (AT), Karlsruhe (DE), Mittelfranken (DE) and Stuttgart (DE). The Flemish provinces are ranked at 22 (Vlaams-Brabant), at 58 (Oost-Vlaanderen), at 62 (Antwerpen), at 86 (West-Vlaanderen) and at 87 (Limburg).

The regional patent map for Flanders (version 2017)) allocates patents to the departmental level. Based on inventor addresses, the top-five are Leuven, Gent, Halle-Vilvoorde, Kortrijk and Tielt.. For applicant addresses, the top-five is composed of Leuven, Brugge, Kortrijk, Gent and Tielt.