

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.

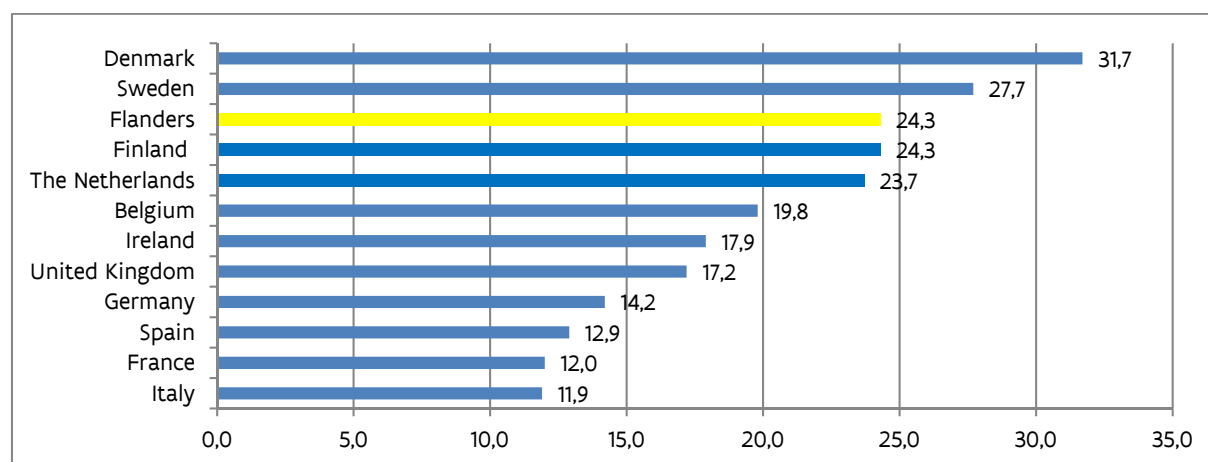
2 Scientific publications

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 2014, there were 24.3 publications per 10,000 inhabitants, whereas there were only 14.2 publications per 10,000 inhabitants in 2003. Flanders now ranks in thirteenth position in Europe together with Finland after Denmark and Sweden.

Table 8: Evolution of the publication output per 10,000 inhabitants for Flanders (2006-2014)

	2006	2007	2008	2009	2010	2011	2012	2013	2014
only scientific journals	14,7	15,2	17,1	17,3	17,8	19,3	20,0	20,3	22,5
scientific journals and proceedings	16,4	17,4	19,9	19,1	19,7	20,9	22,3	22,3	24,3

Figure 30: International comparison of the publication output per 10,000 inhabitants (2014)



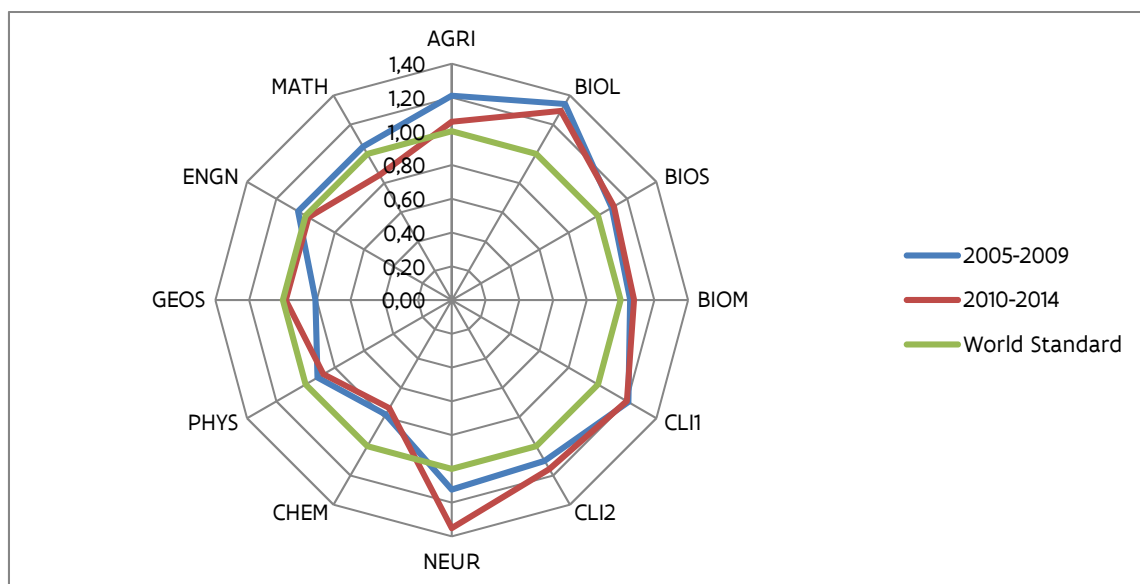
The share of Flemish publications in the total figure for Belgium shows an upward trend from 66% in 2002 to approximately 73% in 2014. The Flemish share (journal articles only, all S&T fields) of the world total of scientific publications increased from 0.86% in 2002 to 0.99% in 2013 (an increase of almost 18%). In the past ten years, the share of most European countries in the global total started to decline for France, Germany, Sweden, the UK, and Finland. 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 4.89%). China passed France in 2004 and Germany and Great Britain in 2006. By 2013, the Chinese share had already risen to 15.87%.

All publication output for the period 2008 to 2013 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 87%. Over 11% 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 around 7% 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 2005 to 2014 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 2014 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), 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 (2010-2014).

Figure 31: The scientific publication profile of Flanders in 2005-2009 and 2010-2014 based on the Activity Index (AI)



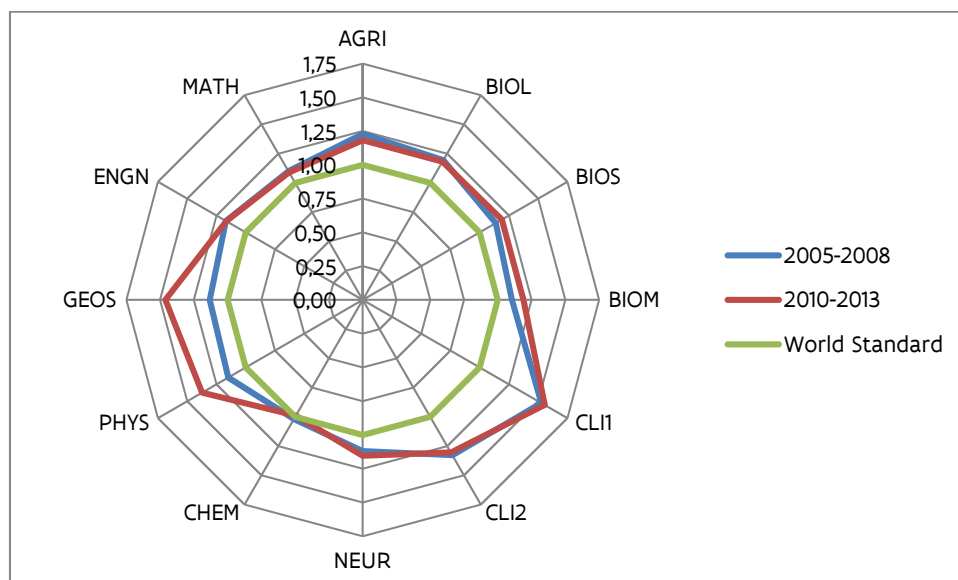
- AGRI = Agronomy and Environmental Sciences
- BIOL = Biology (at the organism and the supra-organism level)
- BIOS = Life Sciences (general, cellular and subcellular biology, genetics)
- BIOM = Biomedical Research
- CLI1 = Clinical and Experimental Medicine (general and internal medicine)
- CLI2 = Experimental 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 (2005-2008 and 2010-2013), 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 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).

Figure 32: The scientific citation profile of Flanders from 2005-2008 and 2010-2013 based on the Activity Index (AI)



4 Co-publications

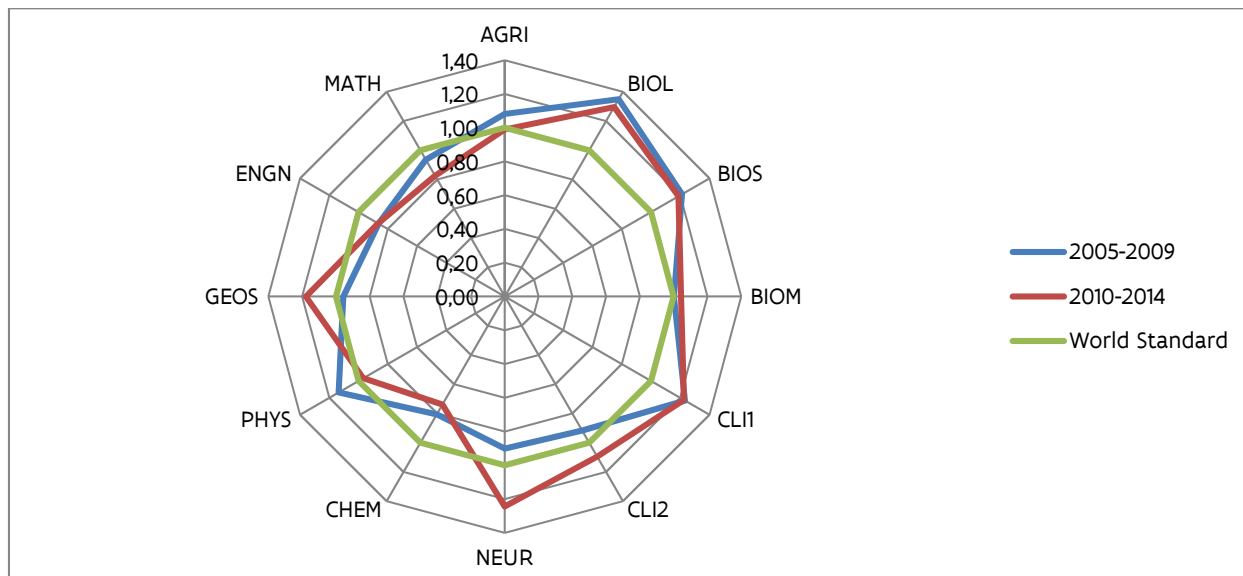
Flemish scientific publications are increasingly the result of close international cooperation. In 2014, almost 66.8% of the publications were written with at least one foreign co-author. Flanders occupies a leading position with Denmark (62.7%) and Sweden (62.4%) in the ranking of countries involved in co-authorship (2013). An analysis of the major co-publication links for Flanders for the period 2008-2013 reveal strong cooperation links with the Netherlands and medium co-publication links with Germany, UK, France, Switzerland, Hungary, Sweden, Spain, Austria and the United States. Other (but weaker co-publication links) can be found for most of the other EU-28 countries, with some African countries and other countries like Canada, Australia, New Zealand, Vietnam, Armenia, Georgia,...).

The relatively important link with some African countries (for example, the Democratic Republic of Congo) can partly be explained on historical grounds, although in general cooperation with Africa is still rather limited.

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 CL11. In the second

period (2005-2009), 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, technical sciences and mathematics decreased.

Figure 33: The scientific co-publication profile of Flanders from 2005-2009 and 2010-2014 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 49,833 publications published between 2000 and 2012, of which just 20,034 were found in the WoS (under the categorizations SCIE, SSCI, AHCI and the proceedings for CPCI-S & CPCI-SSH). The other 29,799 contained 19,966 articles in magazines, 760 books (author), 1,312 books (editor), 6,956 chapters in books and 805 proceedings. Analysed by discipline (period 2000-2011), economics has the greatest share (14.0%), followed by law (13.8%), social health sciences (10.3%) and psychology (9.8%).

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 those for the other reference countries, has increased in recent years.

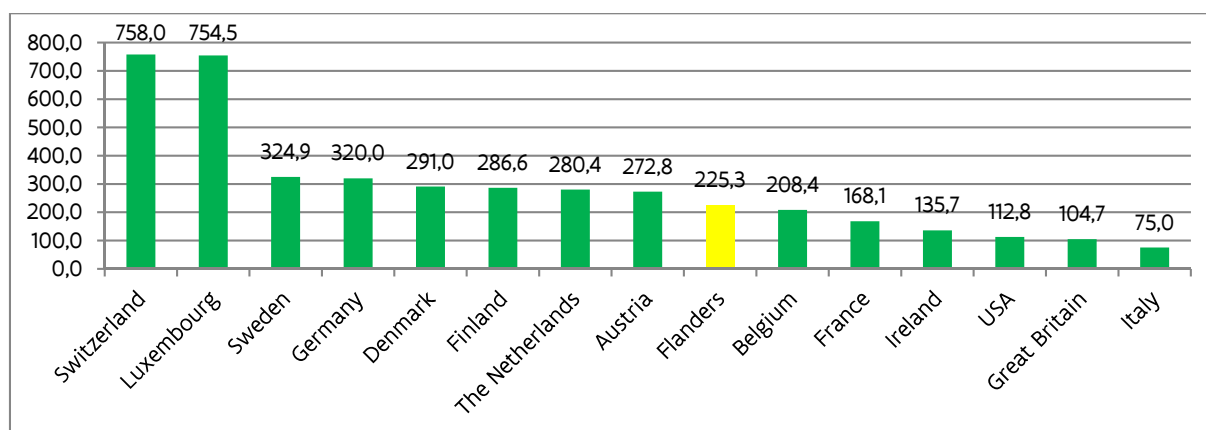
Between 1980 and 2012, 41,765 EPO patent applications with a Belgian inventor and/or applicant were made and, at the moment when the analysis was made, 19,129 or 46% had been effectively assigned. For Flanders, 28,319 patents applications were made during the same period and 13,257 (51%) were assigned 47%. 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 patents) indicates that Flanders is located in the group of followers (ninth position), with 225.3 patents per million of population, by origin, inventor and/or applicant. This ranking is led by Switzerland, Luxembourg, Sweden and Germany. Flanders is after Austria (eighth) and before Belgium (tenth). Viewed in international terms, 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 9: Evolution of EPO patent applications for Flanders per million of population by origin, inventor and/or applicant (2004-2012)

	2004	2005	2006	2007	2008	2009	2010	2011	2012
Flanders	231,4	272,5	274,7	280,3	270,7	232,4	227,4	233,8	225,3

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

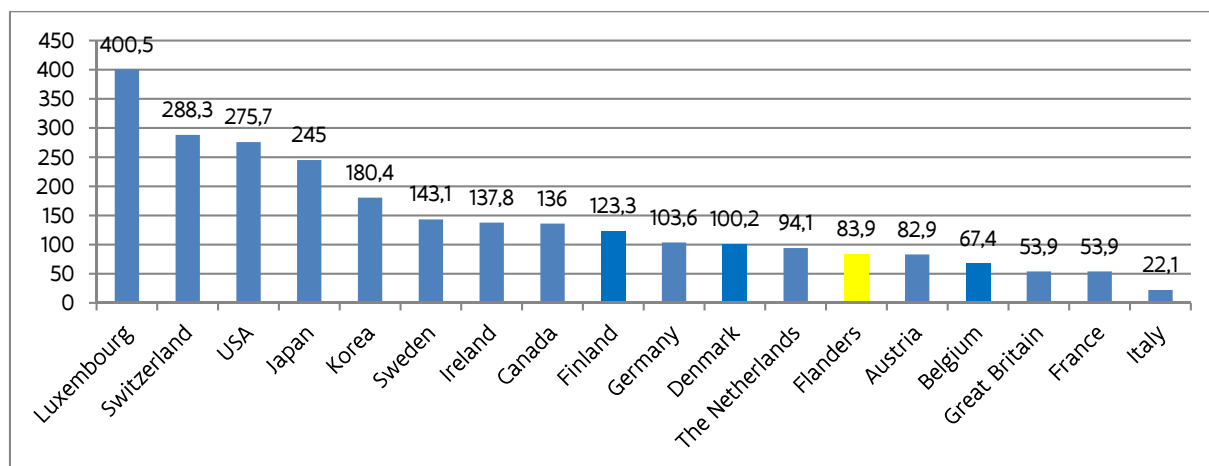


Based on patents granted under the USPTO system, Belgium and Flanders occupy respectively fifteenth and thirteenth place. The leaders here are Luxembourg, Switzerland, the USA, and Japan.

Table 10: Evolution of USPTO patent grants for Flanders per million of population by origin, inventor and/or applicant (2004-2011)

	2004	2005	2006	2007	2008	2009	2010	2011
Flanders	150,3	182,5	172,4	152,2	144,6	126,3	110,8	83,9

Figure 35: International comparison of USPTO patent grants per million of population by origin, inventor and/or applicant (2011)

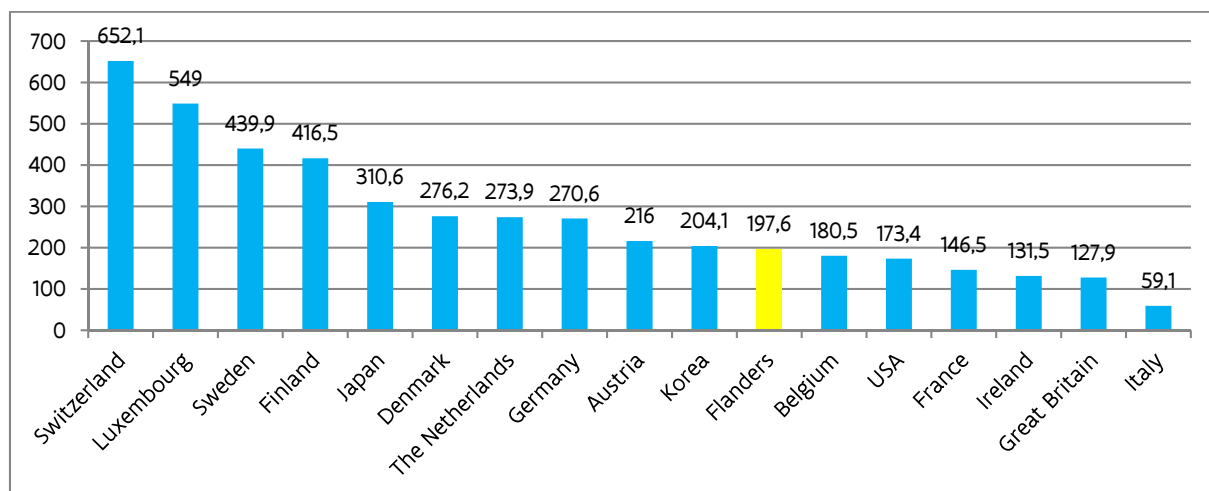


Flanders occupies the eleventh place in the ranking of PCT applications, with Belgium in twelfth position. This list is headed by Switzerland, Luxembourg, Sweden, Finland and the Netherlands.

Table 11: Evolution of PCT patent applications for Flanders per million of population by origin, inventor and/or applicant (2004-2011)

	2004	2005	2006	2007	2008	2009	2010	2011
Flanders	145,1	179,9	192,5	205,8	214,9	189,1	192,9	197,6

Figure 36: International comparison of PCT patent applications per million of population by origin, inventor and/or applicant (2011)



Companies are particularly active in applying for patents (78%). In addition, both the public research centres (IMEC, VIB,...) and the universities are increasingly active as patent applicants (10%). Viewed in international terms, this rate for Flanders is very high. The five most important applicants for Flanders are Agfa-Gevaert (inclusive Agfa Healthcare and Agfa Graphics), Electrolux Home Products Corporation, Janssen Pharmaceutica, IMEC and KU Leuven.

In 34% of all EPO-patent applications with a Flemish inventor - in the last ten years - foreign applicants are involved. These patent applications with Flemish inventor(s) are mainly applicants from the United States (26%), Germany (16%) and France (15%). International collaboration can be illustrated by patents with at least one Flemish inventor and one foreign inventor (co-invention). This is the case in 45% of the Flemish patents, which is quite higher than for other reference countries (34%).

A regional European patent map (version 2016) divided 276 European regions at the NUTS2 level. The European top-five on the basis of information from the *applicants* are: *Nordwestschweiz* (CH), *Oberbayern* (DE), *Stuttgart* (DE), *Helsinki-Uusimaa* (FI) and *Zentralschweiz* (CH). For Flanders: *Vlaams-Brabant* occupies position 44 in this ranking, with *West-Vlaanderen* at 52, *Oost-Vlaanderen* at 74, *Antwerpen* at 82 and *Limburg* at 103. On the basis of information from the *inventors* of the patents, the top-five are Nordwestschweiz (CH), Vorarlberg (AT), Karlsruhe (DE), Stuttgart (DE), and Mittelfranken (DE) The Flemish provinces are ranked at 24 (*Vlaams-Brabant*), at 57 (*Oost-Vlaanderen*), at 64 (*Antwerpen*), at 78 (*Limburg*) and at 79 (*West-Vlaanderen*).

The regional patent map for Flanders (version 2016) divided the patents at the departmental level. On the basis of information provided by the inventors the top-five are *Leuven*, *Gent*, *Halle-Vilvoorde*, *Kortrijk en Roeselare*. The top-five based on information from the applicants are *Leuven*, *Brugge*, *Kortrijk*, *Gent* and *Tielt*.