THE DOCTORAL SPACE REVISITED

A Thinking Exercise in Flanders

KVAB Thinkers in residence programme 2017

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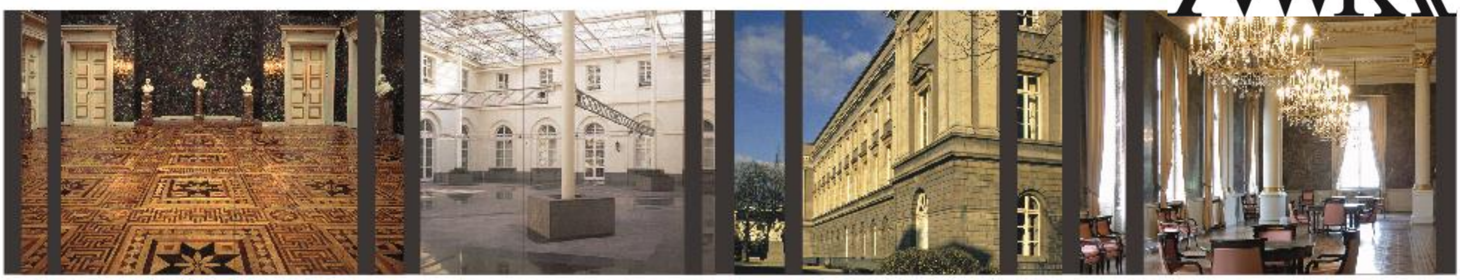

THE DOCTORAL SPACE REVISITED – TABLE OF CONTENTS

Context

The Royal Flemish Academy of Belgium for Science and Arts is responsible for the “Thinker’s Programme”, an initiative, funded by the Flemish Government, designed to address candent topics for Flanders and Europe at large. The programme counts on the collaboration of an “expert (acting as catalyst)”, which, together with a selected group, the Steering Committee, chaired by a prominent member of the Academy, reflect and provide guidance on a given theme, through meetings, debates and workshops involving the main stakeholders. The theme “Doctoral Space Revisited” was selected by the KVAB, classes of Natural Sciences and of Technology and endorsed by the Presidency. The Steering Committee was Chaired by Jean Pierre Henriet, director of the class of Natural Sciences.

The results of the above exercise presented during the Conference *Doctoral Space Revisited* that took place at the KVAB on 7th November 2016 are summed up in the present report.

1 Introduction

Since the beginning of the XXI century the pace of change related both to the concept and framework of the doctoral education (PhD), has increased a lot.

From a requirement to a permanent teaching position at Universities it become a corner stone to the building of a society whose economy and consequent welfare are sustained by knowledge & Innovation. Highly qualified Human Capital is essential not only to develop the economy and its sustainability, but also needed to support society in dealing successfully with the great challenges of this century. With the aim of improving conditions for knowledge creation and innovative ways of using it, most countries invested in research, both fundamental and applied, financed by public and private sources while increasing the qualification of their working force. These resulted in a considerable growth of PhD students' number and had a considerable impact on doctoral education, which finds itself, nowadays, subjected to a force field created by societal needs and graduate's expectations to which universities (as society institutions) have the duty to respond. To construct the appropriate answer a good understanding of the constrains and challenges is necessary. Examples of the «forces» acting upon universities are: The Bologna reform, a struggling economy, funding policies, demographic issues, lack of flexibility inside the system, impact of digital economy and global competition. As expectations of the labor market one can name: Scientific & Technical competences, team work, leadership (to a certain degree) and communication skills, budget setting, project management and readiness to accept responsibility. As far as tools are concerned, universities can count on being knowledge power houses, having the best brains and smartest people in "town", state of the art equipment, access to interdisciplinary approaches and the practice of open science and research integrity.

Since the turn of the century, another most important change has taken place in Europe, which is the increasing numbers of PhD's who pursue postdoctoral training.

Describing how Flanders is positioning itself not only to cope with the many challenges but transform them into development opportunities is the aim of the present report which looks primarily into the doctoral space, having in mind that such a theme comprises not only the PhD thesis period, but also the postdoctoral phase and is strongly influenced by the set of policies implemented to enhance performance of correlated sectors: Science, Technology & Innovation, Economy together with Education & Training.

Note: Comparisons are presented at European level for a choice of countries: The Netherlands, Denmark, Austria, Finland, France, Germany and the UK. The rationale for such group was twofold, neighborhood countries, a couple of Nordic ones, plus the UK. Comparisons with France and Germany were not always included due to the large difference on the size of the systems. Comparison with the United States is also included when deemed appropriate. The data sources for international comparisons were OECD and Eurostat. The extensive data available for Flanders is remarkable; the Human Resources in Research – Flanders (HRRF) database is of the utmost importance to inform decision making processes. The data and the analysis performed by VRWI, ECOOM, and STI in Flanders – 2015 were invaluable as basis for the present report.

2 Setting up the Scene: from EHEA to ERA

The need of educated people to sustain the welfare of the nations coupled to the individual strategy to invest in education, since it means higher salaries and social upward mobility, led, from the nineteen sixties, to a substantial increase in the number of students attending Higher Education. At the time, severe doubts about the efficiency of the system were raised. In fact, Europe had a long over duration of studies (often seven or eight years for programmes that officially lasted five years), which consequently implied high costs for students, families and government, and resulted in late entry into the labour market, all this accompanied by very high dropout rates. On another level there were problems with lack of flexibility in terms of adjusting study programmes to technical and scientific developments, high unemployment among graduates and recognition problems even for Europeans within Europe (1)

This situation led Europe, from 1999, to embark on a major process of reform of its Higher Education Systems aimed at building a Europe of Knowledge, where its citizens are mobile, working, creating and sharing knowledge and so contributing to the economic development and the building of a cohesive society.

The mentioned set of reforms, which has become known as the "Bologna Process", implied the restructuration of Higher Education into a system consisting of two cycles for undergraduate and post graduate studies respectively (later enlarged to three cycles, Bachelor, Master, and Doctor), combined with a credit system for accumulation and transfer, therefore improving recognition and comparability. The approach to teaching and learning supposed to undergo a complete transformation from an ex-cathedra model of teaching into a student-centred approach of the learning process.

In 2010 almost all the countries in the European Higher Education Area had introduced the Bologna reforms, with 95% of Higher Education Institutions with a degree structure based on either two or three cycles and 88% reporting the use of ECTS as a transfer system (2). However, the TRENDS survey 2010 (3) reveals that all is not well. In what concerns mobility while the vertical mobility was increasing the horizontal mobility seemed to be diminishing. At the same time, it was possible to conclude that in the vast majority of countries the restructuring of the degrees was accomplished in a purely formal way. In some cases, the degree programmes were sliced into two cycles lasting three and two years or four and one year, corresponding to Bachelor and Master degrees, without any redesign of the curricular development of the programmes or alteration on course content. The application of ECTS was (is), in many cases, based on the contact hours. Also the process of teaching and learning had not evolved much apart from the more extensive use of ICT. <u>Basically because the extra funds needed to achieve better student-staff ratios and for staff development, needed to focus the learning process onto the student, could not be provided. Hence other sources of funding needed to be found, given the fact that, generally speaking, the public purse no longer supports adequately higher education. To achieve the goals of the Bologna reform more, not less, funding is needed!</u>

As reported in 2015 (4), there is no single model of first-cycle programmes in the EHEA. A unique 180 ECTS Bachelor model exists only in the Flemish Community of Belgium, France, Italy, Liechtenstein and Switzerland. Most countries combine programmes of 180 ECTS and 240 ECTS. In some countries, the number of (usually professional) programmes using the 210 ECTS model is significant as well.

In the second cycle, the most common model is 120 ECTS with two-thirds of programmes following this workload. Other models dominate, however, in particular countries. 90 ECTS is the dominant model in Cyprus, Ireland and the United Kingdom (Scotland) and 60-75 ECTS in Montenegro, Serbia and Spain.

The most typical variant from the Bologna two-cycle model are integrated programmes including both the first and second cycle and leading to a second cycle qualification. This kind of programme in most cases leads to qualifications in regulated professions, i.e. the fields of medicine, dentistry, veterinary, but in some countries also engineering and law.

One may say that the degree structure adopted by different countries reflect their past circumstances which induced the consequent "creative" approach to the ministerial agreements. In particular, second-cycle programme (master) exhibit fine structure when looked at with higher resolution. For instance, the second year (or 60 ECTS) may take the format of a professional project complemented with related courses (ex: management, entrepreneurship, leadership, human resources etc..) or a research project complemented with courses related with research topics in general. These variants depend very much on (a) the national legislation (b) the autonomy of the university and (c) the accreditation agency. Obviously the employability of the graduates plays a major role.

However, if the adoption of a comparable Higher Education structure into three cycles, BSc, Master and PhD, and the recognition of competences corresponding to a given number of ECTS, were somewhat achieved as the Bologna Stocktaking & TRENDS reports (4,5) demonstrate, the same cannot be said about generating and sharing knowledge.

Indeed, if Europe had somewhat managed to become a Higher Education Area (EHEA), the creation of a European Research Area (ERA) is still to be achieved.

"*A unified research area, open to the world based on the Internal Market, in which researchers, scientific knowledge and technology circulate freely and through which the Union and its Member States strengthen their scientific and technological bases, their competitiveness and their capacity to collectively address grand challenges*".

The years since 2010 have been marked by the weak outlook for Europe both in economic and demographic terms, to which youth unemployment has been added. These have lead many governments, the European Commission and the OECD to emphasise the necessity for Higher Education to respond to economic and social needs, enhance the employability of graduates, including via a stronger focus on entrepreneurship, innovation and strengthening university business partnership.

2020 Strategy: It was estimated that Europe will require about one million additional researchers by 2020. Hence, many countries/nations, and Flanders is no exception, adopted specific policies to achieve the stated objective. An example was supporting the increase in the number of PhD holders. <u>However, the policies focused on the supply side rather than on the demand. One supposes that the expectation was/is to create demand once the impact of highly qualified human capital was truly realised and valued</u>.

Flanders: The degree structure is of a first cycle of 180 ECTS and a second cycle with 120 ECTS.

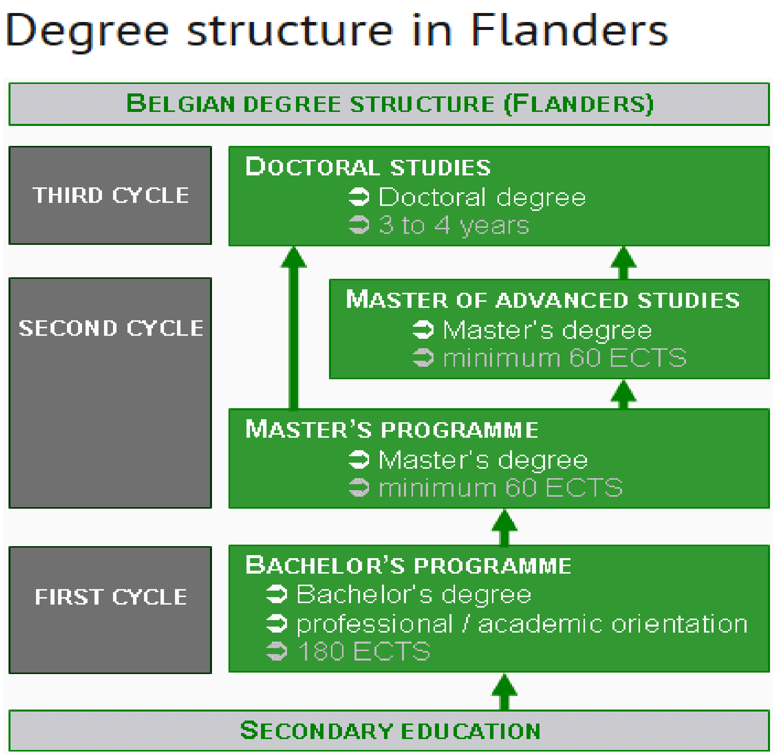

Figure 1

The number of students entering Higher Education at BSc level in the period 2004-2014, increased from 39643 to 46135, corresponding to a growth of 16%, reaching 65% of the eighteen years old (6). More than half of this entrants opted for a professional BSc at a university college. About 32% of the new entries at university have chosen a science & technology domain (7).

The percentage of BSc students continuing to a Master varies considerably across Europe. In Belgium around ¼ of the graduates with a BSc continue into a Master program, usually on the same scientific domain. Such behaviour may have to do with the social perception of the value of a 1st cycle diploma coupled with the employability of the holder (In France about 90% of the 1st cycle students continue to a master). However, there is no available data to corroborate or deny such interpretation.

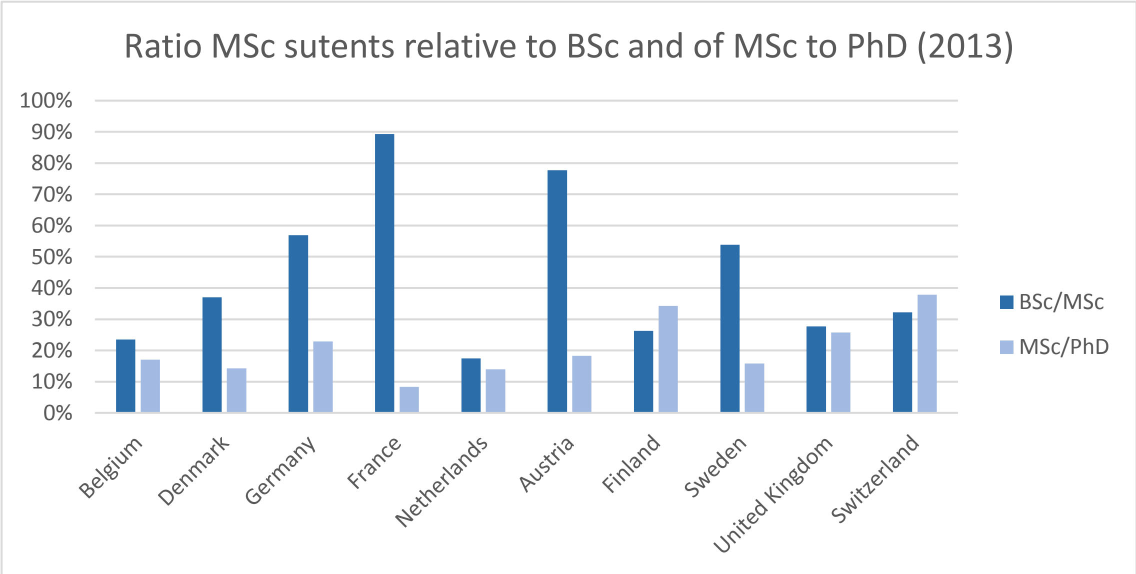

Figure 2, Source: Eurostat

In Flanders during the last 15 years, the number of master and PhD degrees awarded has increased significantly (Fig 3). The ratio Master/PhD increased from around 7% (2000) to 12% (2013). The sudden increase of master's degrees in 2013-2014 is due to the integration in the universities of the College's Master programmes which were not included before. Without that increase, the ratio between the number of doctorates and master's degrees in 2013-2014 remained at the same level as in 2012-2013. In comparison (Fig. 2) higher ratios PhD/MSc occur for Austria, Germany, Finland, the UK and Switzerland. Countries that exhibited approximately the same ratio are: Denmark and The Netherlands (Fig 2).

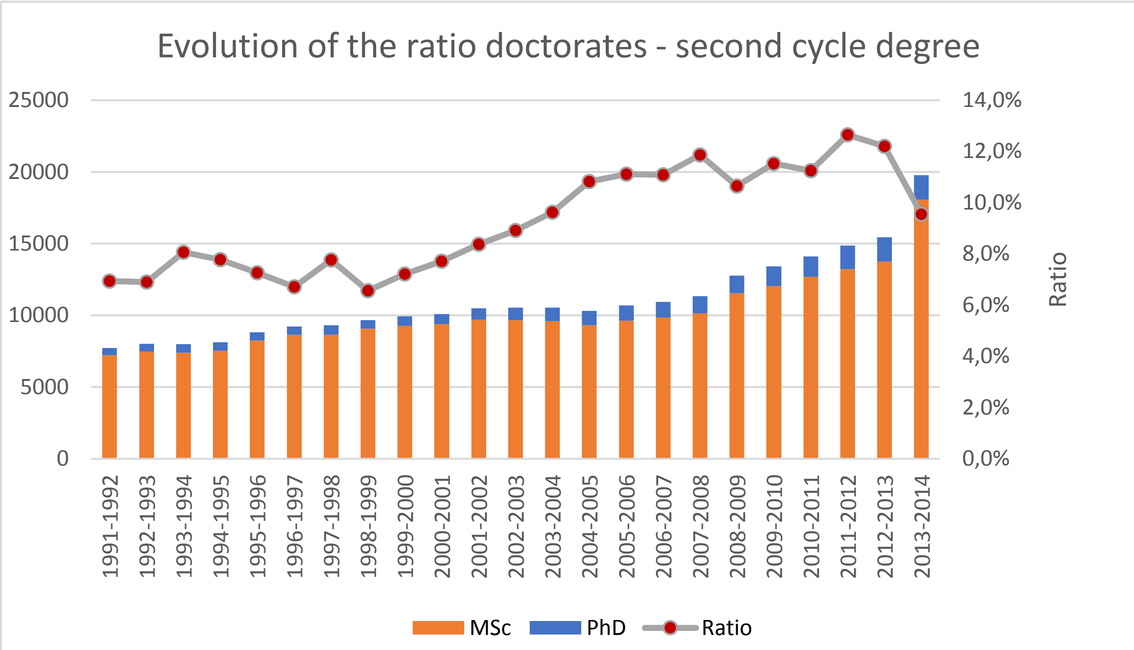

Figure 3, Source: ECOOM (6)

Using a simplistic approach, the above situation may translate into an increase of the workload for the teaching and support staff, due to the coupled effect of the increase of student numbers (BSc, MSc and PhD) with the "extra" year for the duration of master degree studies.
The educational attainment of the population with age 30 to 34 years old with a tertiary degree level (ISCED 5-8), is in Belgium 42.7(%), so well within the 2020 aim.

<u>In Flanders it is not common that MSc holders enter the job market during a period of time before enrolling for a PhD</u>. In fact, both in Belgium and Flanders the usual situation is for the student to enrol for a PhD straight after the Master. On the upside we find that when they earn the degree doctorate holders are amongst the youngest in Europe (31.5 years old without significant differences amongst STEM, SC and Humanities (8,9)) but they lack experience of the work environment which may be detrimental both in finding an adequate position outside academia as well as in their satisfaction with the subsequent career.

Remarks I: Increasing inter-sectorial dialogue and mobility

It may be useful to have data on the employment and earnings of 1st cycle (PBS, ABS) compared with 2nd cycle graduates to enable a better interpretation of the increase of MSc numbers. Another set of data comparing, at international level, numbers MSc (re)entering for a PhD after a period of work can be useful.

Fundamental to promote more inter-sectorial mobility: encouraging the students to work before entering the PhD (criteria for attribution of grants in particular those related with industry IWT (Baekeland and the BOF funds).

Encourage Academic staff to work part time outside the university, perhaps not in a production environment, if that is not at all adequate, but in a R&D laboratory or an advisory agency (all disciplines fit into these designations). Guarantee that so doing is not detrimental for their career but rather taken into account as criteria for promotion.

Have more invited professors, coming from a social/business/industrial environment teaching at universities. Not just for the odd lecture but for a semester, even if it has to be done outside working hours.

Especially important are entrepreneurship, leadership and conflict management competences. This set of skills is needed both in academia and outside, in particular if the graduates comes to occupy senior positions in their career.

3 Doctoral Studies

The Bologna process was late in considering the impact of reform on the third cycle, and only in the Berlin Communiqué in 2003 was the doctoral cycle brought into the reform of degree structures. Doctoral programmes are not only the third cycle of higher education, but also constitute the first phase of a young researcher's career. The core component of the third cycle is the advancement of knowledge through original research (10) and this makes the third cycle unique and different from the first and second cycles. The doctoral training phase constitutes the main link between the European Higher Education and Research Areas, and high quality doctoral programmes are therefore crucial in achieving Europe's research goals. Hence, all over Europe policies to increase the research output and the numbers of PhD graduates were implemented and as a result the global trend is for an increase in the PhD numbers across Europe.

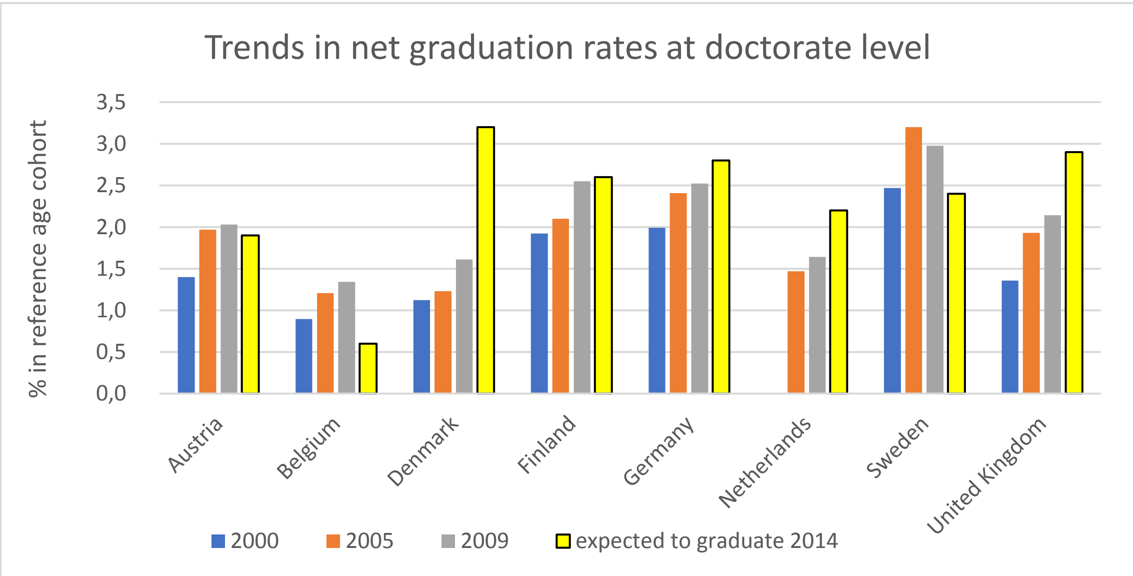

Figure 4, Source: OCDE Education at a glance 2011 & 2016 (figures for 2014).

Flanders is no exception; the number of PhD graduates is increasing (as it is increasing the number of women, constituting nowadays 45% of the total numbers).

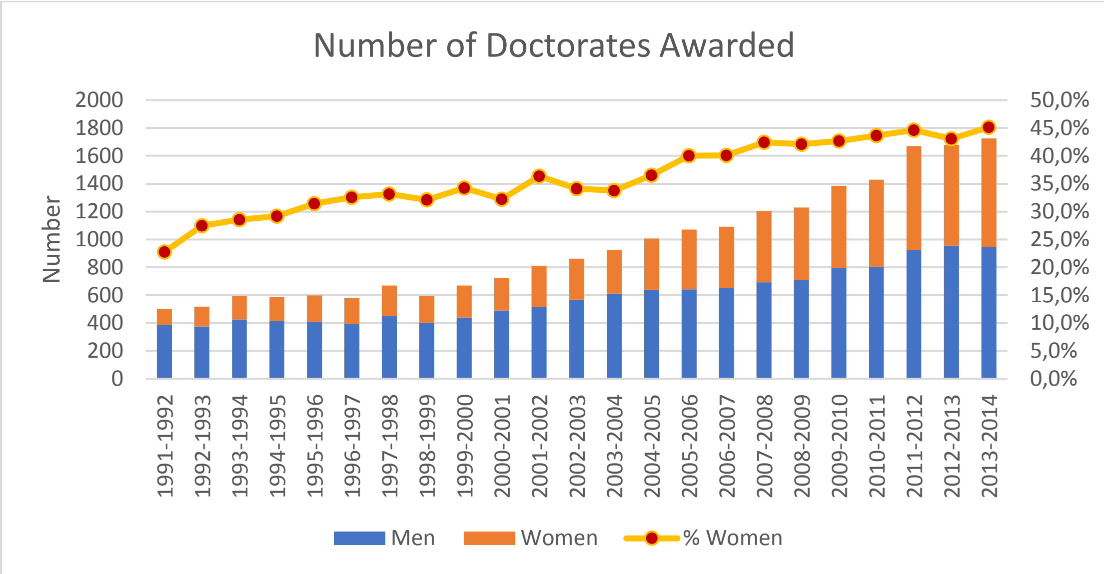

Figure 5, Source: ECOOM (6)

The increase is due not only to the increased weight attached to PhD students, in the funding formula, but mainly with the availability of other funding sources like the FWO (Fonds Wetenschappeelijk Onderzoek) fellowships, the BOF (Bijzonder Onderzoeksfonds), research projects with funds to hire personnel, the Baekeland (EWI) linked to industrial interests plus the international and self-supporting students

In addition, the EWI policy provides extra support aimed at promoting excellence and has performance agreements with several key organizations, namely the VIB, the Institute of Tropical Medicine and the VITO among others.

3.1 The Doctoral Space itself

The environment for pursuing scientific work in Flanders is one of the most reputed in Europe. The landscape for Research, Innovation and Development, includes:

- the five Universities (KULeuven, UGhent, UA, VUB and UHasselt) which generate almost 90% of all non-private scientific output,
- the strategic research centres (Strategische Onderzoekscentral) also referred to as public research organisations IMEC (nano-electronics and nano-technology), VIB (Biotechnology), VITO (energy, materials, environmental and terrestrial observation), iMinds (Broadband technologies) and Flanders Make (Smart Manufacturing) which have created several (109) spin-offs, based on breakthrough research,
- the business enterprise sector which funds about 70% of R&D in Flanders, a very high contribute compared with other European countries.

The business enterprise deserves special attention, it is the key sector if one thinks about innovation and wealth generation. Is a very heterogeneous group including large multinational companies with a significant research budget (whose priorities are not determined by Flanders only) alongside with two groups of SMEs, the high-technology ones and the more conventional ones.

Looking at the research output measured through the number of publications, Flanders ranks fourth in Europe, after Denmark, Sweden and The Netherlands (7). Using number of citations and their impact as a proxy for quality, Flanders score higher than the world standard in a number of selected fields (9). This success is the response of the Higher Education plus R&D Institutions and Companies to the policies adopted by the nation to achieve the goals of the 2020 Strategy through investment in science, research and innovation.

However, in terms of innovation Flanders does not rank amongst the most innovative regions of Europe, coming after Switzerland, Germany, Denmark and The Netherlands, as measured by the EU Innovation score card (2015). The Innovation Index is a composed indicator, hence extracting conclusions is a non-trivial exercise. Nonetheless it is very obvious that in terms of the research system and Human Capital Belgium is second only to Switzerland.

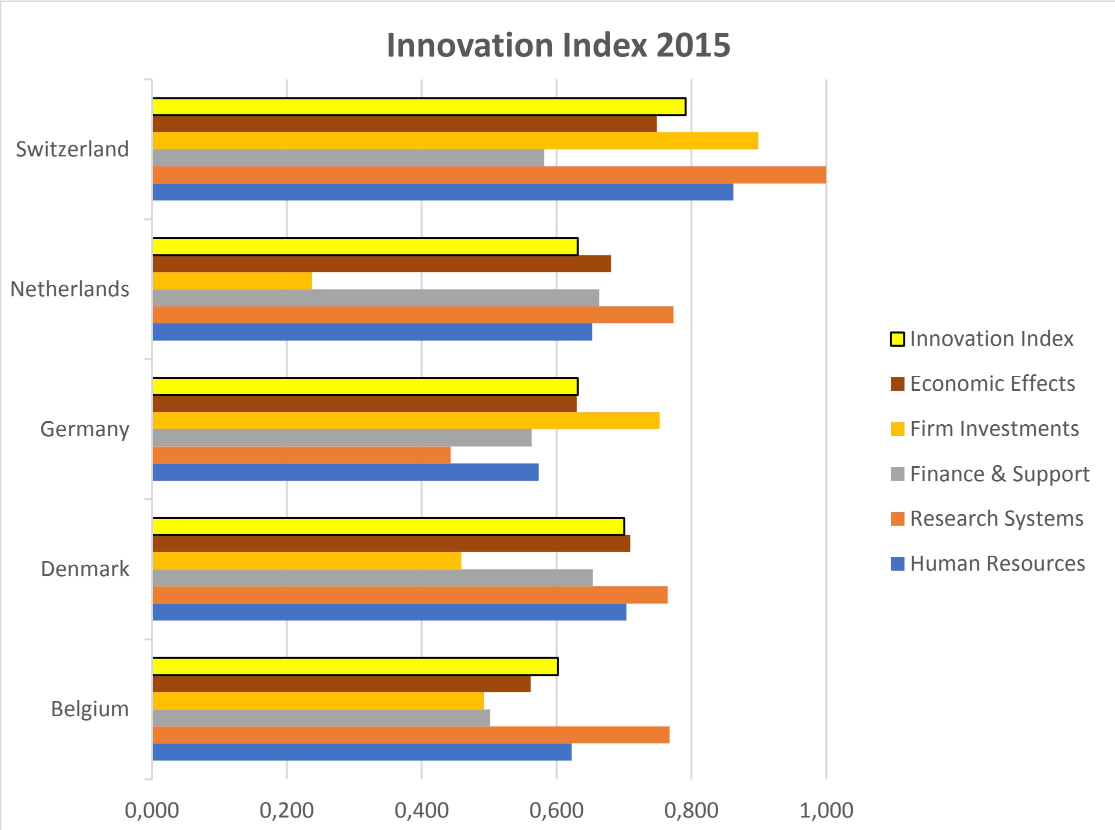

Figure 6, Source: EU Innovation Score card (2015)

Flemish universities are nowadays major power houses for knowledge creation and burst with international activities, hosting and recruiting talent. They exhibit close links with R&D enterprise departments and/or host prestigious research institutes, as autonomous (semi-autonomous) entities where PhDs are trained under the supervision of professorial staff and often recruited as employees in a postdoctoral or / senior researcher capacity.

As mentioned before the above policies enabled universities to invest more in science both fundamental and applied, to recruit an increasing number of PhD students and train them, to enter the labour market outside academia, where their contribution to wealth via innovation is crucial.

At this point it is adequate to look inside this creative environment, searching for good models that could be used by the rest of Europe or to spot issues before they develop into problems. The real asset is the human capital hence we start by looking at the evolution of the personnel related with the Doctoral Space.

Figure 7 shows a marked increase on the percentage of grantees, that is people without a permanent contract with the Institution. Given the increase of student numbers at all levels and the negative evolution (percentage) of Academic staff, both as assisting and independent it begs the question if Postdoctoral fellows are being use as source of cheap labour?

We call attention to the variation on the percentage related with the "other" which are interpreted as representing Technical and administrative staff.

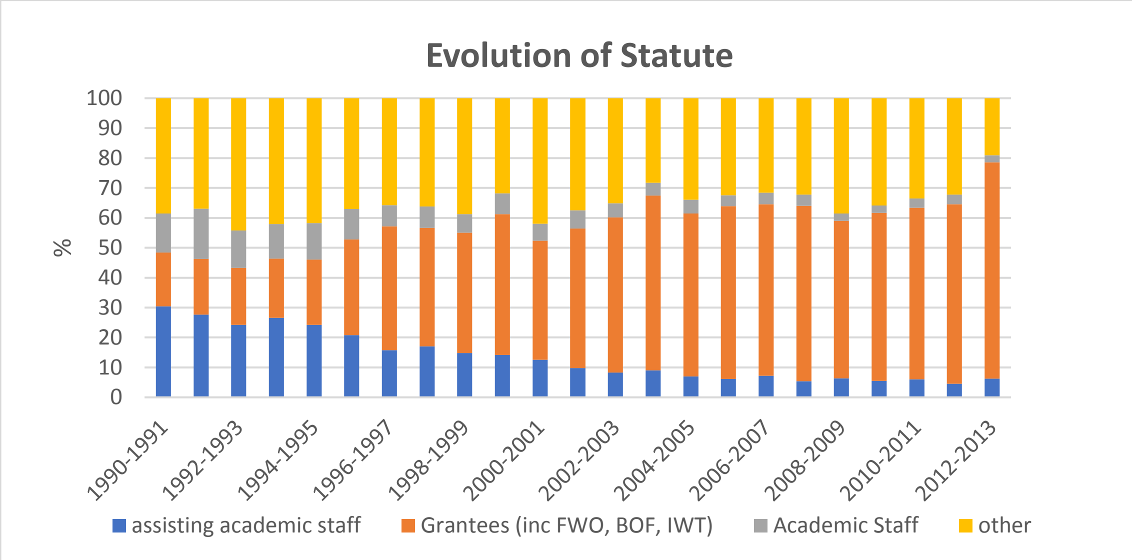

Figure 7, Source: ECOOM (6)

A comparison of the numbers of doctoral students, postdoctoral fellows and Independent Academic Staff depicted on Figure 8, confirms the growth on the number of doctoral students, which is joined, in this trend, by the postdoctoral fellows. Noticeably the Independent Academic Staff (ZAP) category is nearly constant (or with very small increase) over the period of 15 years.

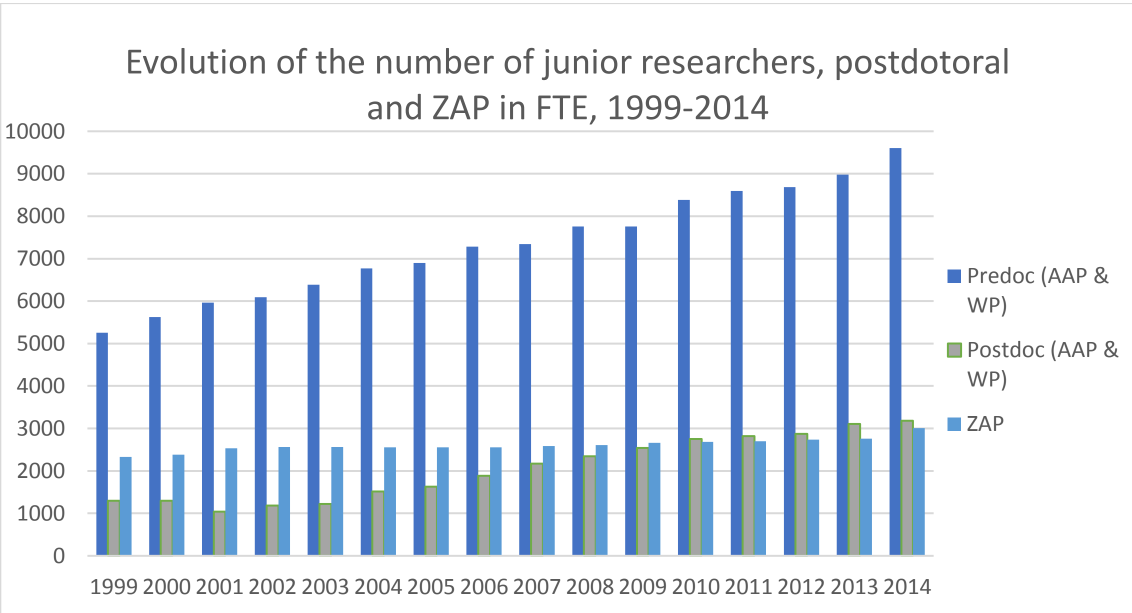

Figure 8, Source: ECOOM (6)

This evolution taken jointly with that of the student's number at undergraduate level may indeed reveal a substantial increase on the workload of the teaching and support staff. The ratio Academic staff to junior research at doctoral and postdoctoral level which was 2.81 in 1999 is now 4,25 (2014) (6). It looks that the system is under stress and the FWO, IWT and BOF grant holders both at Post-doctoral and doctoral level are helping to hold it together!

The average time to get a PhD is 4.5 years, however, the degree of attrition for doctoral students is quite high, 47.4% graduating within eight years, 50% drop outs considering the same period and just 30% finishing within 4 years (11,12) *(see note 13)*. The degree of achievement seems to be related with the type of scholarship or appointment across the junior career, with competitive scholarships both FWO and BOF exhibiting rates of success higher than 65% (for a period of 4-5 years) which grow to 84% and 76%, respectively if a period of 8 years is considered. The Assistant lectureship scores only 40%, which may be explained by the teaching duties that such an appointment requires. Hans Groenvynck and others consider that the higher degrees of success for FWO and BOF grantees might be due also to previous involvement with research and with a supervisor's support before even starting their research work, which proves the point on the importance of the PI for a successful outcome and the importance of early contact with research beforehand (related with the master project?)

The duties of the PhD students vary from Faculty to Faculty or even from Principal Investigator to Principal Investigator. In some instances, the students will perform research only, under guidance, namely if they are non-Dutch speaking. In other cases, the student may be asked to teach/support lab classes for undergraduates. So gaining a lot more competences, of speaking in public, organizing ideas, critical thinking etc… than their fellow students which did not have such experience, therefore increasing their chances of finding employment also in a non-academic environment. However, often times such contributions are not properly acknowledged resulting in a poorer portfolio for the student.

If enquires are maid into the motivation for obtaining a PhD it is clear that in most cases the aim is to pursue an academic career. In 2013 ECOOM has conducted a survey including all the junior researchers in the 5 Flemish universities. The results show that 58% of the respondents aimed at a university career and 32% indicated interest in the industry (6), which is an encouraging figure for employment outside academia. If the PhD work is developed in collaboration with a strategic research centre it is more likely that the career aim changes from academic into a research one. If the PhD training, involves a company, large or small, the chances of employment within the business sector will increase as well as the change in the aims of the graduates and even a higher chance of getting a better suited employment.

The importance of tracking the graduates is becoming more and more important. In the US there are voices advocating that the criteria for funding research, which in the US and Europe, already includes the potential impact of research on economic activities, should move forward more effectively by tracking the activities of people rather than only counting the number of publications and patents (14).

Remarks II: Relate graduate's aims with the job market situation; help developing realistic expectations

Is it possible to establish a relationship between the aims of the doctorate students and the type of grant? Would a higher number of IWT Baekeland grants be appropriate, namely involving SMEs? The careers of doctorates as well as postdocs are not tracked after they leave the university. So, unfortunately there is no data documenting such important area. Where are the Baekeland PhDs compared with the FWO and BOF?

There is no systematic tracking of doctoral graduates after they leave university. A uniform protocol for data gathering accepted by all does not exist across the system making meaningful comparisons impossible and evidence based policy difficult. This is not easy to implement; information on the advantages for both, the university and the graduate is needed as well as adequate incentives which may play a role. Surveys are carried out by OECD, Eurostat among others, but there is nothing like the banner into one's hand! Obviously a 100% tracking is impossible but serious attempt to have reliable data on the career of the Flemish doctorates outside academia is needed. Sooner or later universities and research institutes will be confronted with the need to provide information to society on the results of the funding received to increase the number of PhD graduates and their impact on innovation and economic output. In the end of the day it is the quality of the Human Capital that matters and we better know where our assets are!

Complete information on the employment market (including very explicitly the situation inside universities covering all categories of staff, from high level administrative staff, high level techniciens, academic personnel to full professor (including tenure track) should be made available to the PhD candidates upon enrolling for PhD so that more realistic expectations can develop.

The dropout rates are high namely if the «normal» period of 4-5 years is considered. The causes for this can vary enormously, however, it would prove useful to have more detailed information and analysis about the causes *(see note 13)*.

3.2 Doctoral Schools

Universities have recognized that doctoral training must increasingly meet the needs of the employment market which is wider than academia. Consequently, doctoral programmes changed a lot in recent years, becoming more outside employment geared, including interdisciplinary training, the development of transferable skills and operating within appropriate time duration, three to four years full-time as a rule. Most of them offer, nowadays, geographical as well as inter-sectoral mobility and international collaboration within an integrated framework of cooperation between universities and other partners, in particular enterprises and business. All over Europe doctoral schools are coming into being resulting from joint ventures involving international partnerships among universities, other Research Performing Organisations, industry and business. They provide a dynamic research environment and create reliable quality standards for supervision. At the same time taught courses have been introduced, some with credits attached.

The need for restructuration of doctoral education within universities is perhaps one of the more challenging issues that university leadership faces nowadays. The apprenticeship model of doctoral education lies at the very heart and foundation of European universities and so is among one of the issues faculty resist more to change.

The tradition of central European universities being constituted by strong, self-contained, quasi-independent faculties makes cross fertilisation a complicated issue impacting in a detrimental way on the achievement of true inter and trans-disciplinary approaches.

In Flanders the five Universities have responded to the need of changing the profile of "research only" PhDs giving them opportunities to obtain other skills and competences. The demanding new organisation towards that end is met by the doctoral schools at each university. It is noteworthy and very encouraging to observe how professionally these doctoral schools are organised inside Flemish universities in general. Manny employing highly qualified staff (PhD level) to manage them, are led by a director or Dean of the School reporting directly to the rectorate or to the Dean of the Faculty and involve the PhD community in analysing important questions and informing the decision making process.

Instrumental to this achievement has been the support provided by the Flemish government (EWI), the OJO initiative, upon the advice of VRWI (15). The FLAMES initiative (statistics courses), also funded through EWI (OJO) had also the objective of promoting interuniversity collaboration. This was cleverly done through a financial incentive of a 25% increase for projects carried through interuniversity collaboration (involving at least 3 of the 5 universities). Another initiative supporting doctoral training was YouReCa.

However, there is still a lot of development needed to support adequately the students and supervisors on their aims and work. Towards this end the continued support of the university leadership is essential.

Remarks III: The strategic role of Doctoral Schools. Help to build the bridges involving all the sectors into partnership.

The remit of the doctoral schools is focused mainly on organisation matters and data collection issues, as in many other countries, which is perhaps to be expected given the "autonomy of the Faculties" and the relative novelty of the initiative. The dominant model is that of acquisition of transversal skills via taught courses, and a choice of seminars until attaining the required number of credits if they are mandatory, which is not always the case. As could be expected the attendance of such courses is often times seen as a waste of time by the supervisors and students alike. In some faculties such training is not compulsory in any format. In spite of the work of the doctoral schools, the majority of graduates have not had any contact with employment outside academia. One is tempted to remark on the appropriateness of having an internship before graduation. The internship could/should involve employers (Government is an employer as well!), the aims of the candidates and the university. Another suggestion is to require the student to draft a business plan related to the her/his area of study. This means that adequate support will be specifically required. Such request (of a business plan) might have an important effect on the view the graduate have on her's/his's opportunities in the job market outside academia. This being particularly important in the fields of humanities and social sciences.

A second stage of the OJO initiative?. Now on entrepreneurship, which is an area not receiving enough attention during the PhD studies.

Inclusion of the doctoral student in the network of stakeholders related to the project he or she is carrying to obtain the PhD degree can improve a lot the prospects of employment and enable learning the ropes. Obviously that depends entirely on the PI. In some of the doctoral schools training for the PIs is also available; making that training compulsory for "recent" PIs might be accepted without resistance, in particular if appropriate incentives are in place. "The PI of the Year" distinction granted by the university and presented by the Rector! The existence of a mentor (from a different Faculty, University or even better outside academia) in parallel with the supervisor is not current practice. Not to be understood as the existence of an ombudsmen, which exists in all visited schools. Interuniversity cooperation (even across border) could be increased.

Career advice and support exist linked with the doctoral school only in some cases. It would be desirable to extend such practice to all universities and include post-doctoral fellows. The leading universities sharing their experience with others and together learning what work and what does not. Ending this set of remarks there is the need for every PhD student to develop a career plan to be discussed and its evolution accompanied both with the supervisor and mentor. Such practice could avoid deception at the end of the PhD.

<u>There is no brand of Flanders doctoral space.</u>

The building of the brand would be helped trough the tracking exercise.

3.3 Doctorate Holders

The increased specialisation in science and research has made professionals with PhDs a cornerstone of Science & Innovation systems in Europe and indeed world-wide. Hence the number of doctorate holders in relation to the overall population has increased considerably during the last two decades and today represent a considerable percentage of the population as evidenced both by the OECD and the ECOOM for Flanders (7).

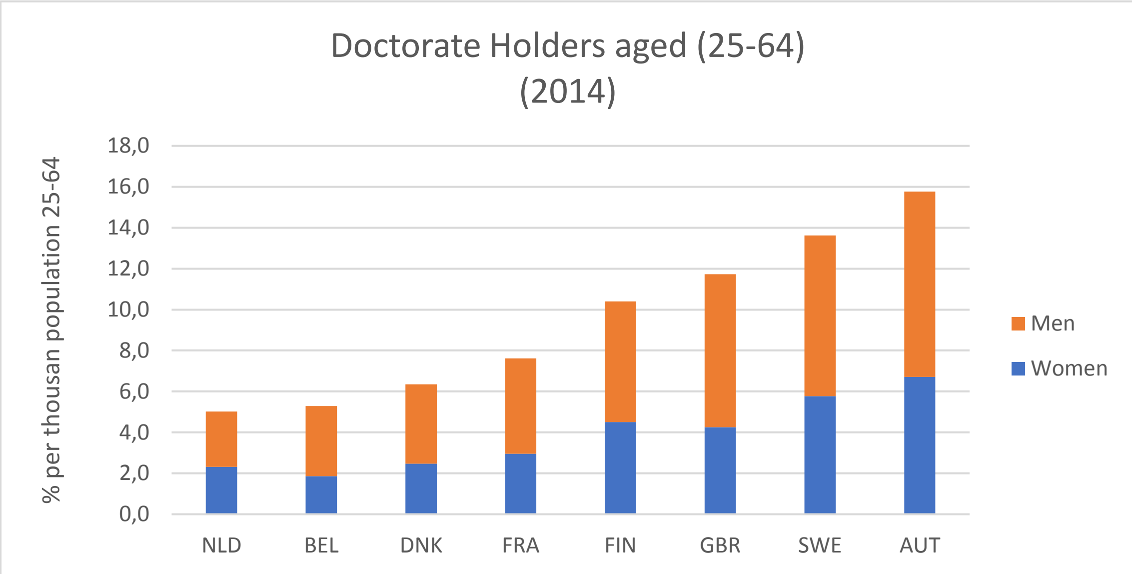

Figure 9, Source: OECD Science, Technology and Industry Score card 2015

The proportion of PhD holders is already considerable in the cohort 25-64, for most countries in Europe. Figure 10 shows that, in Flanders, the rate of "new" doctorates in the cohort 25-34 has grown higher than Belgium, France and The Netherlands.

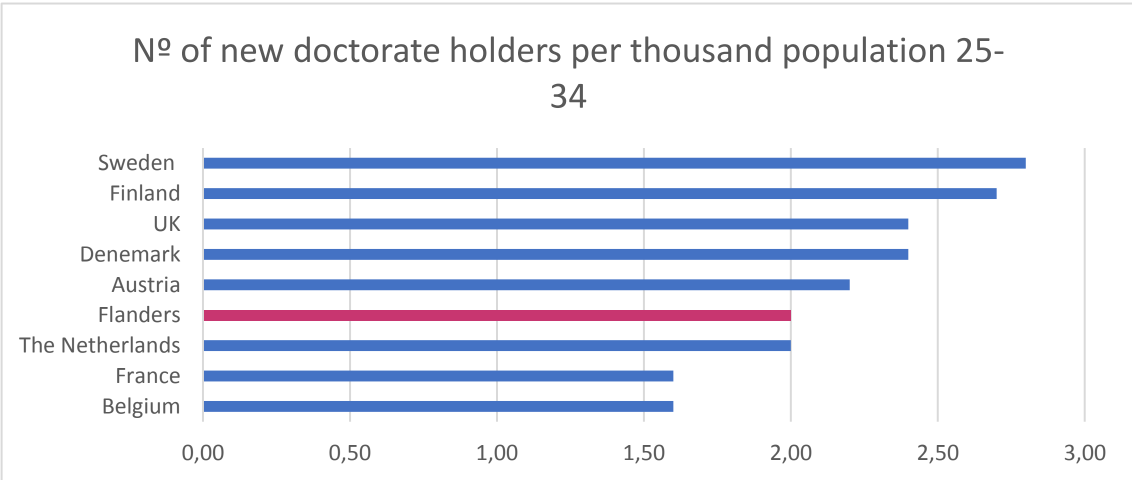

Figure 10, Source: ECOOM (6)

The next step is to look at the employment situation of the PhD graduates.

3.4 Careers of Doctorate Holders

There have been concerns, at both sides of the Atlantic of producing a high number of doctorates for the job market, however, despite those concerns, in terms of employment doctorate holders are at vantage when compared with other tertiary degrees.

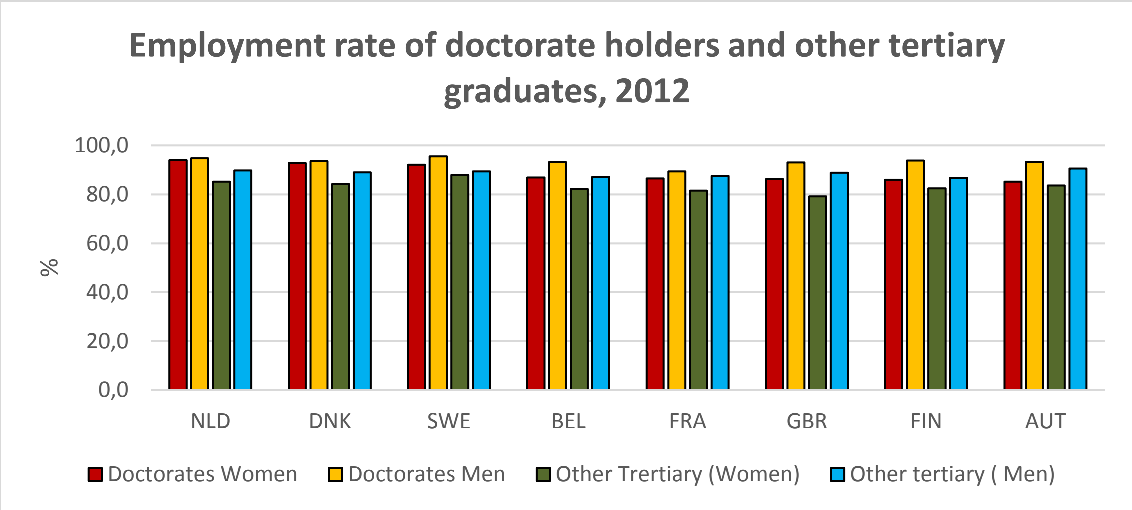

Figure 11, Source: OECD Science, Technology and Industry score board 2015

Another indicator related with the doctorates contribution to the achievement of ERA is the percentage of doctorate holders which work as researchers in Europe and the respective sector of employment.

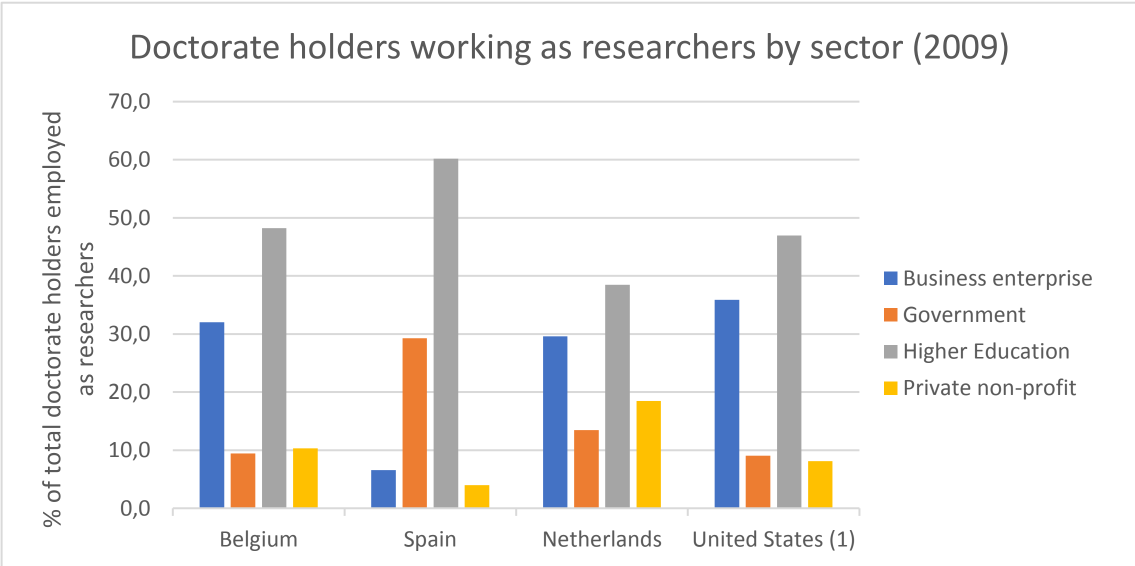

Figure 12, Source: Eurostat

As could be expected the higher education sector is the one that employs the highest percentage of doctorate holders followed by the business sector. It is to be noted that the percentage for business in Belgium is high, on the other hand government employs less doctorates than The Netherlands and Spanish do.

Remark IV: Role of Social Innovation

This situation could be looked into by the relevant partners. Doctorates contribute most definitively to all kinds of innovation and not only technology related ones hence their contribution is important in all sectors of activity. The role of Social innovation to stimulate growth is underestimated in many European countries and Flanders seems to be no exception to the mainstream in this aspect.

The next step is to look into the "quality" of employment using as proxies the percentage of doctorate holders on temporary contracts over career path and the satisfaction with the salaries

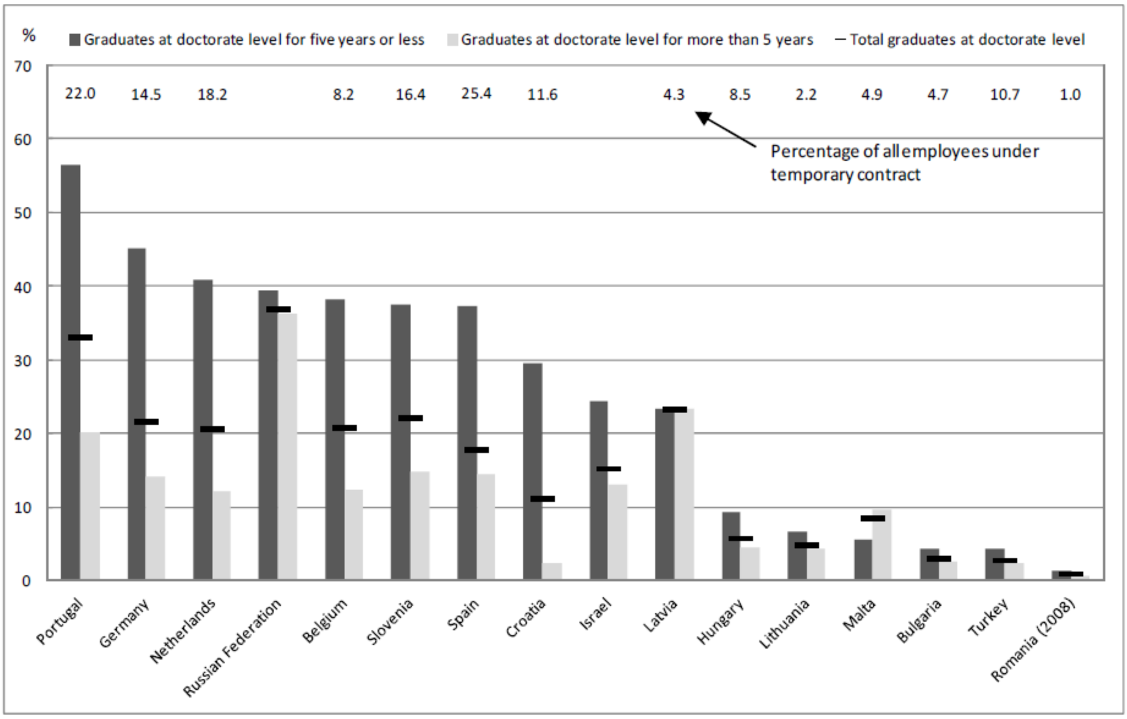

Figure 13, Source: (CDH 2009) (11)

From figure 13 we conclude that in Belgium 38% of the doctorates graduated for less than 5 years have a temporary position. Unfortunately, this is not at all uncommon across Europe, on the contrary, and it might relate to the increased number of postdocs hired under a temporary position. In Belgium that percentage reduces to 15% for graduates that have obtained their degree more than 5 years before.

Remarks V:

These results are already dated (2009) and the subject deserves another study to find how the situation has evolved and if specific policies are required. Judging from the evidence collected for Flanders it might well be the case.

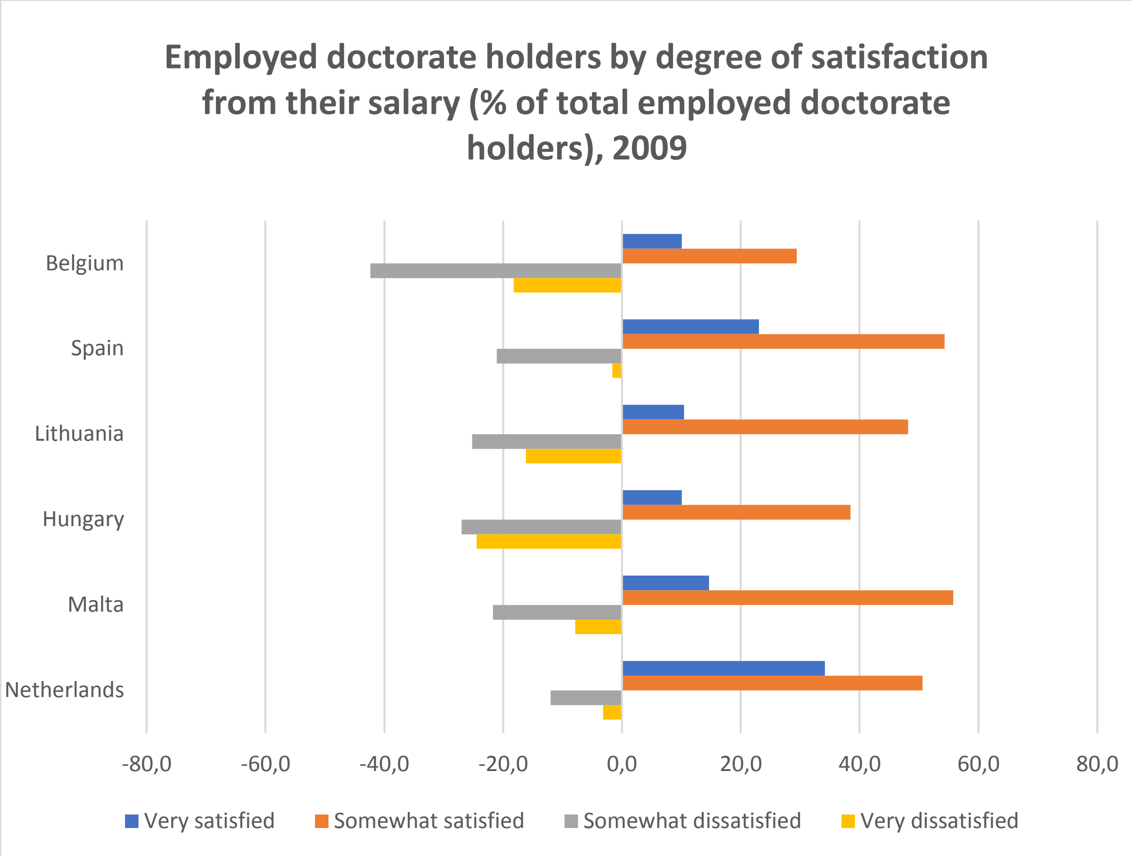

Figure 14, Source: Eurostat CDH

Belgium is the country where lack of satisfaction with the salary is higher; this might be explained by the reasonable salary/grant received while working for their doctorate.

3.5 The case for postdoctoral fellows

The backbone of the research output in Flanders is the postdoctoral community!

In an attempt to identify what a postdoctoral fellow stands for it is proposed (the US definition (16) that a post-doc is somebody, holding a doctoral degree, who receives mentoring to be prepared for an independent academic research career, in exchange for providing labour, producing data, writing manuscripts, preparing grant applications and (when there are no language barriers) have teaching duties up to a maximum of X hours per week or semester. These fellows, often times act as direct supervisor (or in the field supervisor) of doctoral (or master students). This is viewed as an apprenticeship for a faculty position (11). But is this meaningful in Flanders (or elsewhere in Europe) nowadays?
The next two figures are intended to emphasize the increasing gap between "permanent" (with a position at the university) and temporary (Docs or Postdocs) personnel.

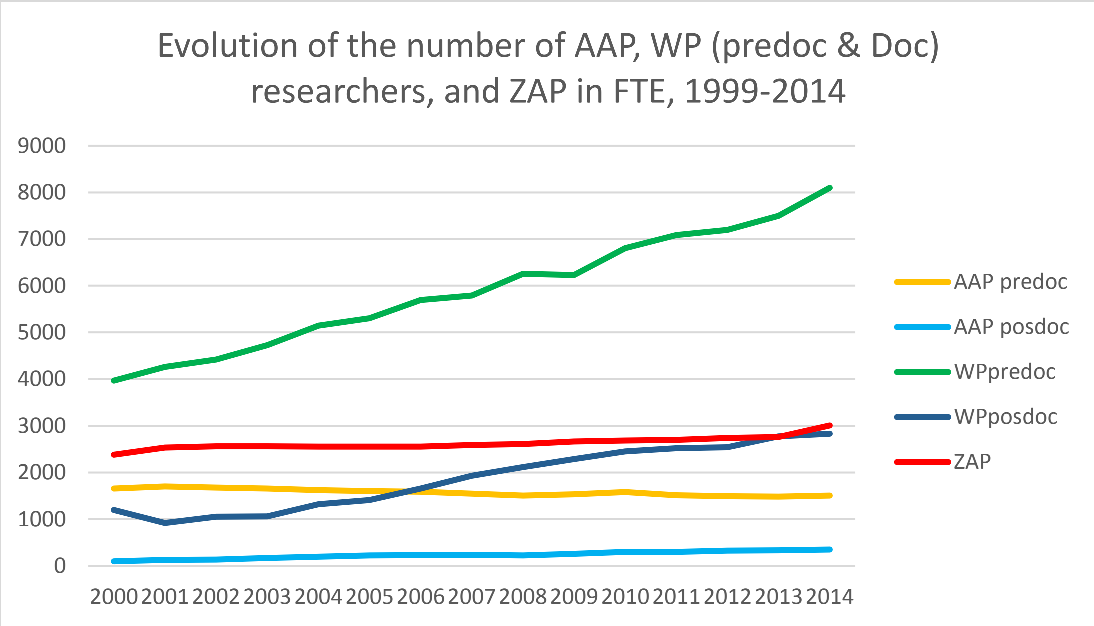

Figure 15, Source: ECOOM (6)

In what follows independent research institutes are not considered. In Flanders postdoctoral mandates can have different origins (a) on a 3 years (with the possibility of being renewed once) fellowship from the FWO, which requires a PI inside the university taking responsibility for following the work development (b) results from a BOF grant which is attributed by the university using funds disbursed by the Flemish government to that effect, (c) takes the form of a research contract funded by a research project. In any case the role of the PI is crucial in contributing to a good performance of the postdoc. It is essential that all the relevant activities of the fellow are fully acknowledge: co-supervision of PhD or Master thesis, major contribution in publications (first author), ownership of fundamental ideas for the research proposal are just a few examples.

From 2000 the total number of researchers at the Flemish universities (all categories depicted on figure 15) has risen (from 8882 in 1999 to 15 796 in 2014). This increase is mainly due to the growth (2.26) of the externally funded researchers at both pre- and post-doctoral level. During the same period the senior academic staff (ZAP) has increased only by 1.29 and the junior staff (AAP) has remained nearly constant. This translates into an increased responsibility to the PIs in terms of supervision of PhD students as well as that of mentoring Post-Docs, as evidenced by figure 16. One also notes the increase on the numbers of post-docs per ZAP.

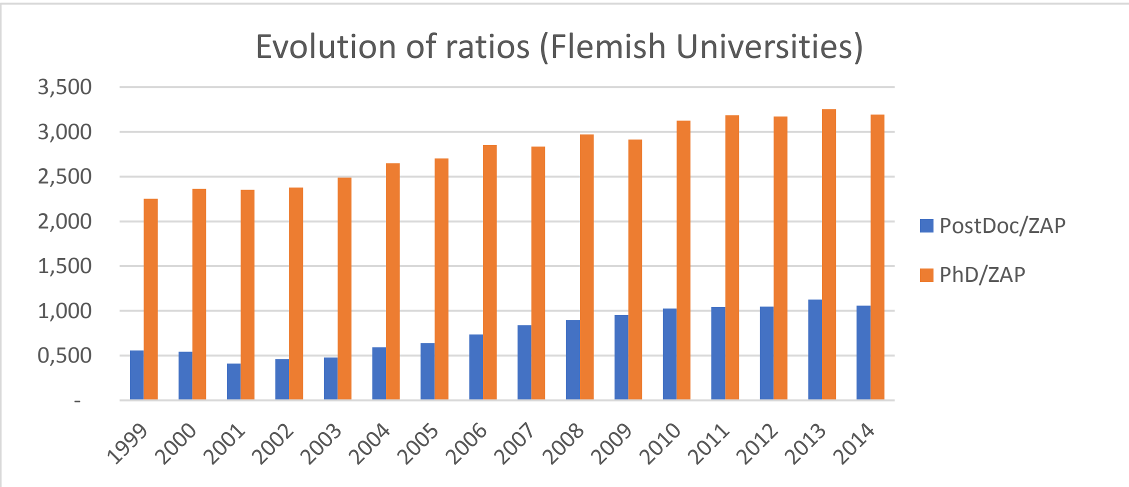

Figure 16, Source: ECOOM (6)

The VRWI study 27 reports that 28% of the PhD graduates will continue into a postdoctoral position; this figure includes foreign postdocs as well as those paid by the university funds (the AAP). Some postdocs get a tenure track position and are included in the ZAP category which in almost 100% of the cases leads to a permanent teaching position. VRWI, based on a study by ECOOM reports that the time elapsed between the conclusion of the PhD and the appointment as Autonomous Academic Staff has increased.

Of particular concern is the growth on the numbers of Post-Docs that remain at the university after a period between 5-7 years and even after a period higher than 7 years after having finished their PhD. (VRWI Study 27 and HRRF2013 ECOOM). Bearing in mind the period of three years of the Post-doctoral grants the above data means not just renewal of the grants but also a change of the source takes place so enabling such situation. It can be concluded that the definition above of a postdoc being somebody, holding a doctoral degree, ***who receives mentoring to be prepared for an independent <u>academic</u> research career***, …. Is no longer entirely correct. Further, it seems that there is a slow but "inexorable" accumulation of postdocs inside the universities looking for an opportunity to enter an academic career, but have to give up.

<u>Remarks VI: Postdoctoral experience is very valuable and cannot be wasted.</u>
The Doctoral School services are needed at postdoctoral level. Tracking of Postdoctoral fellows, in Flanders, is an absolute must. Again a common protocol needs to be agreed among all stakeholders, and some kind of reward invented to increase the level of answering. This should not be seen as vital information that cannot be shared, in order not to deprive the owner of some competitive advantage but rather as a contribution to the Flanders brand in what concerns scientific employment.
In terms of the grants, namely the FWO, a suggestion might be to consider non-renewable grants together with an enlargement by one/two years of its the duration. This could bring about considerable advantages in terms of building the grantee portfolio, namely would enable the complete (co) supervision of a PhD or a higher time devoted to work with industry and to plan the next move.
Policies to increase inter-sectorial postdoctoral «employment» are needed. It is never too much to emphasize that all sectors of economic/ social activities should be considered. In Europe the tendency is to have a very narrow understanding of sectors of activity that could join in postdoctoral work.

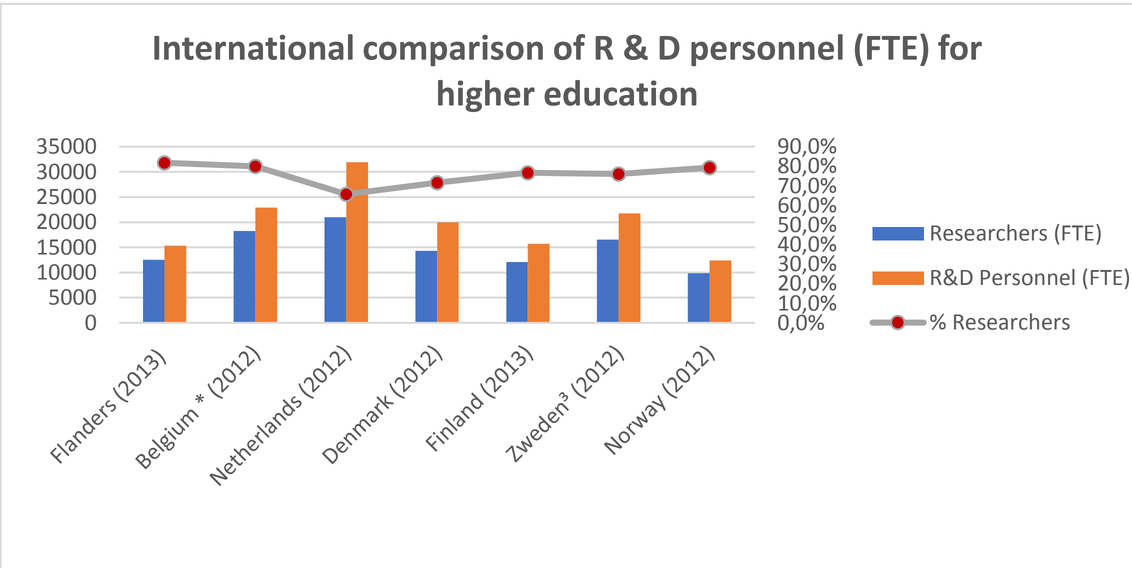

Figure 17, Source: OECD Science, Technology and Industry score board 2015

In terms of the R&D personnel in Higher education, a European comparison (figure 17) shows that Flanders is the region which has the highest percentage of researchers. R&D personnel include all technical and support as well as the researchers. Here researchers are defined as professionals engaged in the conception and creation of new knowledge, products, processes, methods and systems and are directly involved in the management of projects.

As far as it was ascertained the Universities in Flanders do not have a research career, hence the above numbers of researchers may reflect once again the high number of postdoctoral and doctoral fellows in the Flemish universities. More so the figures may indicate that postdoctoral fellows are performing important research support functions and doing so without a career perspective.

4 *Investing in Human Capital and Knowledge: effectiveness of the policies*

In what follows a comparison is presented of the results from the Science & Innovation policies deployed to increase the number and qualification of researchers (aimed at by the Strategy 2020) throughout Europe. We start with the percentage of R&D personnel in the active workforce and follow with its sector of employment.

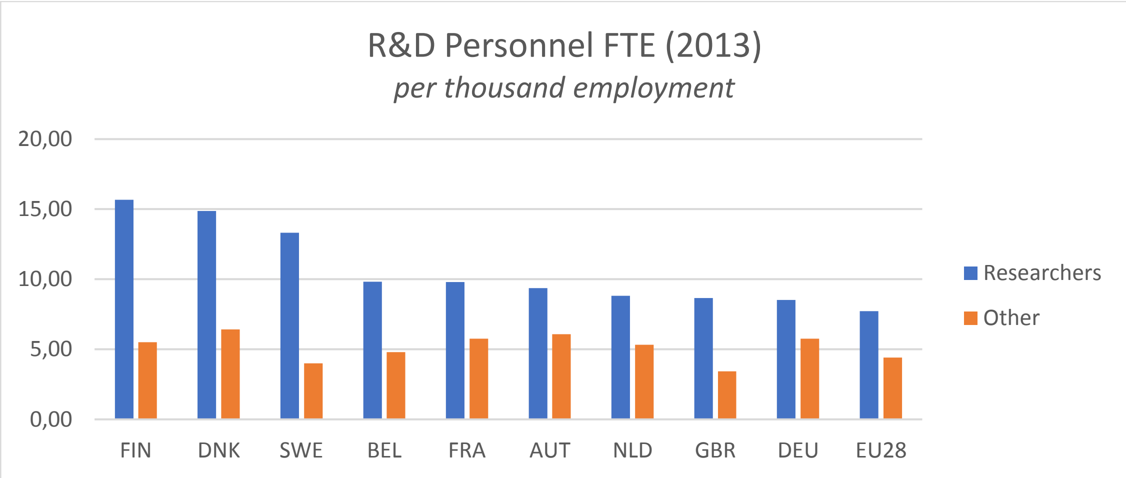

Figure 18, Source: OECD Science, Technology and Industry score board 2015

Looking at the employment sector we note that the business sector employs a considerable higher number of R&D staff compared with the government. For Belgium (for Flanders that information was not available) the percentage of researchers employed by the government could be higher when compared with France and Germany; however, the situation is not as bad as it was concerning the number of doctorate holders employed by the government (figure 12).

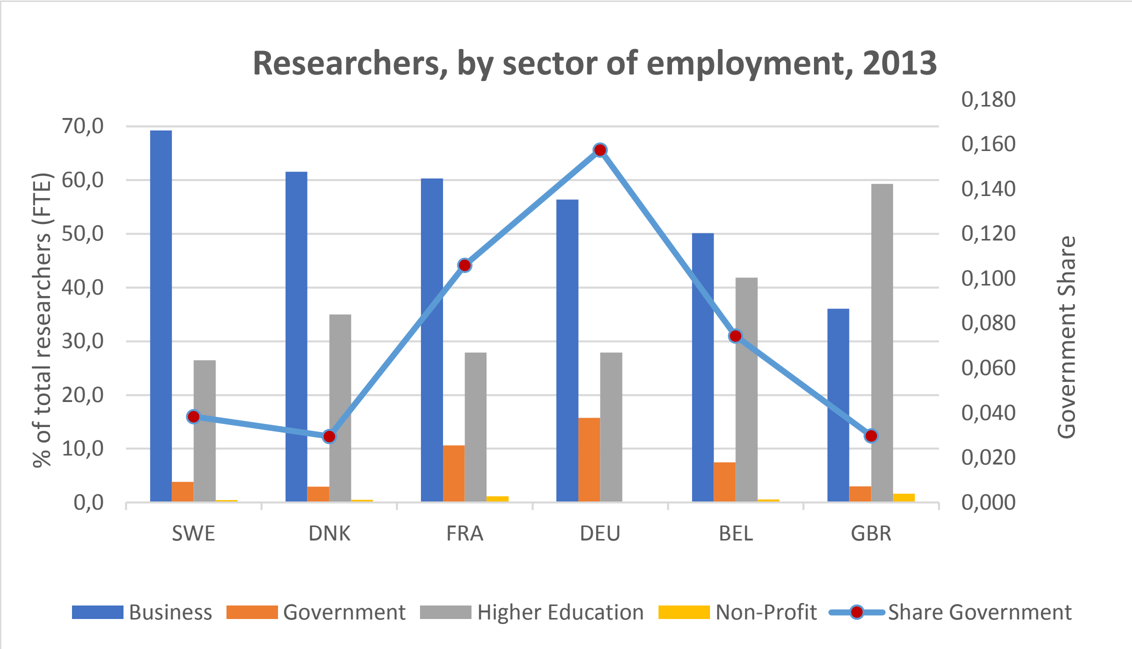

Figure 19, Source: OECD Science, Technology and Industry score board 2015

The profile of R&D employment in Flanders is similar to the distribution shown in figure 19. The major employers being the business sector (companies) followed by Higher Education.

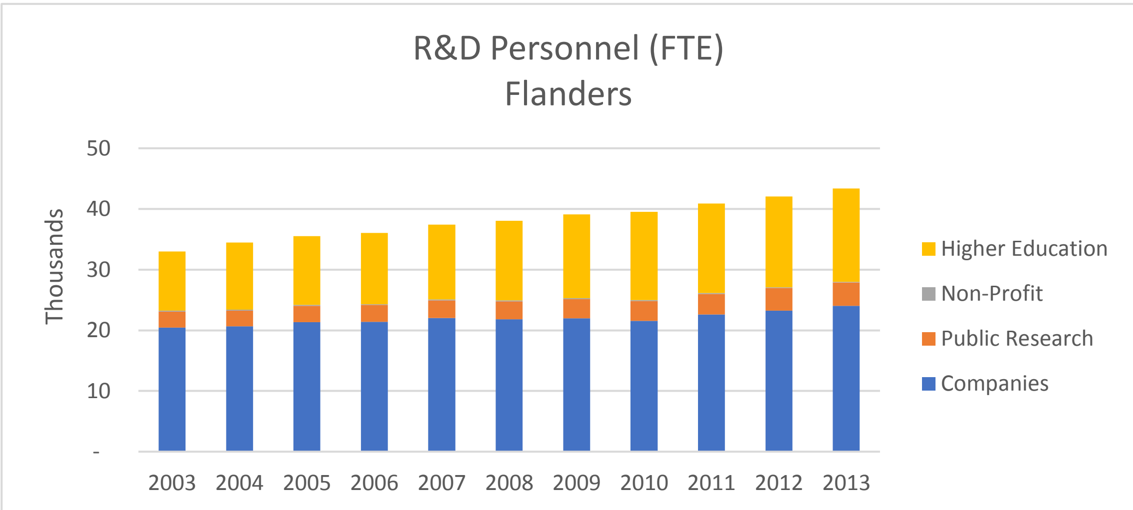

Figure 20, Source: ECOOM (6)

The qualification of the R&D workforce is high, with the percentage of Masters and PhDs vastly exciding that of BSc and others, namely in private companies.

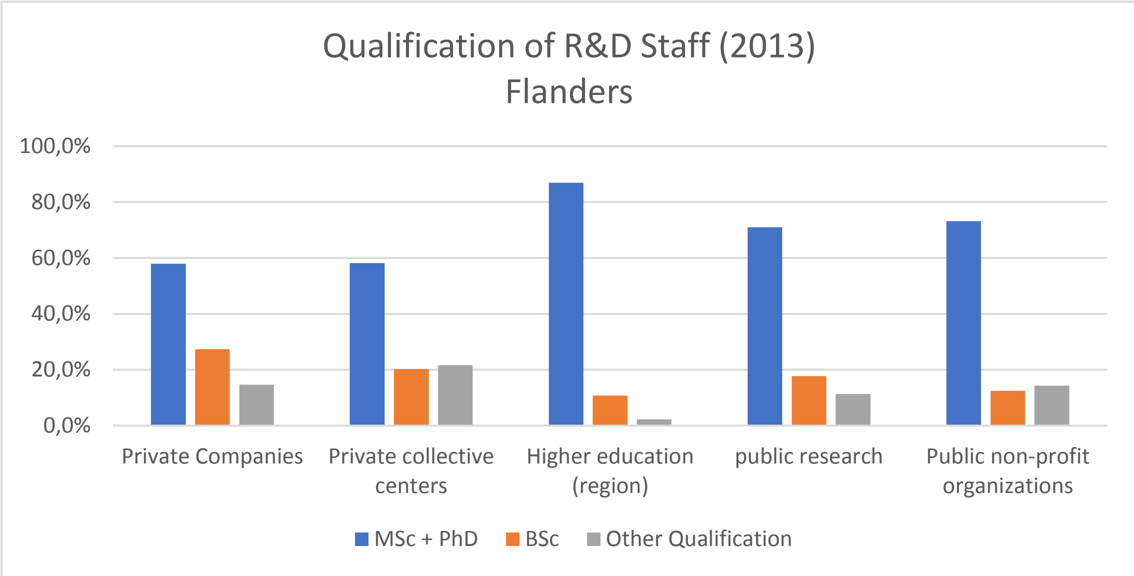

Figure 21, Source: ECOOM (6)

It is interesting (and very perplexing) to note that it is Higher Education that exhibits the lower ratio Technical & other Staff / Researchers compared with other sectors (Figure 22).

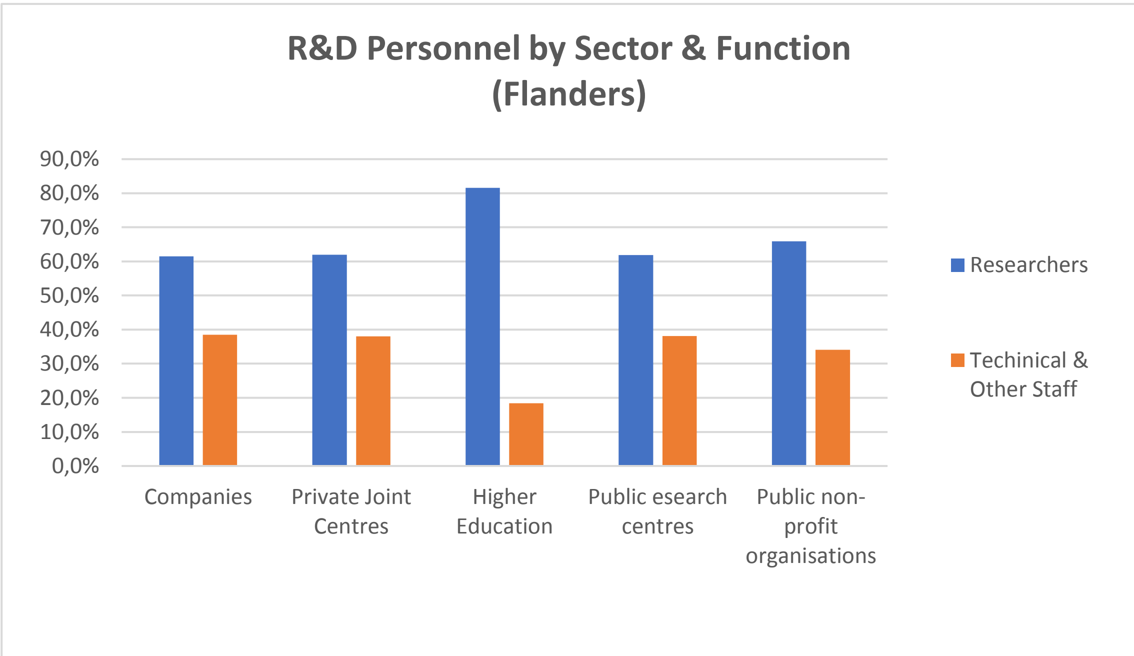

Figure 22, Source: ECOOM (6)

This is not what would be expected to find in Universities with such relevant research output as the Flemish universities and might be interpreted as resulting from postdoctoral fellows working as highly qualified technical staff.

Remark VII: Universities need highly qualified technical and administrative staff.
The highly qualified (PhD) technical staff is one of the most important factors to enable research performance at high level. Hence a career with long time perspective open to these professionals should be considered. What exists now in terms of career is not adequate.

Is there or not a research career inside the universities? Is there or not an adequate technical & support staff career inside the universities?

In Higher Education: Need for policies concerning gender balance? And internationalisation?

In terms of gender differences, the number of female students is higher than men both at BSc and Master and lower for PhD. This is the situation of the majority of countries in Europe with the exception of Finland where the number of female doctoral students is higher than men for the three degrees.

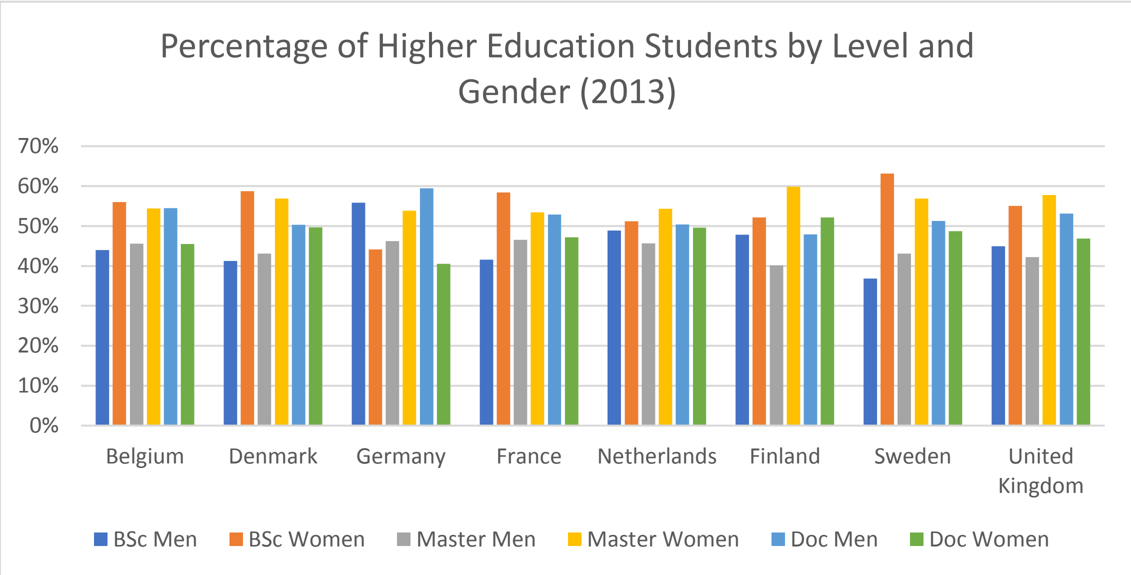

Figure 23, Source: Eurostat

For Flanders the outlook on gender distribution is not very different from the figures reported for Belgium. Looking into more detail into the gender distribution of doctorate holders, it is visible that only in Finland and Spain is balance achieved.

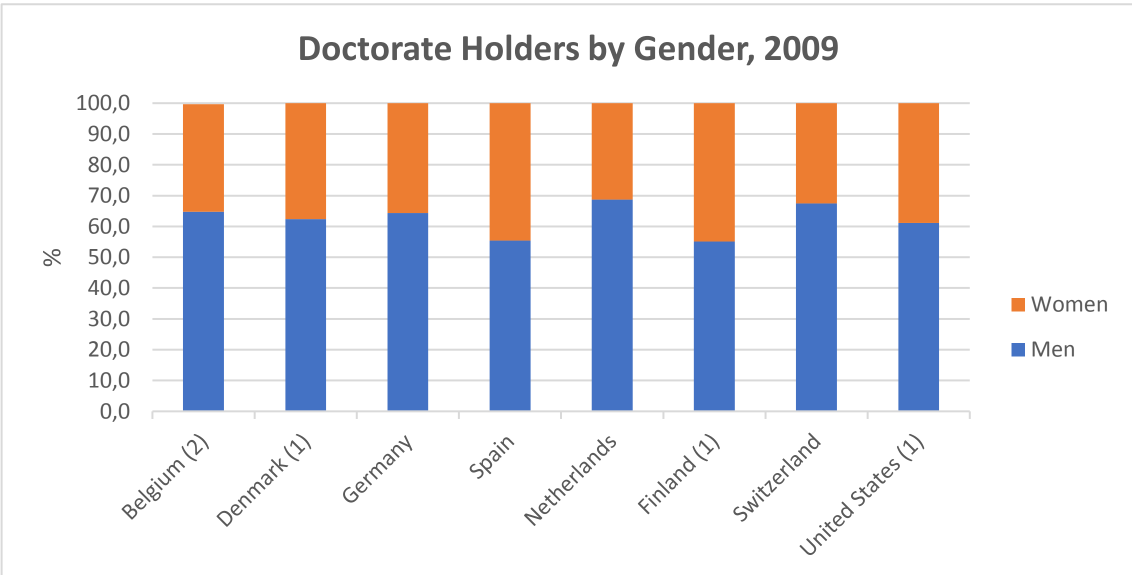

Figure 24, Source: Eurostat CDH

Data points to the difficult and problematic question of having children and working towards a PhD at the same time. Going inside the universities, ECOOM reports for 2014, the following distribution of Teaching Staff:

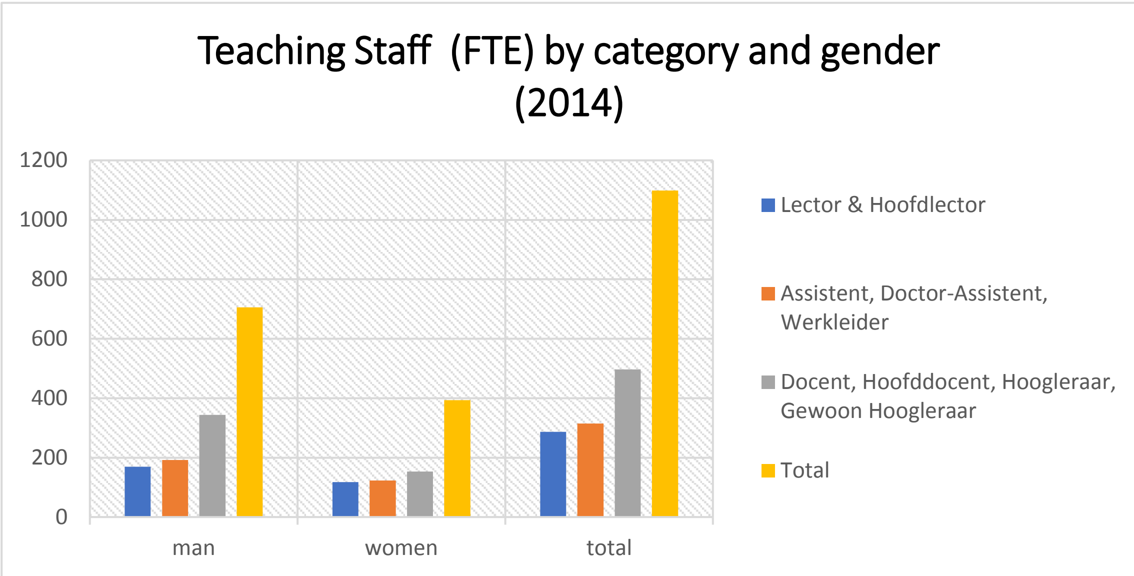

Figure 25, Source: ECOOM (6)

What is of concern, more than the existing gender gap, is the evolution of that gap which is described as the vertical segregation, very evidently depicted on figure 26.

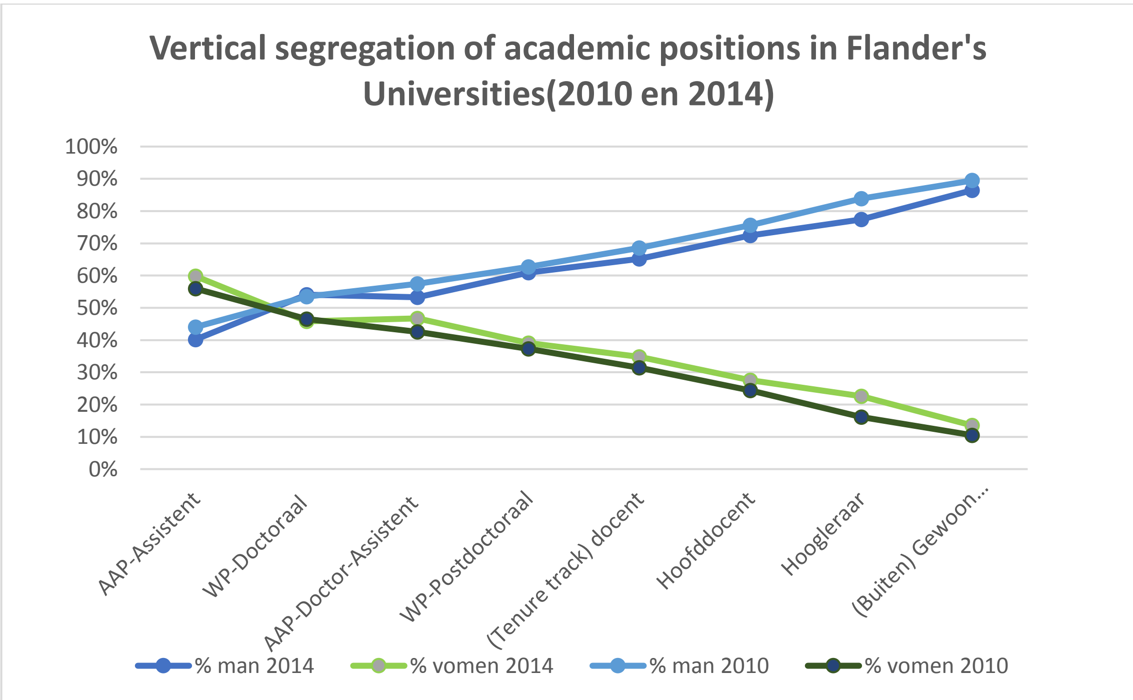

Figure 26, Source ECOOM (6)

Gender unbalance increases as one goes up the qualification ladder, demonstrating once again the growing difficulties of achieving compatibility between a demanding academic career with raising a family. In the four years 2010 - 2014 the gender gap has not diminished! Which calls out for adequate policies to address this issue.

The EWI, as far as was ascertained is the only entity which explicitly tried to promote a higher level of gender balance through using a specific parameter to distribute the funding for the Special Research Fund at the Flemish Universities (Bijzonder OnderzoeksFonds, used for fundamental research). This parameter is calculated using the percentage of women in various academic positions (post-doc, professor) and constitutes the only example of performance based research funding where diversity is taken into account. Currently this amounts is only 2% of the total funding.

Remark VIII: Gender policies

It is very obvious that in Flanders both the «liking pipeline» and the «glass ceiling» are at work damaging the country performance and its ability to attract talent. A gender policy is needed to enable that both men and women contribute to the maximum of their ability to the welfare of the country and the performance of the universities.

Looking at the teaching staff distribution, in terms of nationality, at Flemish universities it was surprising to realise how small the numbers of non-Belgium staff are.

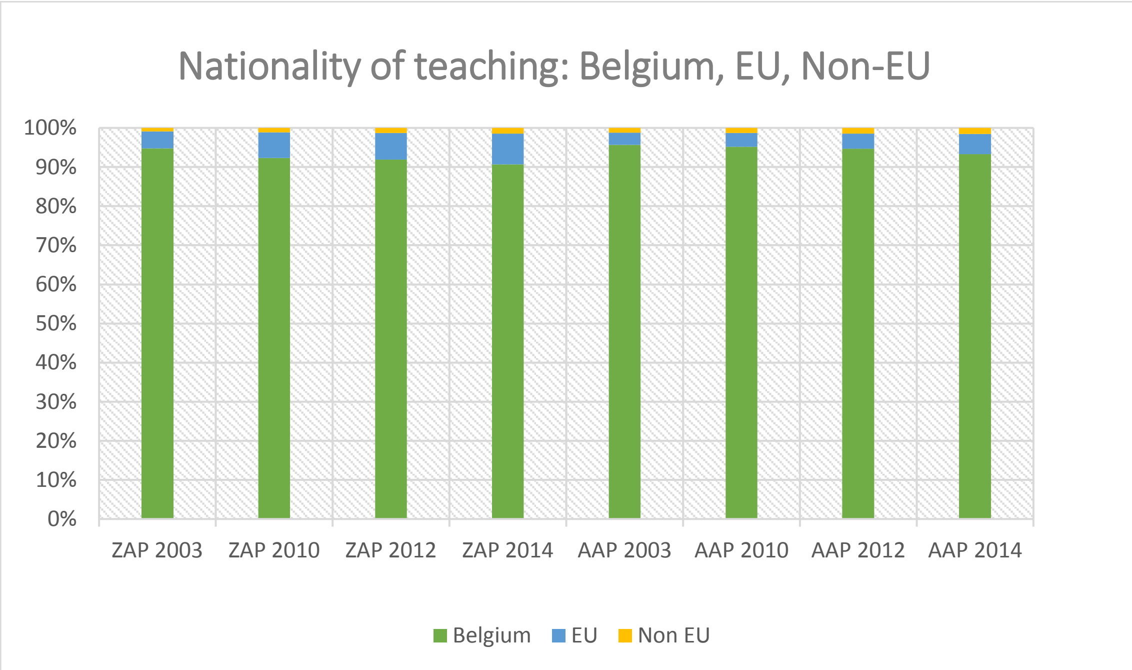

Figure 27, Source: ECOOM (6)

The situation improves if one looks at the case of the doctoral and postdoctoral community.

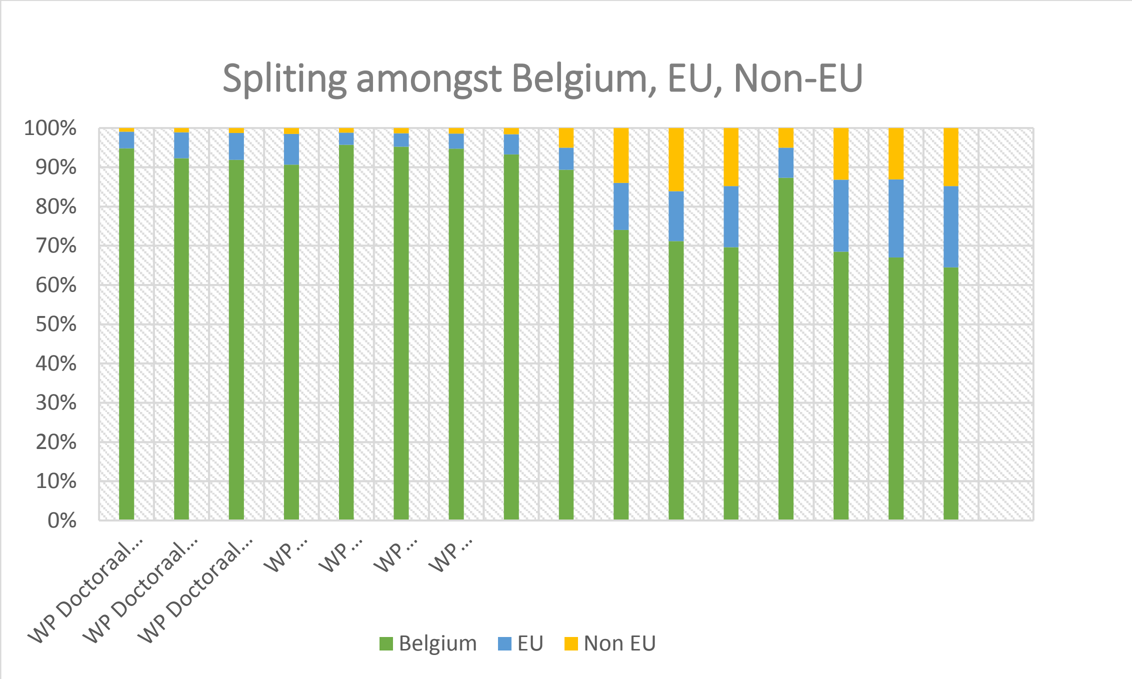

Figure 28, Source: ECOOM (6)

5 *The Future and Concluding Remarks*

Anticipating the future and «leading the revolution» or remain a follower?

Industrial revolution is the name given the movement in which machines changed people's way of life as well as their methods of manufacture.

- 1st IR: Used water and steam power to mechanize production and transport goods.
- 2nd IR: Used electricity to create mass production.
- 3rd IR: Used Electronic and information technology to automate production.
- 4th: A digital revolution, a fusion of technologies, a blurry of the lines between physical, digital and biological spheres. Artificial Intelligence is no longer scientific fiction.

All of them where accompanied by serious societal challenges with massive alteration in the job market. Jobs being lost and new skills required.

<u>The speed of change is now much higher!</u>

Anticipating the skills needed

The economic world forum in 2016 dedicated several sessions to the impact of technology on the job market. The expected changes on our way of life to occur in the next 10 years include, among others, that 10% of people will use clothes connected to the internet, 5% of consumer products printed in 3D, the first city with more than 50,000 people and no traffic lights – driverless cars and the first Artificial Intelligent machine on a corporate board of directors. Some of these, if not all, may seem today very farfetched, but the fact is that we have already about nine million devices in the internet of things and intelligent homes.

A number of notes emerge from the above:

1. Understand and make good use of connectivity is a must.
2. The needs of the job market CANNOT be predicted… but a coder will possibly be all right for the next 5/10 year otherwise physics, psychology, and language skills including computer language need to be combined! Ex: Data mining is about comparing patterns not fishing out data so linguistics and sociology might come in handy.
3. Multidisciplinary teams will be essential in dealing with the anticipated changes. Hence Chemistry, Physics, Biology, Engineering and Medical Sciences need continuing to mingle but **it is not enough** we need to build real and solid bridges across all the disciplines.
4. Only universities can do what is required, far and foremost research based EDUCATION without borders.

How can Flanders make an impact?

Working in multidisciplinary teams is essential - That needs training! for it is not so obvious as it seems. Use the competences and structures already in place (doctoral Schools, doctoral committees, postdoc community and the diverse advisory boards to promote strongly: Flexibility, Interdisciplinary approaches, Mobility between different disciplines faculties/universities and sectors). Invest on the public understanding of Science. Involve society at large. It is a change of mentality more than anything else.

Flanders Transdisciplinary Summer Conferences – The brand of Flanders Doctoral Education organised an involving ALL the doctoral schools in Flanders (aim at going across the border) where Science, Engineering, Humanities and Arts should be brought together to learn each other "languages" and challenges. Post Docs have the key competences and outlook to be the pivots of this initiative.

Upskilling & retraining on demand - Actual post-docs can organise themselves in order to upskilling and/or retrain people, on demand. It requires a business plan and support from the universities.

A common platform (owned by the 5 universities) for non-present and blended learning. Involve society needs. Post Docs mostly would like an academic career so teach as well as research, use that for a not so common initiative.

Conclusions

It has been shown that The Research and Higher Education Systems in Flanders are amongst the best in Europe. However, not enough interdisciplinary knowledge exists and a transdisciplinary approach to research is not common practice. Reinforcing the bridges with the productive sector is needed, as well as an enlarged vision about the constituents of this productive sector. Arts, Humanities, Sciences and Engineering contribute equally to the wealth of the country and its social cohesion.
The role of Social innovation to stimulate growth is underestimated in many European countries and Flanders seems to be no exception to the mainstream in this aspect.

There appears to be a considerable mismatch between the post-doc numbers and that of (available?) tenured posts at the universities. From the figures there were in 2014 about 3000 post-docs working in Flanders, quite a high number for the country. Those are the health the wealth of Flanders.

It is important that such situation (difficulty in obtaining a tenured position and late entry into the job market outside academia) does not translate in wasting the knowledge pool of Flanders. The differences in competences between a PhD holder and a person with postdoctoral experience needs to be clearly stated and explained to society at large. So that employers know when there is an advantage of hiring somebody with postdoctoral experience.

Address the remarks in the text to the stakeholders:

I. Post-Docs and Docs: remain flexible about the "kind" of employment, invest in networking, prepare the next move, using the «what if» principle. Understand the «languages» of other disciplines.
II. Universities: Involve industries and other employers in the process, through joint activities (not only projects), mobility from industry to academia and vice versa. Give higher importance to doc and post doc alumni keeping track of their careers and maintaining contact whenever possible.
III. Training in transversal skills and career planning should ALWAYS be included as mandatory for a successful completion of the PhD degree as well as made available to postdoctoral fellows.
IV. Advertise the advantages of hiring people with postdoctoral experience.
V. Have an adequate gender policy at all levels inside the Higher Education and Research Space in Flanders.
VI. To Government value and support the advisory institutions like the VWRI, ECOOM and others whose work is fundamental to inform decision making.
VII. To FWO consider non-renewable postdoctoral grants spanning four/five years. *Proof of concept* (JPH) grants
VIII. Think about future challenges outside the box.

<u>To take advantage (or even to manage) the immense changes that are brewing it is important that human capital is qualified at the highest possible level, obviously inside universities (a must) but working outside academia as well. Having a post-doctoral experience may become the key to deal successfully with the constrains and consequences of what is already called the fourth industrial revolution.</u>

A major requirement across the whole spectrum is and will be ETHICS.

Thanks: This work could not have been done without the help of colleagues in Flanders, the Steering Committee and Jean Pierre Henriet. A word of special thanks to Karen Vandevelde and Elie Ratinckx for their contribution in providing additional references and constructive comments.

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(13) Note from the authors: the figures were calculated using data that did not distinguish between junior researchers (anybody who does not (yet) have a PhD and do not intend to get such degree) and PhD students.

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