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HOW TO BOOST THE PHD LABOUR MARKET? FACTS FROM THE PHD SYSTEM SIDE

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Abstract

OCDE publications in the early 1990s on Science-Technology-Economy alerted several member countries on the prediction of a future shortage of skilled researchers and its possible impact on the economy. Consequently, on the decade 1998-2009 the number of doctorates handed out in all OECD countries grew by 31%. Doctoral holders are not only the most qualified in terms of educational attainment, but also those who are specifically trained to conduct research. Although the unemployment rate for doctoral holders is stabilized around 3% since 2006, nowadays it is becoming more and more difficult for them to find a job corresponding to their qualification. The recruitment of PhD graduates in the private sector (business, industry) should be considered a key avenue in converting research into commercialized innovations, technological progress and productivity growth of the countries. Universities and R&D and innovation policy makers are committed in boosting the PhD labour market. This paper discusses the diagnosis of the situation of the PhD job market, the careers and mobility of doctorates holders along the OCDE countries. Having analyzed the employment of PhD holders in the private sector and bearing in mind that most of the doctoral programs conform to a classical old model, our interest is focused on exploring significant relationships between the intensity of graduate's employment in private sector and new strategies implemented in recently upgraded doctoral systems. Conclusions relating recent reforms in the PhD system established in some OECD countries and their PhD labour market are stated out.
In this study we make intensive use of the data collected through a collaborative project launched by the OECD with the UNESCO Institute for Statistics (UIS) and Eurostat (OECD/UIS/Eurostat project) aimed at developing internationally comparable indicators on the careers and mobility of doctorate holders in 2009, the CDH project

Keywords: Career of doctorate holders; PhD; R&D and innovation; Reforms in Doctoral Education; University-governemnt-industry links;

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How to boost the PhD labour market? Facts from the PhD system side

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Abstract

OCDE publications in the early 1990s on Science-Technology-Economy alerted several member countries on the prediction of a future shortage of skilled researchers and its possible impact on the economy. Consequently, on the decade 1998-2009 the number of doctorates handed out in all OECD countries grew by 31%. Doctoral holders are not only the most qualified in terms of educational attainment, but also those who are specifically trained to conduct research. Although the unemployment rate for doctoral holders is stabilized around 3% since 2006, nowadays it is becoming more and more difficult for them to find a job corresponding to their qualification. The recruitment of PhD graduates in the private sector (business, industry) should be considered a key avenue in converting research into commercialized innovations, technological progress and productivity growth of the countries. Universities and R&D and innovation policy makers are committed in boosting the PhD labour market. The main purpose of the study is twofold. First, to identify from both perspectives, the academia and the R&D and innovation policies, the factors and actions that may play a relevant role in boosting the PhD labour market, especially in the absorption of PhD holders by the private sector. Secondly, to evaluate the real impact of these factors in the PhD labour market.

This paper discusses the diagnosis of the situation of the PhD job market, the careers and mobility of doctorates holders along the OCDE countries. Facts from their satisfaction in terms of salaries, benefits, job security, working conditions or opportunities of advancement are shown. Having analyzed the employment of PhD holders in the private sector and bearing in mind that most of the doctoral programs conform to a classical old model, our interest is focused on exploring significant relationships between the intensity of graduate's employment in private sector and new strategies implemented in recently upgraded doctoral systems. Conclusions relating recent reforms in the PhD system established in some OECD countries and their PhD labour market are stated out.

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[1] The 'Careers of Doctorate Holders' (CDH) project aims at developing internationally comparable indicators on the careers and mobility of the most qualified personnel in science and technology. It brings together researchers from 25 countries under the auspices of the three major international organizations: OECD, Eurostat and the UNESCO Institute for Statistics.

1. Introduction

Doctorate holders constitute a vital human resource in the research sector and, as such, contribute to rising competitiveness in knowledge economies. In many fields, universities produce many more PhDs than it could accommodate in tenured positions and private sector (business and industry) is unable to take up the slack. Supply has outstripped demand and although many PhD holders end up employed, many doctorates are taking jobs that do not require a PhD, which is a waste of resources. In Cyranoski et al. (2011) this fact is sketched in what they called *The PhD Factory* (this contribution is included in the interesting issue '*The future of the PhD'* [3]). Universities and education and R&D policy makers are committed to solve this problem and put particular emphasis on strength the relations between companies and universities, promoting the recruitment of graduate students in the private sector. This co-operation can be considered an important avenue in converting publicly funded basic research into commercialized innovations, technological progress and productivity growth. Types of links between universities and firms have been analyzed by Bonaccorsi and Piccaluga (1994), D'Este and Fontana (2007), De Fuentes and Dutrénit (2012), Giuliani et al. (2010), Mora Valentin (2002), Taran Thune (2009a, 2009b) and Schartinger et al. (2002). Recently, *Open R&D and open innovation* has appeared as a new phenomenon defined as "the use of purposive inflows and outflows of knowledge to accelerate internal R&D and innovation, and expand the markets for external use of the R&D and innovation". This new concept has implications in the role of the R&D at the universities and may foster its journey from *the ivory towers to knowledge brokers* as is pointed out by Asakawa et al. (2010) and Gassman et al. (2010).

Conferred by universities, doctorates require at least three years of study beyond a master's degree (which itself requires four or five years of post-secondary study) and a successful defense of a dissertation. American universities geared the first: by 1970 the United States was producing just under a third of the world's university students and half of its science and technology PhDs. Since 1998 the annual output of PhD in the United States has increased about 48% from 45.876 to 67.716[4] in 2009. Since 2000, the number of OECD-area doctorates increased to reach more than 223.000 new doctorate holders in 2009. Between 1998 and 2009 the number of doctorates handed out in all OECD countries grew by 31%, compared with 17% in France and 2% in Germany. In Spain the amount of PhD holders has increased around 33%. Even Japan, where the number of young people is shrinking, churned out about 67% more PhDs. In 2009, the PhD holders in the United States were just 30% of all OECD new graduates at doctoral level, as is shown in Figure 1. United States, Germany and United Kingdom together accumulate half of all OCDE new graduates at doctoral level in 2009. Spain accounts for approximately 3% of that total, ranked seventh, after Korea, Italy, France, Japan, United Kingdom, Germany and the United States.

Most countries, convinced that higher education and scientific research are key to economic growth and prosperity are expanding doctoral education. Combined with increasing rates of unemployment of young professionals in some countries, this expansive policy is further enhanced. A small but growing proportion of the population obtains an advanced research

[2] The 'Knowledge for Innovation' (KnowINNO) project brings CDH methodology into a wider context of comparative analysis of knowledge flows and returns on investment of the long academic training of doctorate holders. It is also coordinated by the OECD and partially funded under the Seventh Framework Programme (FP7) of the European Union. The project involves researchers from 12 countries.

[3] Nature 472, 21 April 2011

[4] Source: Education at a Glance 2011: OECD Indicators, OECD, Paris.

program degree. Figure 2 shows the graduation rates at doctorate level in OECD countries in 2009[5]. In the decade 2000-2009 the OCDE average of new doctorate graduates per 1000 population aged 25-34 has increased from 1 to 1,5 while for the same period the EU-27 average has increased from 1 to 1,6.

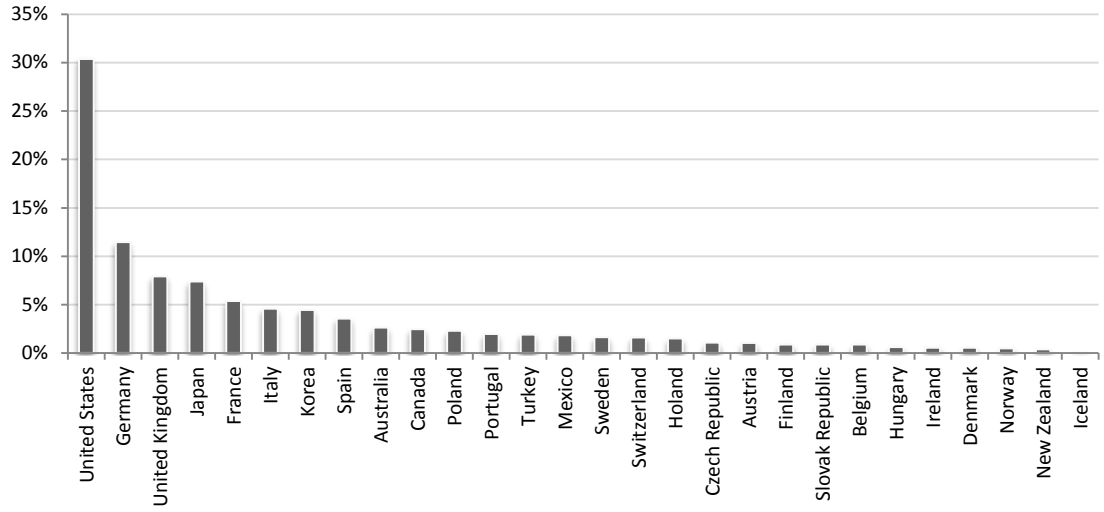

Figure 1. New graduates at doctorate level, 2009 (as a percentage of total OECD new graduates at doctorate level)[4].

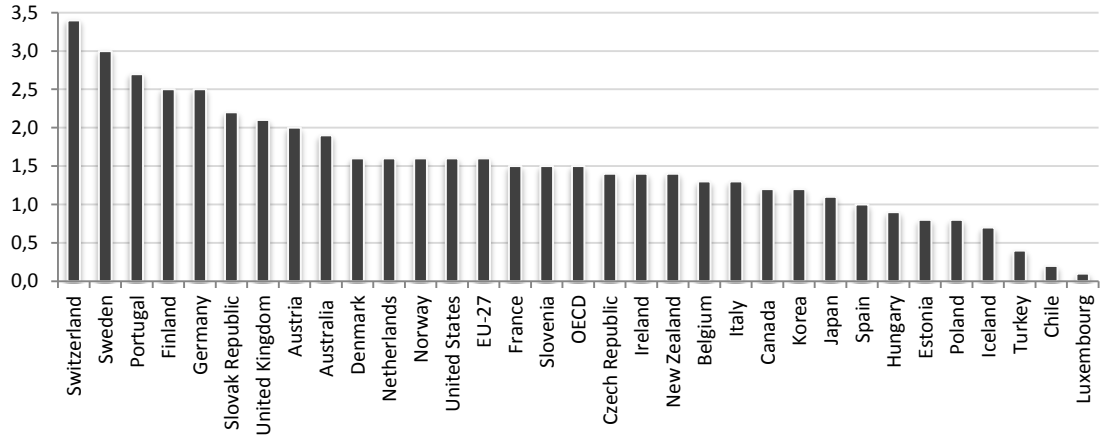

Figure 2. New doctorate graduates (ISCED6) per 1000 population aged 25-34, 2009[4].

Public authorities of developed countries since 1990 have increasingly provided strong incentives to train PhD graduates, bearing in mind that economic competition between countries were more and more based on their abilities to innovate. An interesting analysis of the incentives of the PhD supervisors and the PhD students can be found in Mangematin (2000). Clearly, such expansion of PhD holders results in an extraordinary amount of good research, but there are reasons for caution. Firstly, because unlimited growth could dilute the quality of PhDs and secondly, because increasing government research funding drives expansion of doctoral and

[5] Source: OECD, Education Database 2010.

postdoctoral education without giving enough thought to how the labor market will accommodate those who emerge. Actually, the PhD system is driven by the supply or research funding, not the demand of the job market, but unfortunately, earning a PhD does not guarantee a permanent position in either academia or industry. Graduate students struggle to find faculty positions in academia and often they only get a postdoc or other untenured academic position, and the rise of the postdoc has created another obstacle on the way to an academic post. Even if graduate students obtain a job outside academia, in much of the cases they are taking jobs that do not require a PhD. This lack of job opportunities for science and engineering PhDs has been analyzed by Dany and Mangematin (2004), Enders (2002a and 2005), Fox and Stephan (2001) and Stephan et al. (2004). Most of the recent academic contributions on PhD holders tell us a lot only about those who enter academia, and the analysis is typically limited to PhD graduates involved in academia after graduating, for example as contributors to the most prestigious journals; see for instance Cruz-Castro and Sanz-Menendez (2010), Jacob and Legfren (2011), Enders (2002b), Morrison et al. (2011), Banes and Randall (2012) and references therein. The science and technology transfer operated by the recruitment of PhD graduates in the private sector is highlighted by only a few studies and are mentioned only in some statistics, see for instance Zacker, Darby and Armstrong (2002) and Zacker, Darby and Torero (2002) and references therein. On the other hand, Lee, Miozzo and Laredo (2010) have recently study career patterns of PhD focused on science and engineering, and examine the different types of careers highlighting the types of competences acquired from doctoral education valuable in the different career types. A very interesting work is the one published by García-Quevedo et. al (2012) analyzing the determinants of the demand for PhDs in the firms. The results from their analysis show that cooperation between firms and universities encourage firms to recruit PhDs and pointed out the existence of accumulative effects in the hiring of PhD graduates. These results are consistent with those obtained in Benito and Romera (2013). That work analyze the main drivers of the R&D and innovation and also provide measures of the influence of government funding for private R&D and innovation in the PhD graduate employment.

Despite all these contributions several questions still arise.

1) The growth of the PhDs production shows no sign of slowing. Ph D graduates in much of the world may never get a chance to take full advantage of their qualifications although few PhD holders end up unemployed. *Is it clear that spending years securing this high-level qualification is worth for their jobs? What is the return on investment of their long academic training (more than seven or eight years)?* Much of the increase is due to an improved participation of women. *How is the balance? Which is the distribution by gender over the fields of study and employment sectors?*

2) Human resources are recognized as being key to the creation, commercialization and diffusion of innovation. Among them, doctorate holders are not only the most qualified in terms of educational attainment, but also those who are specifically trained to conduct research. The main purpose of the doctoral education is to produce an original and valuable open-ended piece of research able to contribute to its discipline, the PhD thesis. Accompanying its production, the process of a PhD study can be perceived as a journey of individual learning to acquire knowledge in the discipline and also procedures to construct knowledge. Those successful post-graduates should leave university with knowledge and skills, some of which are subject-specific and others that are more general and transferable. *What share of doctorate holders goes into a research*

career? What type of jobs do doctorate holders get on the labour market? Do they get stable research positions? What employment sectors are the most receptive for PhD holders?

3) Mobility is often seen as a key vehicle for knowledge transfer. *How mobile are doctorate holders between countries? How mobile are doctorate holders between employment sectors?* About the level of satisfaction with their employment situation, *are they satisfied with their benefits, salaries, intellectual challenges, social status and working conditions?*

4) Universities are committed to the new role of doctoral education, tackling the problem of training researchers for high-level positions in careers inside and outside academia. Although most doctoral programs conform to a model defined several centuries ago, many countries have therefore recently reformed their doctoral programs in order to facilitate the entry of new doctoral graduates on the labour market, notably by developing their skills in management, teamwork, fund rising or other so-called "soft skills" which are increasingly requested by potential employers. The necessary changes are both curricular and institutional. In this matter, beyond faculty members, students, administrators, trustees, and even people from the public and private sectors must create pressure for reform PhD systems. To facilitate change, actors should move away from excessive competition and develop structures and procedures to foster cooperation between universities. So, *what has been the reaction of the different countries in terms of reforming their PhD systems?*

In this paper we try to answer some of the issues above. We focus on the analysis of the career of doctorate holders and the evaluation of the new PhD training systems designed in OECD countries. The paper is organized as follows. Section 2 shows facts and figures about the employment situation and the level of satisfaction of the PhD holders along OECD countries. Section 3 examines the recent changes introduced in the PhD systems of different countries. Section 4 presents conclusions and recommendations.

2. The career of doctorate holders

'Career' refers to an individual's work and life roles over their lifespan. It can encompass a number of distinct areas, types of role, employment sectors and so on. Over the past decade there has been a growing interest in the role of the doctorate and how it should be promoted as an appropriate basis for a career in any sector as, historically, it has primarily been seen as training for an academic career. This is an emerging topic of focus and there is widespread acknowledgement of the need to increase our understanding of career pathways for doctorate holders by collecting more data.

Collected data ranging from European university level can be found in: *The situation of doctoral candidates within Europe*, Eurodoc (2010); the annual survey conducted by the UK national agency *HESA*; the annual *COTEC* (Spain) report or the *STELLA* survey of Italian doctoral graduates (2009). The Final Report of the *DOCENT Project* (2010) reviews material collected on good practice on employability for doctoral graduates within the European framework. The Careers of Doctorate Holders survey for the reference year 2006 (CDH 2006)

was the first international, coordinated round of this data collection. In total, 26 countries participated in the initial CDH 2006 survey and the main findings of the first data collection and their results on employment and mobility patterns are presented in Auriol (2007; 2010). In 2010, the CDH survey was carried out for a second time with reference to the 2009 data (CDH 2009) for most of the countries, and to 2008 data for four countries, referring to graduation years 1990 onwards. The survey was again conducted in 26 countries, i.e. 16 EU Member States, 3 EU Candidate countries, 2 EFTA countries and 5 other OECD countries from the rest of the world. Further information on the CDH project is available under www.oecd.org/sti/cdh.

In the framework of the CDH project, the data collected through the European and non-European countries participating in the 2011-2012 exercise help to determine the employment picture of the PhD holders in 2009.

Which are the main characteristics of the 1990-2009 doctoral population, in 2009?

The highest numbers of PhD holders correspond to United States (708 900; in 2006, the number of 1990-2006 graduates was 340 800), Germany (360 460; in 2006 the number was 273 150) and Switzerland (143 647). *Women are still under-represented at this level of education and accounts for 37% on average, similar proportion as in 2006*. Their share among total 1990-2009 doctoral holders represents more than 40% only in one-third of the OCDE countries participating in the exercise. The median age at graduation of recent doctorate holders reaches 35 years, for natural science and engineering doctorate holders the median reaches 32 years, 36.2 years for medical sciences and 37.6 years for humanities.

In 2009, for most countries the share of the 1990-2009 doctoral graduates in natural sciences accounts for 26% (20% in 2006). Graduates in natural sciences represent 41.8% of total doctorate holders in Israel and 18% in Sweden. Graduates in engineering for most of the countries represent 18 % (the same in 2006); exceptions to this are Spain (8%), Israel (9.4%) and on the other extreme the Russian Federation (26.2%) and Bulgaria (26.5%). Medical sciences represent 17% of total doctoral holders. This field of specialization remains the first field of doctorate award in Germany representing around 30% of the German doctorates (30.6% in 2006). Social sciences represent 18% of total doctorate holders, humanities 13% and agricultural sciences 5%.

One way for doctoral students to expand their knowledge of cultures and languages, and better equip themselves in an increasingly globalised market, is to pursue their higher-level education in countries other than their town. Some countries, particularly in the European Union, have established policies and schemes that promote such mobility to foster intercultural contacts and help build social networks. *Data on doctorate holders in 2009 reveal that in European countries 15% to 30% have experienced mobility over the past ten years*. International mobility of professionals is driven by a variety of motives ranging from personal and family considerations to academic and job-related reasons. For countries where data are available, the highest mobility rate corresponds to the graduate students of Denmark that reaches 30.3%, followed by Malta, Belgium and Austria. In Spain, 21.1% of doctorate holders had stayed abroad in the last ten years, the breakdown of their last destination was: 13.1% in Europe, 5.1% in the United States and 2.9% in other countries (see Figure 3). Similar pattern follows the rest of the countries for which data are available. Over respondent, national citizen with a doctorate having lived or

stayed abroad in the past ten years, 6 out of 10 have been in Europe and 2 out of 10 in United States.

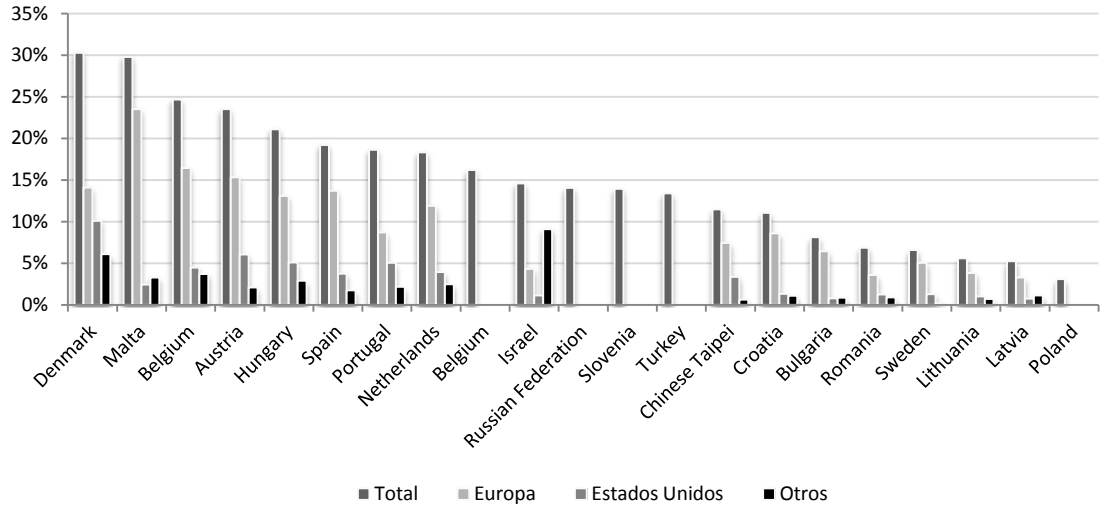

Figure 3. International mobility of doctorate holders, by main destination, 2009[6,7].

Which are the main labour market characteristics for the 1990-2009 doctoral population, in 2009?

The unemployment rate for doctorate holders (defined as then number of unemployed people in %age of the total labour force) remains stabilized in less than 2%, even under the influence of the emerging economic downturn of 2008. On average, across the analyzed countries the unemployment rate of doctorate holders in 2009 is 1.2% (see Figure 4). The highest rate corresponds to Finland and Spain, 2.1%. This figure is especially relevant, bearing in mind that unemployment rates for those with a tertiary education, remained below 10% in all OECD countries, even in Spain which had however one of the highest unemployment rates (9% - ranks second among OECD countries) for tertiary educated individuals, more than twice the OECD average of 4.4%.

In comparison to other OECD countries, the employability of doctorate holders in France (which did not take part of the OECD/UIS/Eurostat project) follows a different pattern. While the employability of higher education graduates increases with the level of education[8], since the early 2000s there has been an exception to the rule at the doctoral level: whereas in 2007 young French people with master's degrees has an unemployment rate of 7%, the figure for French doctorate holders is 10%[9].

[6] OECD/UNESCO Institute for Statistics/Eurostat data collection on careers of doctorate holders 2010.

[7] OECD/UNESCO Institute for Statistics/Eurostat data collection on careers of doctorate holders 2006 for Austria, Belgium and Denmark. Also, data of main destinations for Spain.

[8] In 2009, the unemployment rate in the EU-27 area for people in all ISCED educational level (people from 15 to 64 years) was 9%, compared with the 5% for people attained with first and second stage of tertiary education (level 5 and 6). Source: Eurostat.

[9] Source: Centre d'analyse stratégique. Labour and Employment: La note d'analyse nº 189, 2010 (http://www.strategie.gouv.fr).

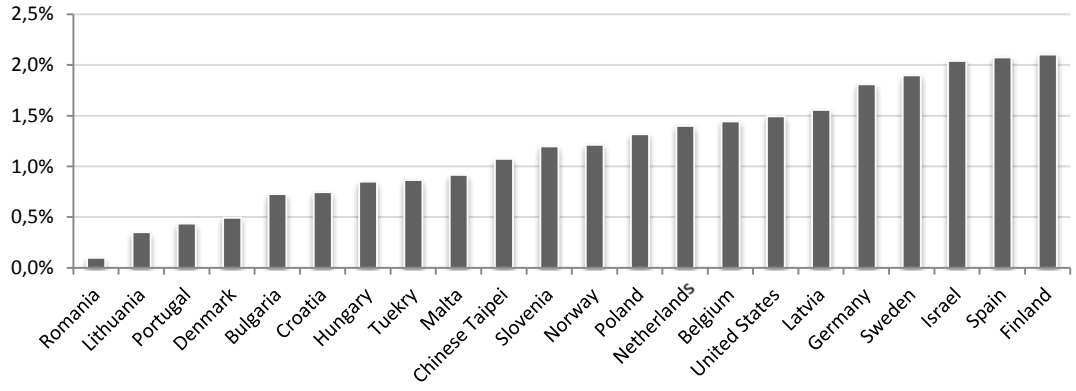

Figure 4. Unemployment rate of doctorate holders, 2009[6].

In most countries, the unemployment rate of females with university degrees is higher than that of men with the same educational level. Figure 5 shows that unemployment rates of doctoral graduates follow a similar pattern. Generally, women take longer (in years following the doctorate award) than for men until their unemployment rate stabilizes around 2%. Spain is the second country with the highest unemployment rate of graduate women (2.57% against 1.7% for men), closely followed by Germany (2.45% against 1.5%) and Finland (2.35% against 1.9%) as is shown in Figure 5. For women, 3% of doctorate holders were unemployed in Spain in 2006. In Germany, for women 3.9% of doctorate holders were unemployed in 2006 and 4.7% in 2004. This data show that women are more likely to be unemployed. This may be due for several reasons, among which include their younger age as compared to men and higher share in disciplines for which unemployment is higher, like the humanities.

By field of study, women represent more than 45% of total employed PhD holders in humanities, more than 44% in social sciences, more than 47% in medical sciences and 24% in engineering. In United States, 88.7% of the employed engineering doctoral holders are women, and 74.3% of the employed natural sciences doctoral holders are women, which are unexpected shares since for the rest of the countries women represent around 24% of employed engineering doctorate holders, and 36% of employed natural science doctorate holders. In Romania and the Russian Federation, 57% of the employed medical sciences doctoral holders are women.

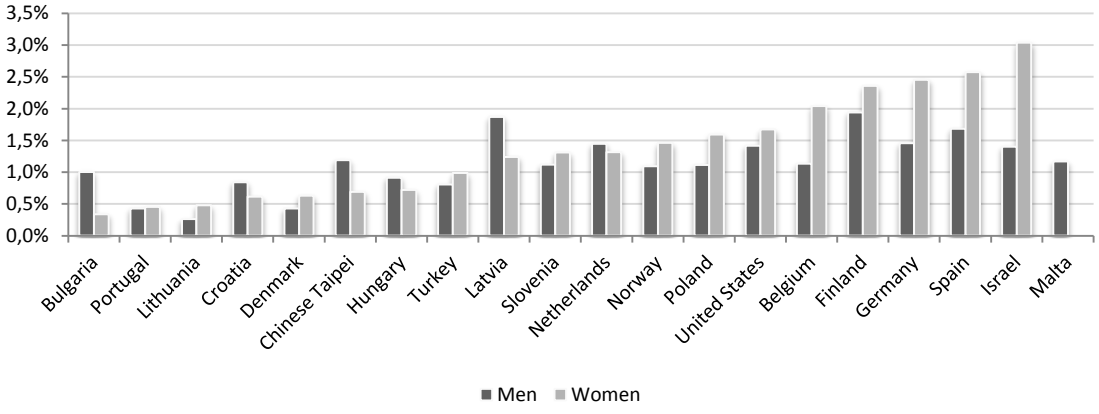

Figure 5. Unemployment rate of doctorate holders by gender, 2009[6].

By fields of doctoral degree and taking both men and women together, the unemployment rates of doctoral graduates in the humanities are generally higher than those in other fields (3.9% in Netherlands). Table 1 shows the unemployment rate of doctorate holders by field of doctoral degree in 2009. Agricultural sciences also account for high rates of unemployment (9.9% in Israel). In Spain, the highest unemployment rate is for agricultural sciences (4.6%), but only 3% of the Spanish graduate students are in this field of study. *Engineering and social sciences presents the lowest rates of unemployment, 65% of the countries participating present an unemployment rate of engineering doctoral graduates less than 1%*. For social sciences this figure is 50% of the countries and for natural sciences 40% of the countries. It is remarkable that the previous CDH project' data collections (2004 and 2006) had revealed relatively higher unemployment rates of doctoral graduates in natural sciences and engineering, and one of the reasons for this may be the economic downturn following the burst of the 1990's IT bubble.

Table 1. Unemployment rate of doctorate holders by field of study, 2009[6].

	Total	Natural sciences	Engineering	Medical sciences	Agricultural Sciences	Social sciences	Humanities	Unknown
Romania	0,1%	0,4%	0,0%	0,0%	0,2%	0,0%	0,0%	
Lithuania	0,4%	0,2%	0,3%	0,6%	0,0%	0,3%	0,7%	
Portugal	0,4%	0,2%	0,6%	1,1%	0,4%	0,4%	0,3%	
Denmark	0,5%	0,6%	0,1%	0,4%	1,0%	0,4%	1,1%	
Bulgaria	0,7%	0,8%	0,6%	1,1%	0,0%	0,0%	1,5%	
Croatia	0,7%	0,4%	0,0%	1,5%	1,0%	1,1%	0,5%	
Hungary	0,9%	0,5%	0,9%	1,1%	0,0%	0,0%	2,8%	5,6%
Tuekry	0,9%	0,7%	0,8%	0,8%	1,7%	1,2%	0,2%	
Malta	0,9%	1,4%	1,9%	1,6%	0,0%	0,9%	0,0%	
Chinese Taipei	1,1%	1,7%	0,9%	0,8%	2,5%	0,7%	1,0%	2,3%
Slovenia	1,2%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
Norway	1,2%	1,0%	1,1%	1,0%	1,2%	0,9%	2,2%	2,9%
Poland	1,3%	2,1%	0,8%	0,7%	1,7%	0,4%	1,8%	
Netherlands	1,4%	1,7%	1,3%	0,6%	1,7%	1,3%	3,9%	
Belgium	1,4%	1,4%	0,9%	0,7%	0,7%	1,9%	3,7%	2,5%
United States	1,5%	1,7%	1,6%	1,5%	1,6%	1,1%	n.a.	
Latvia	1,6%	1,8%	0,7%	1,3%	2,8%	1,5%	2,4%	
Germany	1,8%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
Sweden	1,9%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
Israel	2,0%	2,2%	n.a.	2,4%	9,9%	1,0%	3,7%	
Spain	2,1%	2,8%	1,5%	1,2%	4,6%	1,4%	2,4%	
Finland	2,1%	3,1%	1,4%	0,8%	3,4%	2,3%	3,6%	8,8%

What type of jobs do doctorate holders get on the labour market?

Although there is an employment premium linked to doctoral education, the transition to full employment can take several years and the match between educational attainment and occupation it is not perfect. Especially in the early stage of their careers, doctorate holders are on temporary contract and in particular they can be employed in postdoctoral position for several years. Figure 6 depicts rates by type of contract for employed doctorate holders. The proportion of permanent contract for the employed doctorate holders in most of the countries reaches more than 75%. Moreover, *more than 50% of the countries participating present a proportion of permanent contract greater than 80%*, accounting for 83.5% on average. Romania, Turkey, Bulgaria, Lithuania, Hungary and Malta present permanent contract rates greater than 90%. An exception to this is the Russian Federation which presents the lowest rate

of permanent contract in 2009 (62%). This rate in Spain accounts for 76.1%. Actually, those high rates of temporary contracts are due the greater frequency of post-doctoral work, especially with development of research project financing.

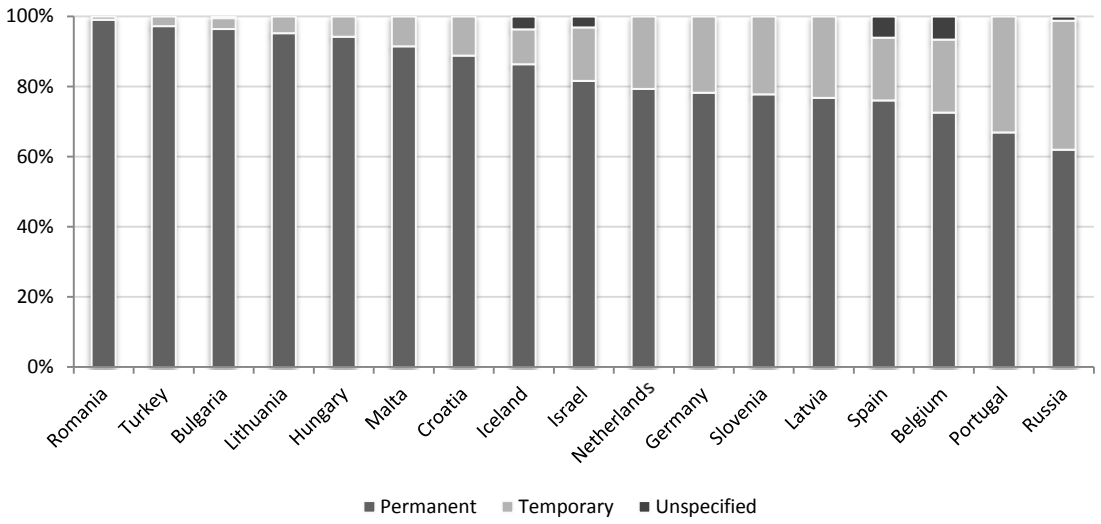

Figure 6. Employed doctorate holders by type of contract, 2009[6].

According to the field of study we found out substantial differences (see Table 2). For most countries, in the fields of natural and medical sciences the rates of permanent contract represent around 83% (75% in 2006). Engineering sciences present the highest rate of permanent contract, 87.2% on average (93% in 2006). This rate in Germany reaches 87.7% and in the Russian Federation represents 59%. The ratio of permanent contract in social sciences ranges between 60% in the Russian Federation and 99% in Romania and represents 70% in Portugal and Latvia. The ratio for permanent contracts in humanities represents 80.6% on average (75% in 2006) and it is lower than those in other fields. For the Russian Federation this ratio represents 47.3%. In agricultural sciences, the ratio of permanent contracts reaches 58.9% (Malta) to 100% (Bulgaria), and it represents more than 80% in 60% of the countries.

Getting people working as researchers in the labour market is critical for innovation. In the OECD countries for which data are available, a majority of doctorate holders are employed as researchers, but in contrast to common beliefs, the majority of researchers do not hold a doctoral degree. In general, for the OECD countries with data, less than 50% of researchers have doctorate, with Poland and the Slovak Republic being the exceptions[10]. The share of researchers with doctorates is larger in the higher education sector, and for the countries with data, the share of business sector researchers with doctorates is often less than 40%. In 2005, this share in the business enterprise sector accounted for 15%. In 2007, French doctorate holders accounted for only 13.6% of business researchers, versus over 50% of engineers[11].

[10] OECD Main Science and Technology Indicators database, February 2011.

[11] Source: Centre d'analyse stratégique. Labour and Employment: La note d'analyse nº 189, 2010 (http://www.strategie.gouv.fr).

Table 2. Employed doctorate holders, by field of study and type of contact, 2009[6].

	Natural sciences			Engineering			Medical sciences		
	Permanent contract	Temporary contract	Unspecified	Permanent contract	Temporary contract	Unspecified	Permanent contract	Temporary contract	Unspecified
Belgium	72,4%	21,0%	6,6%	80,3%	15,1%	4,6%	71,1%	21,3%	7,7%
Bulgaria	98,3%	1,7%	..	96,2%	3,0%	0,8%	95,2%	3,0%	1,8%
Croatia	87,7%	12,3%	..	90,3%	9,7%	..	92,5%	7,5%	..
Germany	78,1%	21,9%	..	87,7%	12,3%	..	71,3%	28,7%	..
Hungary	89,7%	10,3%	..	95,4%	4,6%	..	95,4%	4,6%	..
Iceland	87,0%	13,0%	..	93,2%	6,8%	..	82,7%	17,3%	..
Israel	82,4%	14,0%	3,7%	89,1%	10,4%	0,5%	91,8%	6,4%	1,8%
Latvia	83,5%	16,5%	..	80,8%	19,2%	..	79,6%	20,4%	..
Lithuania	93,5%	6,5%	..	95,6%	4,4%	..	99,1%	0,9%	..
Malta	95,4%	4,6%	..	95,7%	4,3%	..	90,5%	9,5%	..
Netherlands	77,8%	22,2%	..	86,7%	13,3%	..	75,4%	24,6%	..
Portugal	59,8%	40,2%	..	73,6%	26,4%	..	71,3%	28,7%	..
Romania	98,6%	1,4%	..	99,3%	0,7%	..	99,4%	0,6%	..
Russian Federation	66,1%	33,0%	1,0%	59,2%	39,2%	1,6%	67,5%	31,5%	1,0%
Slovenia	77,6%	22,4%	..	76,5%	23,5%	..	79,5%	20,5%	..
Spain	73,8%	23,1%	3,1%	85,7%	9,7%	4,7%	71,9%	17,5%	10,6%
Turkey	97,4%	2,6%	..	97,0%	3,0%	..	97,2%	2,8%	..
	Agricultural Sciences			**Social sciences**			**Humanities**		
	Permanent contract	Temporary contract	Unspecified	Permanent contract	Temporary contract	Unspecified	Permanent contract	Temporary contract	Unspecified
Belgium	73,5%	20,5%	6,0%	71,1%	23,0%	5,8%	63,0%	29,0%	8,0%
Bulgaria	100,0%	0,0%	..	94,2%	5,8%	..	95,9%	3,8%	0,3%
Croatia	93,5%	6,5%	..	83,9%	16,1%	..	85,0%	15,0%	..
Germany	84,1%	15,9%	..	85,6%	14,3%	..	75,5%	24,5%	0,0%
Hungary	97,5%	2,5%	..	96,7%	3,3%	..	97,2%	2,8%	..
Iceland	92,5%	7,5%	..	92,5%	7,5%	..	97,4%	2,6%	..
Israel	91,0%	9,0%	..	80,3%	15,7%	4,0%	66,0%	31,8%	2,3%
Latvia	65,7%	34,3%	..	69,8%	30,2%	..	66,4%	33,6%	..
Lithuania	99,0%	1,0%	..	94,9%	5,1%	..	92,1%	7,9%	..
Malta	58,9%	41,1%	..	90,0%	10,0%	..	91,1%	8,9%	..
Netherlands	81,1%	18,9%	..	80,1%	19,9%	..	76,2%	23,8%	..
Portugal	74,3%	25,7%	..	69,3%	30,7%	..	64,4%	35,6%	..
Romania	99,5%	0,5%	..	99,2%	0,8%	..	98,5%	1,5%	..
Russian Federation	69,0%	29,8%	1,2%	59,8%	38,7%	1,5%	47,3%	51,5%	1,3%
Slovenia	83,9%	16,1%	..	74,8%	25,3%	..	80,8%	19,2%	..
Spain	78,4%	15,1%	6,5%	78,6%	13,9%	7,6%	78,1%	16,9%	5,0%
Turkey	97,9%	2,1%	..	97,9%	2,1%	..	95,7%	4,3%	..

The proportion of PhD holders working as researchers in 2009 reaches 68.6%, on average (see Figure 7). In Portugal and Poland, up to 90% of recent doctorate holders are active as researchers. In Chinese Taipei only 19% of the recent doctorate holders are active as researchers. This represents 30% in the Russian Federation and 63.5% in Netherlands. Table 3 depicts the field of study distribution of doctorate holders employed as researchers and non-researchers, in 2009.On average, the highest proportion of graduate students working as researchers corresponds to natural sciences field (29.5%) followed by engineering (20%) and social sciences (18%). Medical sciences proportion of graduate working as researchers account for 14%. For humanities graduates this share represents 12.5% and for agricultural sciences graduates it represents 6%. Graduates in natural sciences represent on average, 22% of doctorate holders employed as non-researchers in countries participating; engineering graduates represent 18% and medical sciences graduates 20%. This figure rises to 22% for doctorate holders in social sciences.

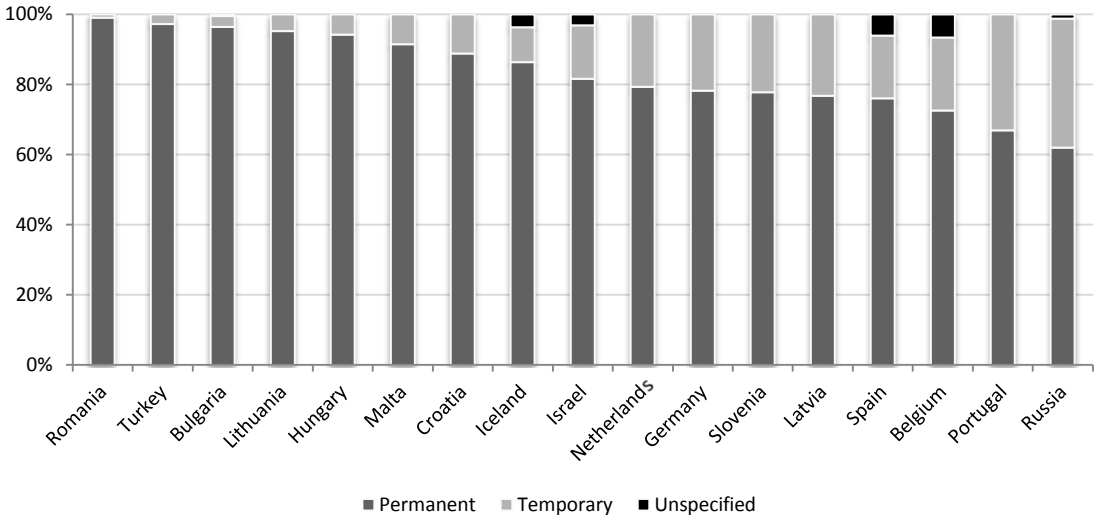

Figure 7. Employed doctorate holders by research status, 2009[6].

Table 3. Field of study distribucion of doctorate holders employed as researchers and non-researchers[6]

	EMPLOYED AS RESEARCHERS							EMPLOYED AS NON-RESEARCHERS						
	Natural Sciences	Engineering	Medical Sciences	Agricultural Sciences	Social Sciences	Humanities	Unkonwn	Natural Science	Engineering	Medical Sciences	Agricultural Sciences	Social Sciences	Humanities	Unkonwn
Belgium	33,0%	21,7%	16,5%	6,3%	11,7%	8,1%	2,7%	36,3%	16,8%	15,6%	8,0%	10,5%	10,3%	2,5%
Bulgaria	19,6%	26,2%	9,5%	8,3%	15,6%	19,7%	1,1%	13,1%	27,3%	11,1%	5,5%	17,7%	24,2%	1,1%
Chinese Taipei	28,6%	37,7%	13,3%	6,0%	7,5%	3,0%	3,8%	15,1%	33,2%	5,6%	4,4%	30,4%	10,4%	0,9%
Croatia	20,1%	21,2%	17,4%	11,1%	16,9%	13,3%		15,6%	14,7%	33,3%	10,2%	17,0%	9,2%	
Hungary	35,7%	11,4%	9,7%	10,0%	19,7%	13,3%	0,2%	20,9%	15,7%	16,2%	8,9%	23,8%	13,2%	1,3%
Israel	48,9%	11,4%	7,3%	1,7%	20,6%	9,7%	0,4%	29,2%	7,1%	12,6%	2,1%	31,9%	15,4%	1,7%
Latvia	29,7%	19,9%	12,3%	3,4%	20,5%	14,1%		33,8%	20,3%	14,9%	3,0%	17,3%	10,7%	
Lithuania	26,1%	19,5%	15,1%	6,3%	19,5%	13,5%		25,1%	18,3%	18,0%	6,4%	22,3%	9,8%	
Malta	16,8%	12,4%	12,5%	0,7%	31,4%	26,2%		15,6%	11,1%	17,3%	3,5%	24,3%	28,2%	
Netherlands	27,9%	20,2%	22,3%	4,7%	19,7%	5,2%		25,1%	15,1%	33,7%	3,2%	15,7%	7,2%	
Norway	27,4%	11,1%	22,0%	5,5%	21,7%	12,2%		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
Poland	23,7%	20,9%	10,7%	5,8%	20,9%	18,1%		20,6%	23,9%	10,3%	10,5%	19,2%	15,4%	
Portugal	34,2%	23,4%	9,0%	3,1%	18,9%	11,4%		18,6%	16,6%	13,5%	5,3%	33,9%	12,1%	
Romania	24,5%	28,6%	9,8%	9,1%	13,8%	14,3%		10,0%	17,5%	25,9%	5,9%	20,8%	19,9%	
Russian Federation	51,7%	17,6%	7,1%	9,3%	12,4%	2,0%		31,4%	29,9%	5,5%	3,3%	20,6%	9,3%	
Slovenia	28,7%	23,0%	11,4%	6,2%	19,1%	11,7%		22,9%	17,3%	16,2%	5,6%	23,4%	14,6%	
Spain	38,9%	9,8%	12,1%	3,1%	22,3%	13,8%		25,1%	5,5%	35,2%	2,8%	16,8%	14,6%	
Turkey	18,8%	15,6%	29,7%	9,7%	15,6%	10,6%		7,7%	10,0%	50,0%	3,6%	17,3%	11,5%	
United States	45,1%	20,9%	9,0%	4,0%	21,1%	n.a.		35,7%	12,4%	9,9%	3,0%	39,0%	n.a.	

Data on their earnings reveal that in most countries for which information is available, doctoral graduates are better paid when they work as researchers, especially in the higher education sector. Non-researchers are better paid in the government sector (see Figure 8). In the United States, doctorate holders earn 12.4% more when they work as researchers (all sectors), and in the business sector, as non-researchers they earn 4% more than researchers. In Spain, the highest earnings are for doctorate holders working as researchers in the business sector where they earn 13.3% more than non-researchers. In the government sector, non-researchers earn 11.8% more than researchers. In the higher-education sectors there is no difference in the median gross annual earning between researchers and non-researchers.

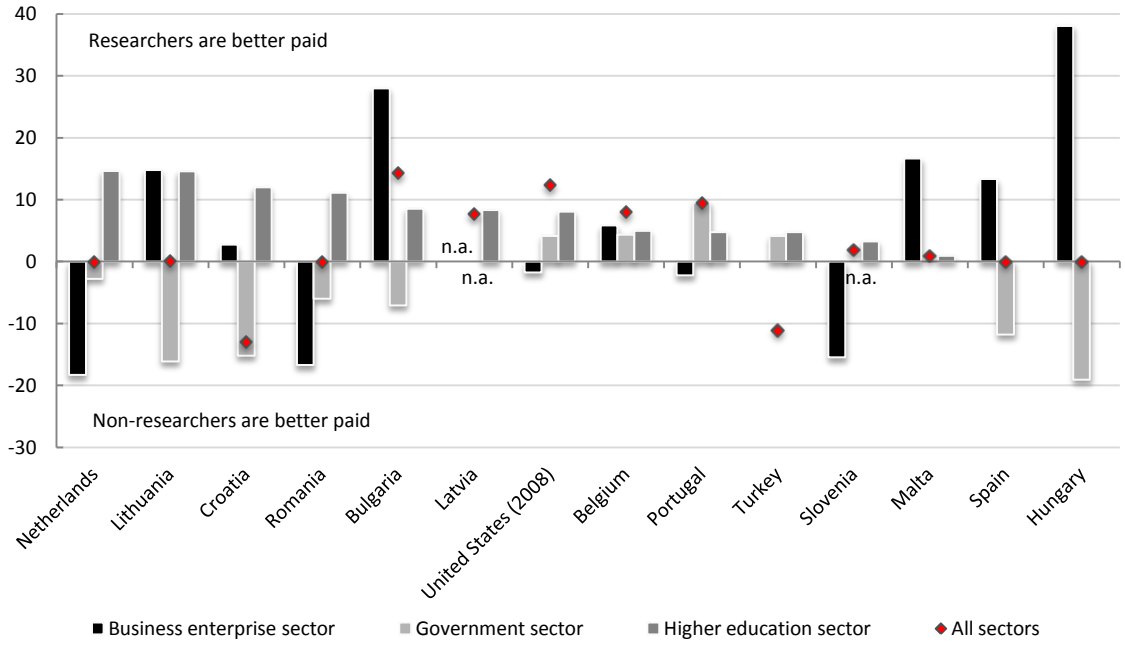

Figure 8. Difference in median gross annual earnings of doctorate holders working as researchers and as non-researchers (as a %age of median gross annual earnings of doctorate holders not working as researchers), 2009[12].

What employment sectors are the most receptive for PhD holders?

In all the OECD countries, except Austria, a majority of doctorate holders are employed in the higher education and the government sectors. In 2009, the share of the higher education sector ranges from 30% in Denmark to 91.8% in Poland (see Table 4). In Spain, 42.7% of the employed graduate students in 2009 were working in the higher educational sector, similar share as the United States graduates (43.5%). In the government sector, the share range from 9.7% in the United States to 38.4% in Spain (the exception is Poland with 0%). In France, the public sector is still the primary employer for doctoral students (54%)[8]. In 2007, the employment rate three years after graduation in the private sector for French graduates was 45%.

In 2009, the business enterprise sector employs a large share of doctoral holders in the United States (32.7%), in Netherlands (34.3%) and Denmark (36.9%). In Portugal, this share accounts for 36.9% and in Spain for 15.1%. In a survey published by the University of Turku in 2011 about the employment situation of doctorate holders in Finland[13], show that at the end of 2008 the best employment situation was with doctorate level degree, whose employment rate was over 90 per cent. The principal employer at that time was: 37% in the university, 23% in the private enterprise and 33% in the government sector (the other 7% are employed in associations, foundations or the like).

[12] OECD Science, Technology and Industry Scoreboard 2011

[13] Source: http://www.utu.fi/tutkimus/tutkijakoulu/DoctoratesLabourMarket30012012.pdf

Table 4. Sectoral distribution of doctorate holders, 2009[6].

	Business		Government		Higher Education		Non-profit private sector		Other educational sector		Total
	% Employed	% Women	% Employed	% Women	% Employed	% Women	% Employed	% Women	% Employed	% Women	
Belgium	33,4%	29,7%	11,8%	34,4%	41,7%	36,8%	11,0%	33,8%	2,1%	59,3%	100%
Bulgaria	5,1%	26,4%	28,3%	48,2%	58,5%	37,8%	6,2%	48,4%	1,5%	50,8%	99,6%
Chinese Taipei	5,7%	4,7%	12,9%	16,3%	79,9%	25,2%	1,4%	14,1%	0,1%	16,1%	100%
Croatia	9,8%	25,6%	29,3%	47,4%	59,2%	40,0%	0,9%	89,0%	0,8%	39,0%	100%
Denmark	36,9%	29,5%	33,1%	42,6%	30,0%	32,1%	0,0%	0,0%	0,0%	0,0%	100%
Hungary	8,6%	29,1%	31,8%	31,2%	57,7%	30,1%	1,8%	33,3%	0,1%	50,0%	100%
Iceland	18,3%	22,7%	29,5%	30,5%	46,1%	33,2%	3,9%	42,6%	2,2%	29,6%	100%
Latvia	14,3%	36,1%	25,9%	55,0%	57,7%	48,6%	0,4%	69,2%	1,8%	44,4%	100%
Lithuania	13,6%	31,3%	20,2%	38,5%	60,6%	45,6%	0,4%	52,8%	5,2%	57,0%	100%
Malta	4,9%	25,0%	18,0%	30,4%	70,6%	20,9%	4,6%	12,1%	1,9%	30,6%	100%
Netherlands	34,3%	20,7%	15,3%	41,6%	28,0%	32,8%	20,0%	36,0%	2,5%	40,2%	100%
Polonia	7,7%	25,6%	0,0%	100,0%	91,8%	44,4%	0,5%	38,3%	0,0%	0,0%	100%
Portugal	2,6%	20,5%	8,4%	46,4%	85,3%	43,3%	3,2%	57,7%	0,5%	52,8%	100%
Romania	10,2%	41,7%	19,1%	45,1%	65,2%	43,6%	0,7%	28,3%	4,8%	53,6%	100%
Russia	15,3%	23,7%	21,5%	39,3%	62,7%	44,2%	0,1%	0,0%	0,4%	64,3%	100%
Slovenia	19,2%	35,3%	23,4%	39,1%	53,7%	37,4%	2,3%	33,1%	1,4%	62,5%	100%
Spain	15,1%	44,9%	38,4%	46,5%	42,7%	42,5%	3,8%	44,3%	0,0%	0,0%	100%
Turkey	11,5%	29,8%	14,9%	34,8%	72,7%	34,9%	0,3%	39,3%	0,6%	51,4%	100%
United States	32,7%	n.a.	9,7%	n.a.	43,5%	n.a.	12,8%	n.a.	1,3%	n.a.	100%

Table 5. Gender distribution of doctorate holders by sector of employment, 2009[6].

	Women					Total	Men					Total
	Business	Government	Higher Education	Non-profit private	Others		Business	Government	Higher Education	Non-profit private	Others	
Belgium	28,9%	11,8%	44,8%	10,8%	3,7%	100%	35,7%	11,8%	40,1%	11,0%	1,3%	100%
Bulgaria	3,3%	33,1%	53,7%	7,3%	1,9%	99,4%	6,4%	24,9%	61,8%	5,4%	1,3%	100%
Chinese Taipei	1,2%	9,3%	88,6%	0,9%	0,1%	100%	7,1%	14,0%	77,3%	1,6%	0,1%	100%
Croatia	6,1%	33,7%	57,5%	2,0%	0,7%	100%	12,4%	26,2%	60,5%	0,2%	0,8%	100%
Denmark	31,4%	40,8%	27,8%	n.a.	n.a.	100%	39,7%	29,1%	31,2%	n.a.	n.a.	100%
Hungary	8,2%	32,5%	57,1%	2,0%	0,2%	100%	8,7%	31,4%	58,0%	1,7%	0,1%	100%
Iceland	14,2%	29,0%	49,3%	5,4%	2,1%	100%	20,5%	29,5%	44,5%	3,2%	2,3%	100%
Latvia	10,6%	29,3%	57,9%	0,6%	1,6%	100%	17,7%	22,6%	57,6%	0,3%	1,9%	100%
Lithuania	10,0%	18,1%	64,4%	0,5%	7,0%	100%	16,4%	21,7%	57,6%	0,3%	3,9%	100%
Malta	5,4%	24,2%	65,3%	2,4%	2,6%	100%	4,8%	16,1%	72,2%	5,2%	1,7%	100%
Netherlands	23,0%	20,7%	29,8%	23,3%	3,2%	100%	39,3%	12,9%	27,2%	18,5%	2,1%	100%
Polonia	4,6%	0,1%	94,9%	0,4%	0,0%	100%	10,0%	0,0%	89,4%	0,5%	0,0%	100%
Portugal	1,2%	9,0%	84,9%	4,3%	0,6%	100%	3,6%	8,0%	85,5%	2,4%	0,4%	100%
Romania	9,7%	19,5%	64,5%	0,4%	5,8%	100%	10,7%	18,7%	65,8%	0,9%	4,0%	100%
Russia	9,0%	21,1%	69,2%	0,0%	0,7%	100%	19,4%	21,8%	58,4%	0,1%	0,2%	100%
Slovenia	18,0%	24,3%	53,4%	n.a.	n.a.	95,6%	19,9%	22,8%	53,9%	n.a.	n.a.	96,6%
Spain	15,3%	40,1%	40,8%	3,8%	n.a.	100%	15,0%	37,0%	44,2%	3,8%	n.a.	100%
Turkey	10,0%	15,1%	73,7%	0,4%	0,8%	100%	12,4%	14,8%	72,1%	0,3%	0,4%	100%
United States	22,3%	10,1%	48,3%	17,0%	2,3%	100%	37,5%	9,5%	41,3%	10,8%	0,9%	100%

All across the countries participating, men dominate in the business sector (see Table 5). In Denmark, Netherlands and United States out of 10 employed men holding a doctorate degree, 4 are in the business sector; whereas that in Netherlands and United States, out of 10 employed women holding a doctorate degree, 2 are in the business sector (3 in Denmark). In higher and non-higher education sectors employed women holding a PhD degree are, in general, over-represented. In Poland out of 10 employed women holding a doctorate degree, 9 are in higher education sector, 8 out of 10 in Portugal and 7 out of 10 in Turkey and in the Russian Federation. In Spain, 4 out of 10 employed women holding a doctoral degree are in the government sector, 4 in the higher degree sector and only 1 in the business sector.

For the countries for which data are available, according to the sectoral distribution of doctorate holders employed as non-researchers, 28.1% of graduates correspond to the business enterprise sector, 23.2% to the government sector, 38.5% to the higher education sector and 6.8% to the private non-profit sector. In United States, out of 10 doctorate holders employed as non-

researchers, 4 are in the higher education sector and 3 in the business enterprise sector (see Figure 9). In Poland these figures are 3 in the higher education sector and 6 in the business enterprise sector. In Portugal these figures are 7 and 1, respectively. In Spain, out of 10 doctorate holders employed as non-researchers, 1 is in the higher education sector, 5 in the government sector and 3 in the business enterprise sector.

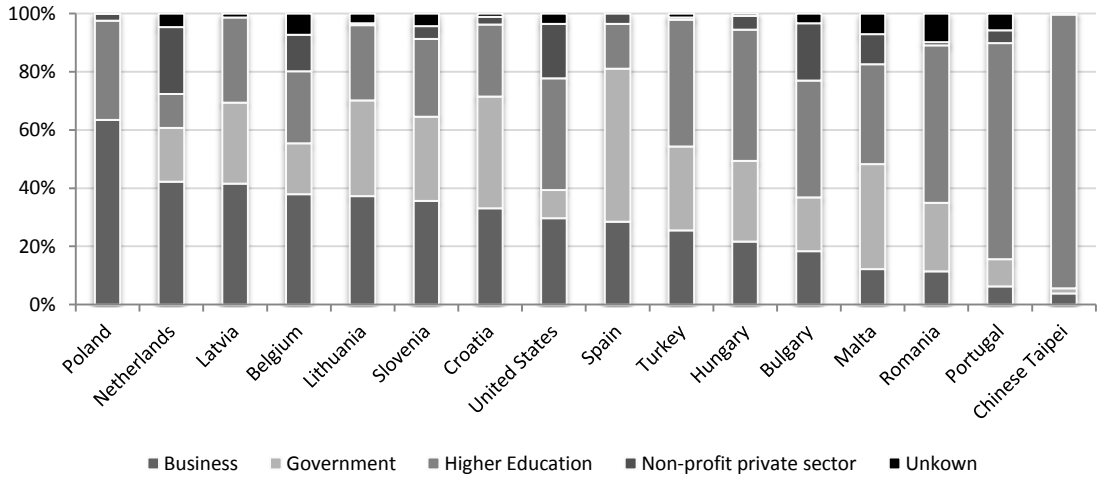

Figure 9. Sectoral distribution of doctorate holders employed as non-researchers, 2009[6].

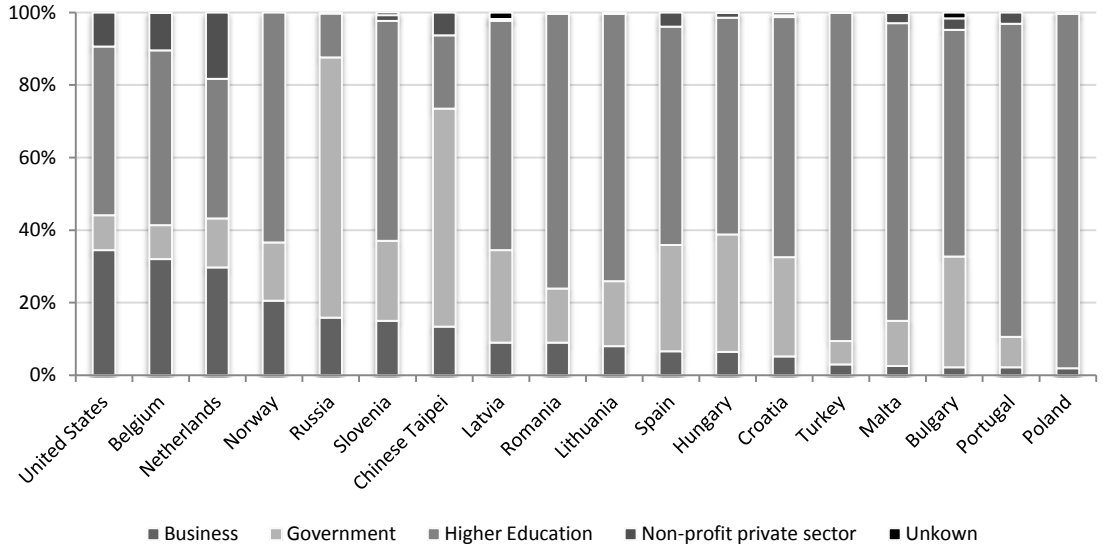

Figure 10. Sectoral distribution of doctorate holders employed as researchers, 2009[6].

Are the PhD holders satisfied with their benefits, salaries, intellectual challenges, social status and working conditions?

Doctoral graduates are satisfied with their situation especially with their contributions to society, intellectual challenge, degree of independence, job security or level of responsibility, but they are less satisfied in terms of salaries, benefits, or opportunities for advancement. Figures 12 to 23 (see Annex 1) depict the responses of doctorate holders in the questionnaire designed in the OECD/UIS/Eurostat project aimed at developing internationally comparable indicators on the career of doctorate holders. Technical guidelines and model questionnaire used in the framework of the Careers of Doctorate Holders (CDH) project can be found in the working paper presented by Auriol et al. (2012). Netherlands shows the highest rates of very satisfied respondents. The rate of employed doctorate holders' perception of 'job related to their doctoral degree' reached 50% (Lithuania) to 86.2% (Turkey) with exception to Belgium (39.2%); on average, women are 2 points (per cent) less satisfied than men over the countries participating.

The Turku University' survey of doctorate holders in Finland shows that almost 75% think that their job correspond to their academic qualification well and only 5% of the respondents experience the level of their job demands considerably lower than their qualifications. Moreover, 54% of the respondent informed that doctoral degree was a prerequisite for their current job, and almost two doctors out of three estimated that they were able to utilize the skills and competencies that they acquired during doctoral studies in their current job.

For a deeper understanding of the driving forces that generate the satisfaction level of employed doctorate holders, we decided to resort to a multivariate statistical method called Principal Component Analysis14 (PCA). For this purpose the original data has been preprocessed as follows. For the sake of simplicity, degrees of satisfaction "very satisfied" and "somewhat satisfied" were merged. Therefore, the data matrix displays for each country (rows) the percentage of graduates who are very satisfied/somewhat satisfied over the eleven employment characteristics considered (columns), i.e., benefits, degree of independence, contribution to society, intellectual challenge, job security, location, opportunities for advancement, level of responsibility, salary, social status and working conditions.

Figure 11 displays a two-dimensional view of the graduates' satisfaction level obtained by using this statistical method. In this plot, each variable is represented by a vector whose direction and length indicates the contribution of the variable to the two principal components picture. Countries are represented by points, and their locations indicate scores over the two principal components. We observe that the first principal component (horizontal axis) has positive coefficients for all eleven variables corresponding to the eleven vectors directed into the right half of the plot. We conclude that all eleven variables are relevant as contributors for this first component15. The second principal component (vertical axis) has negative coefficients for the variables benefits, salary, social status and working conditions, and positive coefficients for the remaining seven variables16. This type of plot allows identifying relative proximities between

[14] Principal Component Analysis (PCA) is a technique used to reduce the dimensionality of a data set. Intuitively, PCA is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. The number of principal components is less than or equal to the number of original variables.

[15] This *averaging* effect over the original variables observed in the first principal component is very frequent when using this technique. Somehow, this component provides an idea of the global magnitude of the data mass.

[16] This *shaping* effect over the original variables is usually observed in the second principal component when using this technique.

countries and between countries and original variables. In Figure 11 countries near the bottom and right square (Netherlands, Slovenia, Spain and Portugal) have the highest scores for the first principal component and the most negatives for the second principal component, highlighting that doctorate holders in Netherlands are the most satisfied with their situation in terms of benefits and salary. On the other hand, graduates of Slovenia and Spain are the most satisfied in terms of social status and working conditions. By contrast, doctorate holders in Turkey, Croatia, Hungary, Russian and Belgium are the most dissatisfied with their conditions. Moreover, the ratings for graduates in Belgium are the most extreme points. Possibly, the factor that explains this lack of satisfaction is that 28.61% of the graduates consider that their job is not related with their doctoral degree. This is the highest rate all across the countries participating. In Finland, the main benefits or advantages that doctorate holders find is a degree itself, in summary, doctoral degree is a necessity or a proficiency requirement to certain tasks. Around 12% of the respondents estimate that the appreciation of the degree has benefited in the work search. However, almost half of the doctors in Finland that has experienced disadvantages of PhD when finding a job estimated that they are overeducated in some job they have applied. In this sense, they experienced that their work possibilities had narrowed. Moreover, 37 per cent informed that they have encountered into negative attitudes and prejudices towards the doctors. Some employers seem to be appreciating the master degree and longer work experience more than the doctoral degree.

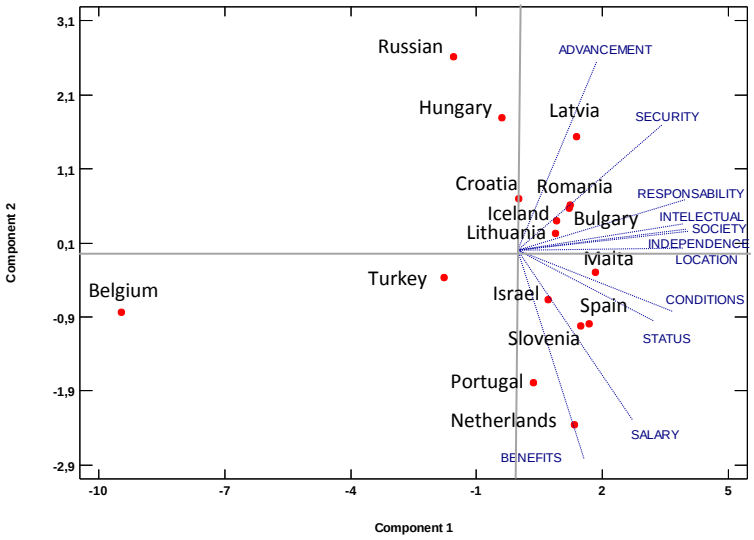

Figure 11. Two-dimensional view of the satisfaction level of employed doctorate holders, 2009.

Highligts

Along this Section a diagnosis of the employed doctorate holders has been presented. Findings in 2009 along OECD countries are not drastically different than those in 2006. The increase of PhD graduates in these three years rises around 13%. In 2009, women represent 37% of doctorate holders. Natural sciences accounts for 26% of PhD doctoral holders. In European countries, 15% to 30% of doctoral holders have experience mobility over the past ten years. The unemployment rate of PhD holders is stabilized less than 2% and in most of the countries permanent contract for the employed doctorate holders reaches more than 75%. The proportion of PhD holders working as researchers in 2009 accounts for 69%, on average. Except Austria, a majority of doctorate holders are employed in the higher education and the government sectors. Doctoral graduates are satisfied with their situation especially with their contributions to society, intellectual challenge, degree of independence, job security or level of responsibility, but they are less satisfied in terms of salaries, benefits, or opportunities for advancement.

3. Reforms on Doctoral Education Worldwide

Focusing on the core of this paper, we return to the employment of PhD doctoral holders in the private sector which is the cornerstone of the innovation and science and technology transfer. In this section we highlights that countries with PhD systems recently updated in order to strength cooperation between firms and universities are able to carry out a higher recruitment of PhD holders in firms.

3.1. Recent developments in PhD training and research career

Educational reforms are increasingly driven by political and economic forces beyond the university. The 2003 Berlin Comuniqué and the Salzburg Principles on doctoral education by the European University Association (EUA) can be seen as the starting point of the reform on doctoral education to the European level. The Salzburg principles formulate general guidelines for doctoral education which include the general nature of doctoral education, the institutional responsibilities for doctoral education, duration of doctoral studies, the status of doctoral students as early researchers or aspects of supervision and funding (EUA, 2007). According to the EUA-Report Trends 2010, the major change in doctoral education across Europe was that it has become an institutional effort of the university itself. The former individualized approach where training took place in a personal relationship between a single supervisor and the doctoral student has been replaced by a structural approach (training in doctoral schools or graduate schools) where it is embedded at the institutional level of the higher education institution.

However, one issue that attracts high levels of criticism is that doctoral education and training should meet *the need of a wider employment market than academia*. This aspect is listed as the first of the "ten basic principles" identified in the EUA report on which further work is required. With the rise in number of doctoral degree holders, not all of them will be able to follow a career in academia, and although there are still some countries in Europe in which industry are not interested in hiring such a highly qualified workforce, the labour market for doctoral degrees holders outside academia is mostly improving. However, there is still some criticism that they don't have appropriate skills and competences. In UK, Netherlands and Austria a professional doctorate has been introduced. Such programs aim to provide the necessary skills and competences to increase employment opportunities outside academia. To gain a professional

doctorate, the requirement to produce original research is somewhat lower; instead coursework is designed to emphasize generic skills and interdisciplinary approaches to problem solving. For the thesis, joint projects are carried out in conjunction with a company or potential employer.

Some countries have developed a new model of knowledge production linking university with industry (Nerad, 2010). Australia, Brazil, Ireland, Germany, Japan and the US are aiming to: (1) link the university more closely with industry; (2) introduce interdisciplinary and problem-solving into doctoral programs; (3) equip their graduates for participation in international networks, and (4) assure doctoral programs are completed in a timely manner. By creating programs that link universities closer to industry and the public sector, it is hoped that doctoral graduates learn to transfer knowledge acquired during their studies to places that immediately use and apply this knowledge. From a perspective of return of investment and productivity this situation is critical in any economy to become more competitive.

3.2. Examples of doctoral training changes worldwide

Country	Initiative	Strategy	Description
Australia	Australian Cooperative Research Centers	Links modes of knowledge production between government, industry and university	These centers emphasize collaborative, multidisciplinary and commercially-oriented research (Harman, 2004, 2008)
Brazil	National Plan for Postgraduate Students	It calls for creating high quality professionals for the productive sector in order to increase the competitiveness of Brazilian companies in the global market	Their specific strategies include align doctoral education with the national goals of self-suficiency in principal sectors of the economy, create links between the academic world and the world of production and invest in R&D in the academic sector, in the industry and business with an investment of $660 million (Ribeiro, 2008).
Canada	Collaborative Research and Training Experience Program[17] (CREATE)	Connect people and skills, more specifically, to place additional qualified candidates within Canadian companies.	This program encourage collaborative and integrative approaches with Canada's research priorities, and facilitate the transition of new researchers from trainees to productive employees in the Canadian workforce. It is expected that linkages between industry and academia will be enhanced, increasing the supply of highly qualified personnel who are "employer-ready"
Finland	Graduate Schools	The majority of the doctoral programs are carried out in the form of national networks (85%), the rest are local doctoral programs within a single university[18].	In addition to universities and the Academy of Finland, doctoral programs are funded by other financiers, such as research institutes, business and industry.
France	Doctoral Departments	A scientific and scholarly environment anchored by recognized research centers and teams, and international dimension, opportunities to	Doctoral Departments often collaborates with a higher education research cluster or research work. These clusters are known as PRES *(Pôles de Recherche et d'Enseignement Supérieur)*. In addition

[17] National Sciences and Engineering Research Council of Canada (http://www.nserc-crsng.gc.ca/professors-professeurs/grants-subs/create-foncer_eng.asp

[18] Source: Academy of Finland

		complete internships in professional settings.	to research contract funded by the Frech Ministry of Higher Education and awarded by Doctoral Departments, there exist several other financing schemes, among them, the funds provided by the France's regional governments and industry (CIFRE[19] program).
Germany	Graduate Schools	Structured Doctoral Programs are organized by one or several collaborating universities, as international research training groups of the German Research Foundation or as doctoral programs/research schools of non-university research institutes[20].	The German Research Foundation supports knowledge transfer by research institutes and facilitates the foundation of research training groups in which universities and companies work closely together. German industry is responsible for carrying out and funding at least two-thirds of R&D activities.
Netherlands	Graduate Schools	They have been established at all Dutch universities with a view to professionalizing doctoral training[21].	A PhD at a Dutch research university generally takes four years and doctoral candidates are often employed by their universities.
Spain	Doctoral Departments	Promote doctoral programs for obtaining PhDs of Excellence and a major boost for building Doctoral Departments in the university campuses[22].	Doctoral programs may be conducted jointly by several universities and have the cooperation with other organizations, preferable with external partners for R&D.
United Kingdom	Doctoral Training Centers	Research funders and education authorities are reshaping the PhD to train students in non-science skills such as networking as well as research.	Doctoral Training Courses (DTC) include formal coursework as well as lab experience[23]. The Engineering and Physical Sciences Research Council (EPSRC[24]) has opened more than 50 DTCs and other British funding agencies and other UK research councils are following the EPSRC's lead. The UK is a leader in many other innovative aspects of PhD reform, such as the co-supervision with an academic and an external supervisor.
United States	Interdisciplinary programs for PhD scientists and engineers	This programs contributes to their preparation to solve large and complex research problems of significant scientific and societal importance at the national and international level[25].	The Integrative Graduate Education and Research Traineeship (IGERT[26]) scheme shows how appropriate reward structures can drive change.

[19] CIFRE (*Conventions Industrielles de Formation par la Recherche*) is a industrial agreement of training through research. The CIFRE grants enable doctoral candidates to prepare their dissertation within an industrial enterprise, in cooperation with an external academic research team. The enterprise and the student enter into a three-year work contract, under which the enterprise pays the student a monthlynet stipend of approximately 1950 euros. Students wishing to obtain a CIFRE grant must apply, with their Doctoral Department, to the national association for technical research (ANRT, *association nationale de la recherche technique*).

[20] Source: The "Research in Germany" portal. Is the central information platform of the initiative to "Promote Innovation and Research in Germany" and is maintained by the Federal Ministry of Education and Research (BMBF).

[21] Source: VSNU, Association of universities in Netherlands.

[22] Source: Ministerio de Educación. Secretaría General de Universidades. Dirección General de Política Universitaria.

[23] Source: Nature, 484, pp.20, 2012

[24] The Engineering and Physical Sciences Research Council (EPSRC) is the main UK government agency for funding research and training in engineering and the physical sciences, investing more than £850m a year, www.epsrc.ac.uk.

[25] National Science Foundation- Directorate for Education and Human Resources (http://www.nsf.gov/div)

[26] http://www.igert.org/

4. Conclusions

In this paper we have analyzed the career of doctorate holders and the evaluation of the new PhD training systems in OCDE countries. At the end of Section 2 the main features of the employed doctorate holders have been presented.

According to the highlights presented in Sections 2 and 3, we can conclude that there are close connections between successful careers of doctoral graduates in the private sector and PhD systems recently updated in order to strength links between academia and the productive sector. Germany, Denmark, Finland, Netherlands and United States are good examples of that fact. We identify two basic rules underlying this connection and they represent a major innovation in the traditional design of the PhD system. The first one is *the active presence of stakeholders from the private sector in Doctoral Schools, Departments and Programs*. This is especially crucial for science and engineering doctoral programs. The second one is *the good level of the effective collaboration between institutions*. This is our main message for countries involved in changing their doctoral systems in order to boost their PhD labour market.

As an example of a reference Doctoral School is SAGA[27], a Marie Curie ITN Network of four years duration. The SAGA project has recruited a number of young (PhD) or experienced (post-doc) researchers. SAGA aims at advancing the mathematical foundations of CAD technology, which can be greatly enhanced by exploiting new techniques from many different mathematical fields. The network has a total of 10 partners: Two partners are industrial companies (Kongsberg SIM A/S, Norway; Missler Software, France), three are research institutes (INRIA, France; GraphiTech, Italy; SINTEF, Norway) and five are universities (University of Oslo, Norway; Johannes Kepler Universitaet Linz, Austria; Universidad de Cantabria, Spain; Vilniaus Universitetas; Lithuania; National and Kapodistrian University of Athens, Greece). In this consortium is integrated a Doctoral School with 10 early stage researchers, 9 experienced researchers and 20 visiting scientists months. The challenges to be addresses in SAGA are organized into four scientific work packages. SAGA offers an environment of researchers from different areas with a common vision, and tailor-made opportunities to learn geometric modeling both from the industrial and the fundamental mathematics perspective. Each individual research project will incorporate a longer stay at a cooperating partner from a different sector (i.e. if the project is hosted by the university, the cooperating partner is a research institute or industry, and vice versa). The training program also incorporates training in complementary skills, such as presentation skills, proposal writing, project management, etc., and annual training events for the whole consortium.

[27] SAGA (ShApes Geometry Algebra): http://www.saga-network.eu/

ANNEX 1

Figures 12 to 23 depict the *Satisfaction level of employed doctorate holders, by criteria of satisfaction, 2009.*

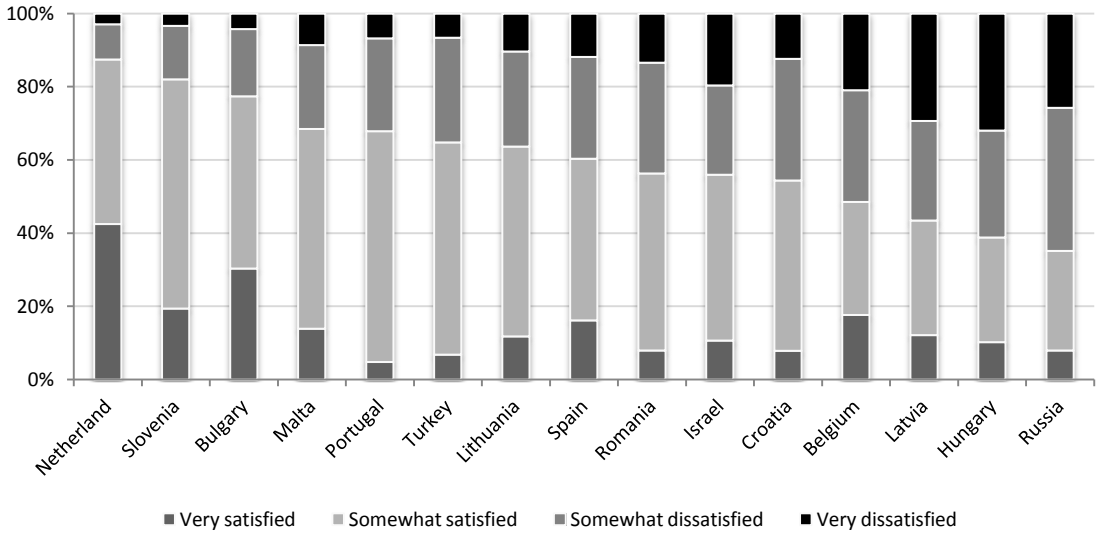

Figure 12. Satisfaction level of employed doctorate holders: BENEFITS, 2009[6,*].

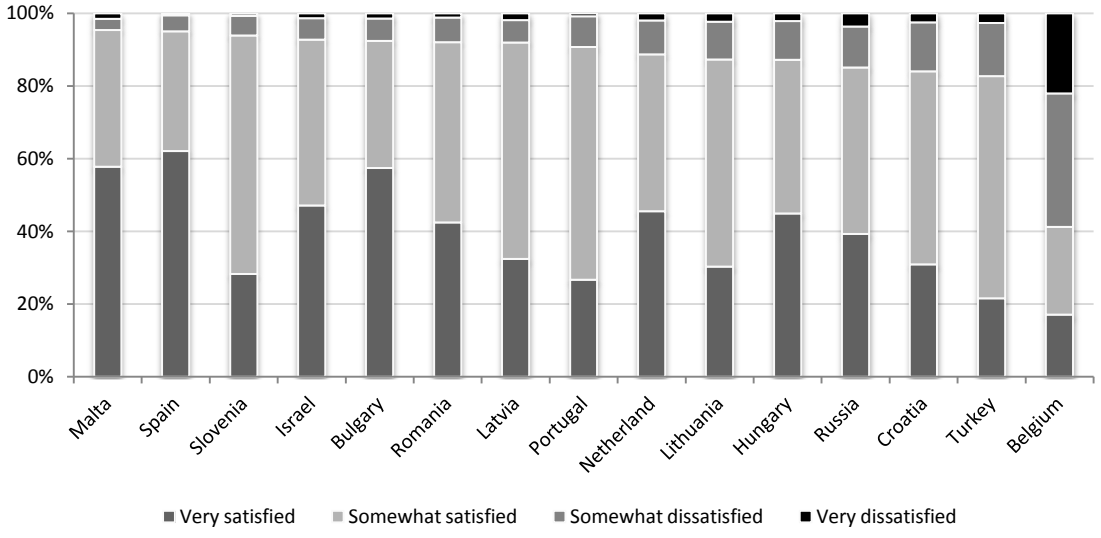

Figure 13. Satisfaction level of employed doctorate holders: CONTRIBUTION TO SOCIETY, 2009[6,*].

[*]Countries are shorted according to their degree of satisfaction adding "Very satistied" and "Somewhat satisfied".

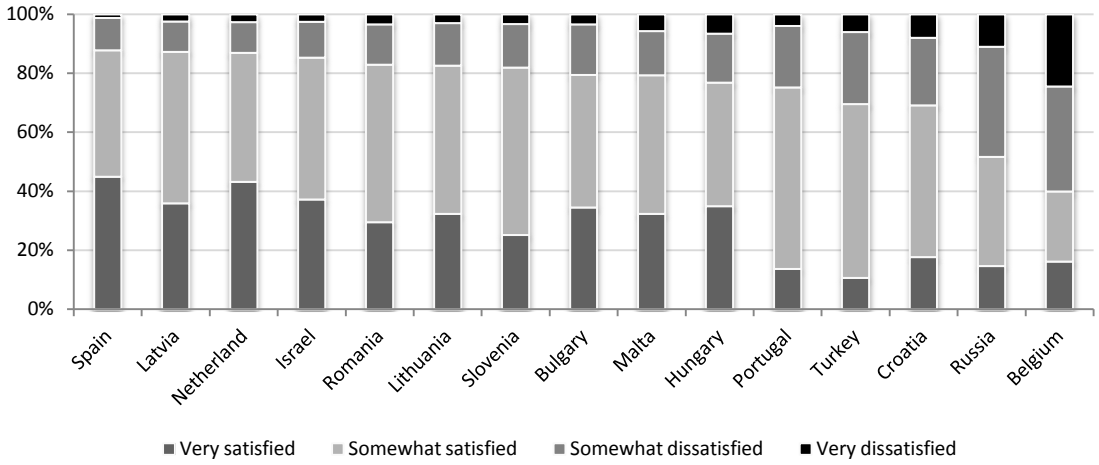

Figure 14. Satisfaction level of employed doctorate holders: WORKING CONDITIONS, 2009[6].

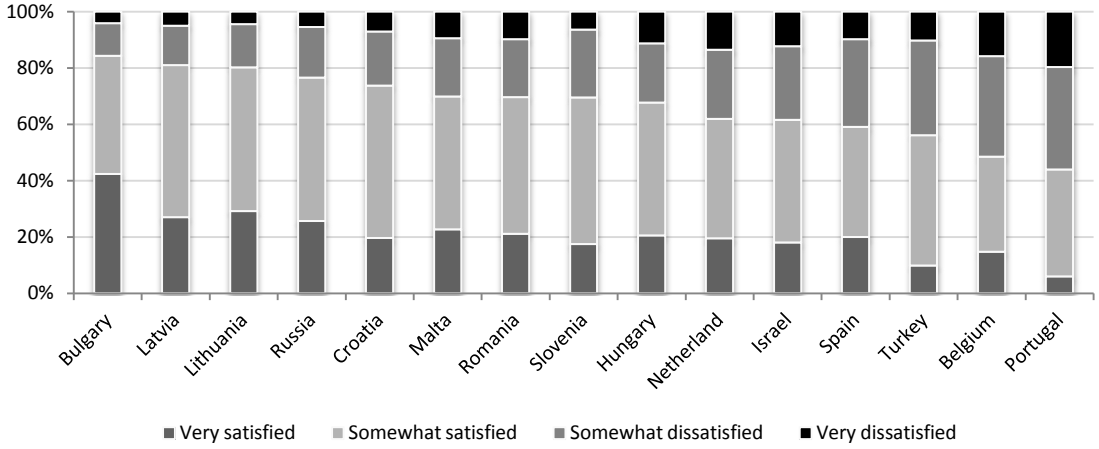

Figure 15. Satisfaction level of employed doctorate holders: OPPORTUNITIES FOR ADVANCEMENT, 2009[6].

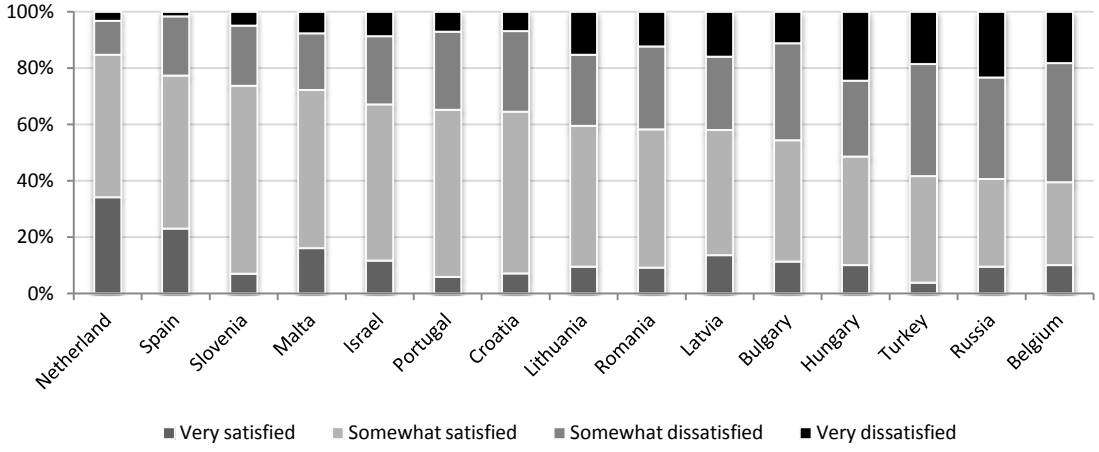

Figure 16. Satisfaction level of employed doctorate holders: SALARY, 2009[6].

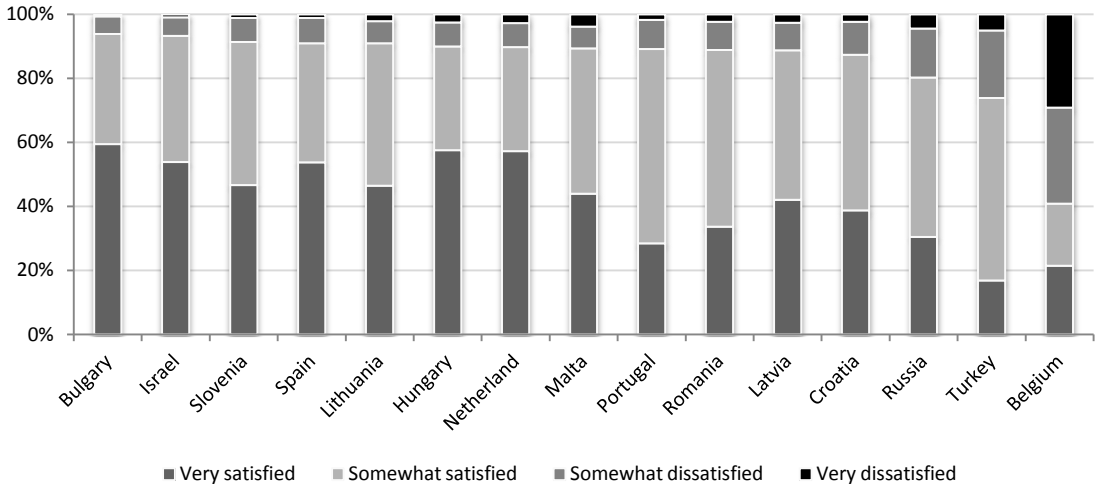

Figure 17. Satisfaction level of employed doctorate holders: INDEPENDENDE, 2009[6].

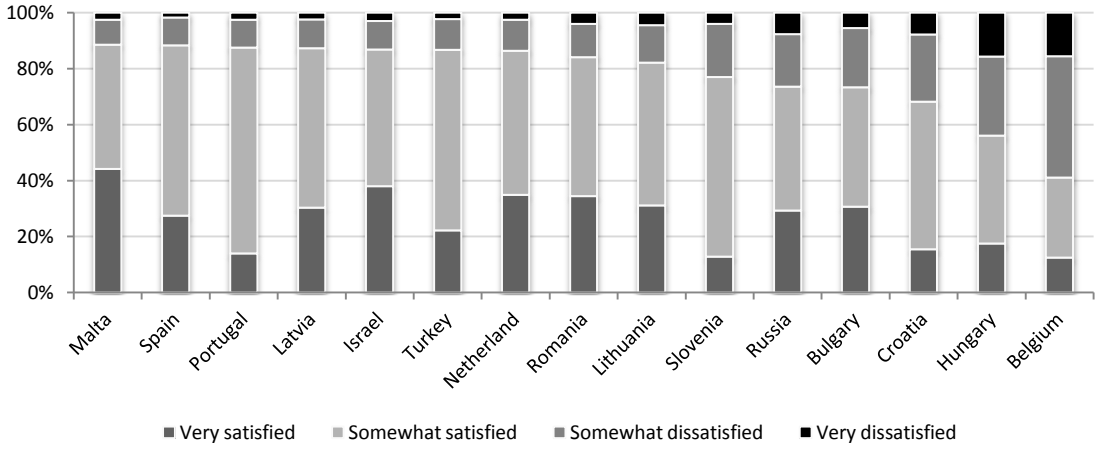

Figure 18. Satisfaction level of employed doctorate holders: SOCIAL STATUS, 2009[6].

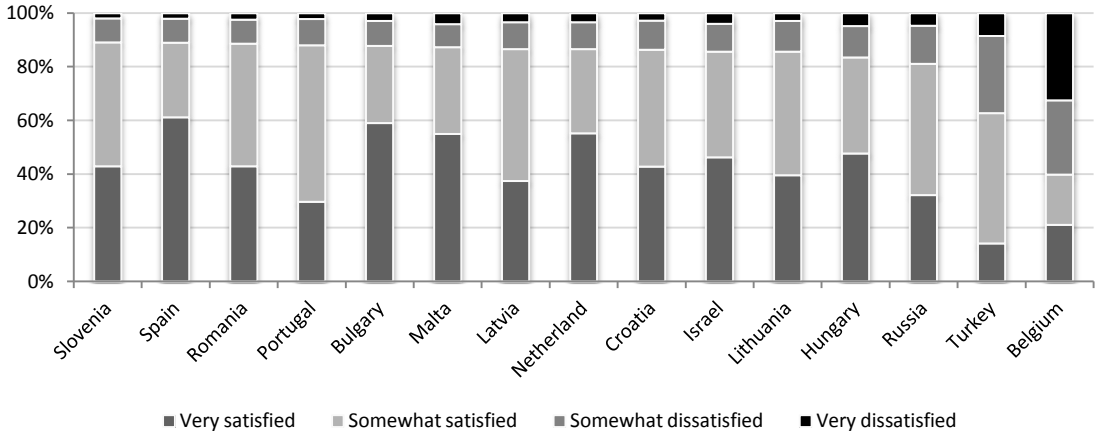

Figure 19. Satisfaction level of employed doctorate holders: INTELLECTUAL CHALLENGE, 2009[6].

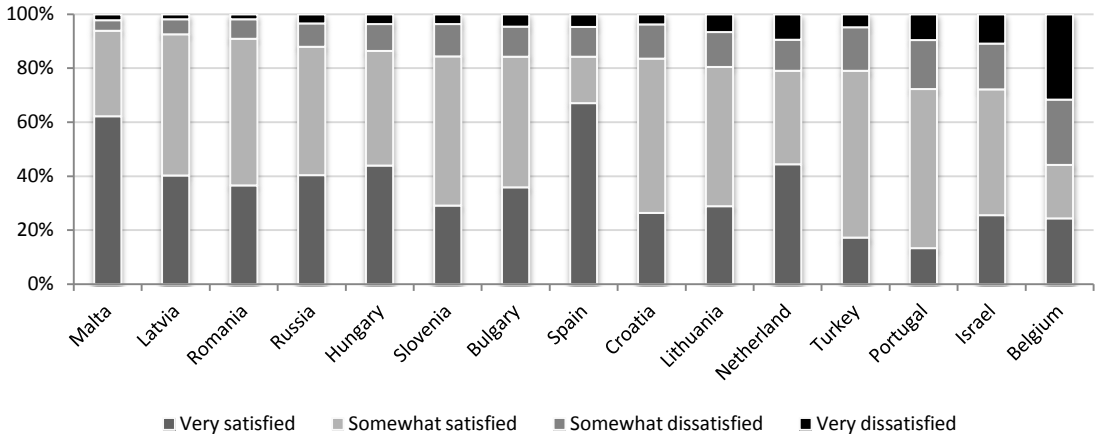

Figure 20. Satisfaction level of employed doctorate holders: JOB SECURITY, 2009[6].

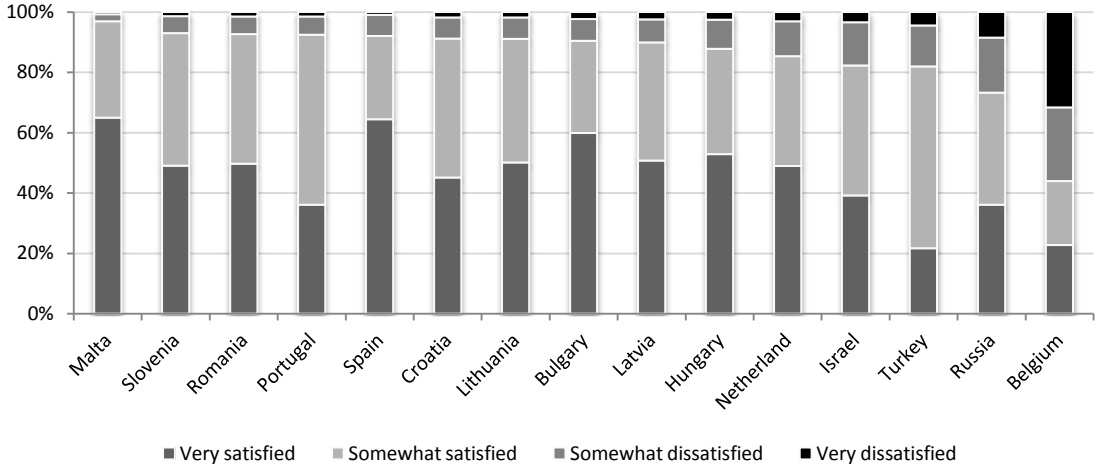

Figure 21. Satisfaction level of employed doctorate holders: LOCALIZATION, 2009[6].

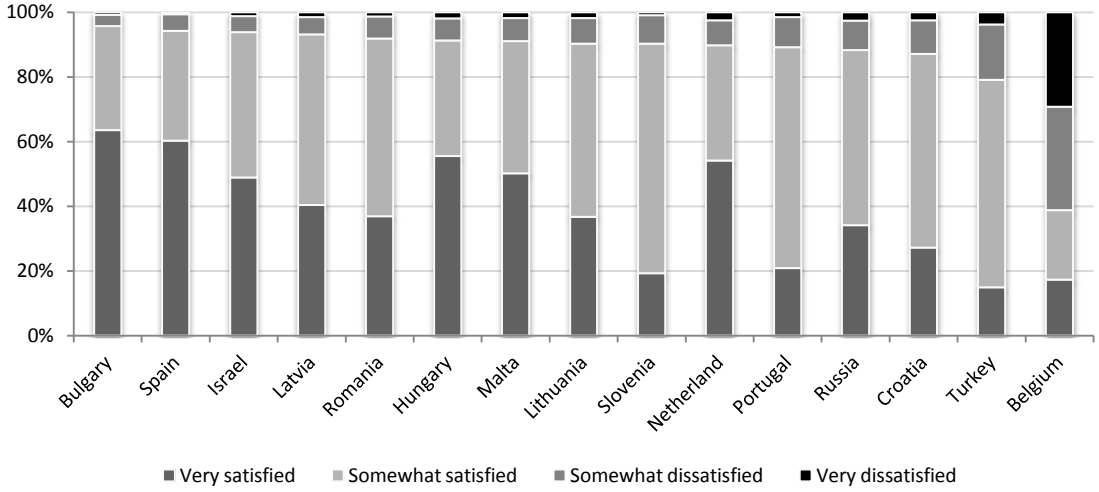

Figure 22. Satisfaction level of employed doctorate holders: LEVEL OF RESPONSABILITY, 2009[6].

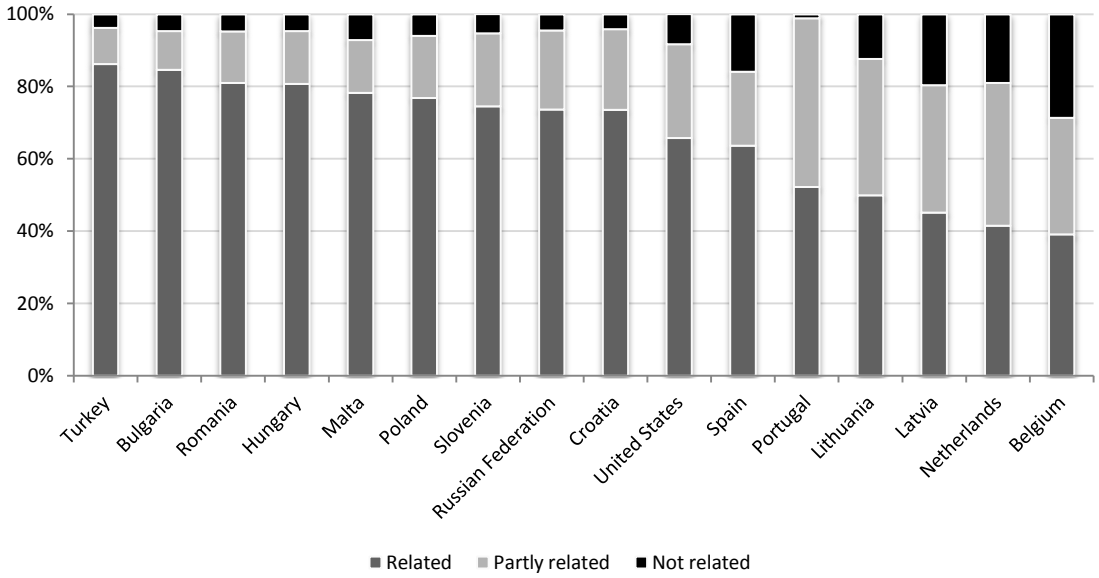

Figure 23. Employed doctorate holders' perception of job relation to their doctoral degree, by gender, 2009[6]

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