e-Skills in Europe

Trends and Forecasts for the European ICT Professional and Digital Leadership Labour Markets (2015-2020)

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Abstract

The ability of economies to remain innovative and competitive relies on the availability of competences of skilled workers in line with rapidly evolving market trends. Arising technologies driving the digital transformation reshape the way of doing business and impact the speed of change of the e-skills and competences needed.

Amending the mismatch between the skills available and those demanded for digital transformation of the economy has been a key priority since the European Commission developed a long term e-skills strategy. While the number of ICT students is now increasing and Member States are stepping up their efforts, the changing e-skills needs that face employers and the ICT workforce have clearly left their marks.

We describe the development of e-skills in Europe, both for ICT practitioners and for e-leadership skills, look at changes in numbers of ICT students and graduates as a major source of talent entering this workforce, and elaborate trends of e-skills and e-leadership skills demand and supply to update a foresight scenario and forecast until 2020.

Content

1 Introduction

ICT has been one of if not *the* most dynamic labour market in Europe and globally, both in terms of number of digital workers and in terms of occupational tasks and requirements. Digital skills and e-leadership are a major policy concern in Europe in order to become more innovative and competitive. Apart from digital skills as the primary domain of expertise of ICT practitioners, there is an urgent need for workers with a portfolio of skills that includes but is not restricted to digital – in ICT as well as in non-ICT occupations that evolve into digital jobs, and in leadership positions which more and more require e-leadership skilled experts who have a T-shaped portfolio of skills, expertise in new technologies and in the development of successful and efficient organisations.

The gap between the demands for digital transformation of the economy on the one hand and the knowledge, skills and competences of the workforce on the other is widely reported and agreed upon in the public and academic realm but notions of its actual size remain vague. In the current economic situation, there is also hope that a successful policy to foster the skills needed for this digital transformation can regain Europe's technological edge and resilience in global competition.

But what digital skills exactly will Europe need to teach to its current and future digital workforce in order to be as sustainable as possible in a fast changing tech environment? From mining into the Labour Force statistics of the past years, it emerges that there have been strong patterns in very recent years that give hints as to the actually massive structural changes that are ongoing within the ICT workforce.

Looking at such patterns alone, however, will certainly not suffice to calibrate forecast scenarios, but stakeholder reports need to be taken into account as much if not more than analysing quantitative trends in the statistics. Therefore, we build on large scale stakeholder engagement for our analytics, having been involved in many invaluable interactions with CIOs, ICT professional bodies and industry associations, Higher Education, policy makers and social partners over the past years, and we would like to express our gratitude to everyone involved in these discussions and fact finding exercises.

There is an urgent need to quantify and forecast the demand and supply for e-skilled work phenomena in order for policy action to be grounded in empirical evidence[1]. While the concept of an ICT practitioner is relatively well captured in official statistics and can rely on an established language to describe and communicate phenomena, for concepts like e-leadership skills and digital jobs, which genuinely are about how ICTs are becoming a more and more important part of non-ICT jobs, this is not yet the case . Therefore the forecast of ICT practitioners can rely on established statistical taxonomies and shared notions, on a comparably better developed common language between employers, educators and policy makers than the e-leadership forecast. The efforts of establishing the notion of e-leadership skills in business, both SME and corporate, policy and academia are ongoing and progress is visible, but measurement remains difficult. The results of the e-leadership forecasting are therefore less elaborate and should be understood as order-of-magnitude estimations rather than exact measurements.

Excursus: OECD measuring of ICT skills at work

The OECD has recently published a paper on "measuring the demand for ICT skills at work"[2]. They operationalise ICT specialist occupations through the PIAAC indicator "use programming languages" broken down by occupation and country. By counting the number of countries in which an occupation appears

1 For the European e-Skills conference 2014 in Brussels (http://eskills2014conference.eu/), we have prepared an analysis of e-skills trends that become visible in official statistics and reported on an experimental pilot survey we had carried out earlier as a proof of concept of e-leadership measurement. These efforts were carried out in relation to two ongoing service contract work assignments for the European Commission ("New curricula for e-leadership (GUIDE)", www.eskills-guide.eu, and "e-Leadership skills for SMEs (LEAD)", www.eskills-lead.eu), but they were not part of the contractual obligations and hence not reported in detail in project deliverables. We received many requests for the figures reported at the conference and would hence like to present them in this working paper.

2 OECD Working Party on Measurement and Analysis of the Digital Economy: NEW SKILLS FOR THE DIGITAL ECONOMY: MEASURING THE DEMAND FOR ICT SKILLS AT WORK. DSTI/ICCP/IIS(2015)4. Paris 2015.

among the top-20 programming intensive and ranking the result they identify ICT specialist occupations. The 20 occupations mentioned in the table below account for 28.7 million workers in the EU-28 in 2014.

Table 1: Top-20 ICT specialist-intensive occupations across countries (adapted from OECD 2015)

Proportion of countries where the occupation is among the top-20

Rank	Occupation	ISCO-08	Frequency	Workforce EU28 (2014)[3]
1	Information and communications technology operations and user support	351	100%	1,282,000
2	Engineering professionals (excluding electrotechnology)	214	95%	3,037,000
3	Software and applications developers and analysts	251	95%	2,965,000
4	Information and communications technology service managers	133	89%	423,000
5	Database and network professionals	252	89%	466,000
6	Physical and earth science professionals	211	79%	346,000
7	Electrotechnology engineers	215	79%	831,000
8	University and higher education teachers	231	74%	1,196,000
9	Mathematicians, actuaries and statisticians	212	63%	106,000
10	Architects, planners, surveyors and designers	216	63%	1,597,000
11	Vocational education teachers	232	58%	868,000
12	Telecommunications and broadcasting technicians	352	58%	408,000
13	Physical and engineering science technicians	311	53%	4,358,000
14	Electronics and telecommunications installers and repairers	742	53%	802,000
15	Blacksmiths, toolmakers and related trades workers	722	42%	2,506,000
16	Life science professionals	213	37%	626,000
17	Metal processing and finishing plant operators	812	37%	567,000
18	Administration professionals	242	32%	3,146,000
19	Sales, marketing and public relations professionals	243	32%	2,487,000
20	Process control technicians	313	32%	652,000
	Total			**28,669,000**

Source: OECD, based on PIAAC.

[3] Source: Eurostat Labour Force Survey (EU-LFS)

An excess demand for ICT specialists would usually be apparent through published vacancies and wage pressure. “If firms face difficulties to fill vacancies for ICT specialists, such a shortage should result in at least one of the following: i) an upward trend in the job vacancy rates for ICT specialists; ii) a longer duration of these vacancies; and iii) an increase in wages for ICT specialists.”[4]

Job vacancy and wage data for occupations (not sectors) are not easily available and comparable across EU Member States. The OECD compares vacancy rates in the ICT services sector (accounting for almost half of all ICT employment according to the definition that we suggest in this paper). Vacancy rates have increased in most countries for which data is available between 2009 and 2014. However, this is notably not the case in the UK which is the only “big” market for which data is available. Still, ICT vacancy rates exceed 1, meaning there are relatively more vacancies in the ICT sector than in the rest of the economy. Wages in ICT have grown slightly more than in the total business economy.

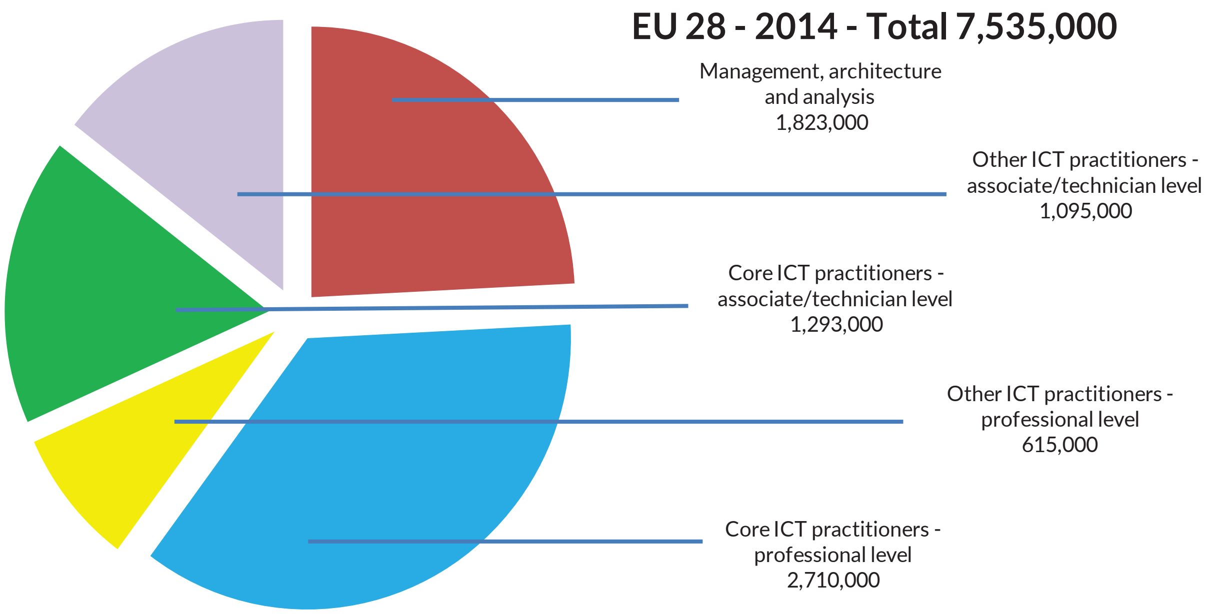
[4] OECD 2015: p.7

2 e-Skills supply and demand in Europe

2.1 ICT workforce

The definition[5] of e-skills through occupation statistics took as starting point a close reading of ISCO descriptions of occupations and has been validated in expert workshops during the past years. **The ICT workforce, according to our definition, in Europe in 2014, comprises 7.5 million workers, or 3.5% of the European workforce.** Broadening up the definition further, including ICT mechanics and manual workers skills would add 1.4 million ICT workers, to a European Labour Force of 8.9 million ICT workers.

Figure 1: ICT professional workforce in Europe 2014 by ISCO-08 skills clusters



Source: empirica calculations based on LFS retrieval by Eurostat. Some further estimates apply.

Data source:

The Labour Force Survey (EU LFS) is conducted in the 28 Member States of the European Union, 2 candidate countries and 3 countries of the European Free Trade Association (EFTA) in accordance with Council Regulation (EEC) No. 577/98 of 9 March 1998. The EU LFS is a large household sample survey providing quarterly results on labour participation of people aged 15 and over as well as on persons outside the labour force. (http://ec.europa.eu/eurostat/web/microdata/european-union-labour-force-survey)

Occupations are defined here according to the International Standard Classification of Occupations (ISCO). The current version, ISCO-08, was published in 2008 and has been used to deliver data since 2011. Therefore there is a break in series between 2010 (ISCO-88, which had significantly fewer ICT related occupations) and 2011.

Data have been kindly made available in several aggregated formats from Eurostat. Aggregation delivers data points as an estimation of workforce totals in a cell, i.e. a combination of categories (country, industry, and ISCO-08 2-digit (sub-major), 3-digit (minor) and 4-digit (unit) groups, and other categories, which have not been used here, such as age and sex). For estimating the ICT workforce totals data are preferably used and represented at ISCO-08 4 digit level. In some cases (some occupations in some countries, less than 10% of all country-occupation cells), only 3-digit data are available. In these cases the relative distribution of the higher level totals across lower level categories was estimated using the distribution from all other countries. Another (very rare) case for estimation appears where higher level aggregate sums do not equal the sum of lower level cells. In these cases the known lower level relative distribution is applied to the higher level total, i.e. the residual is distributed according to relative weight of cells.

[5] The definition of the ICT workforce used has been elaborated before the publication of the OECD work and therefore has not been informed by it. Naturally, we are open to refining the definition taking account of the PIAAC results and discussing new approaches with stakeholders.

The ICT workforce is here defined according to occupational categories from the ISCO – International Standard Classification of Occupations 2008 and quantifications are made using data from the Labour Force Surveys (LFS) of the EU-28 Member States provided by Eurostat.

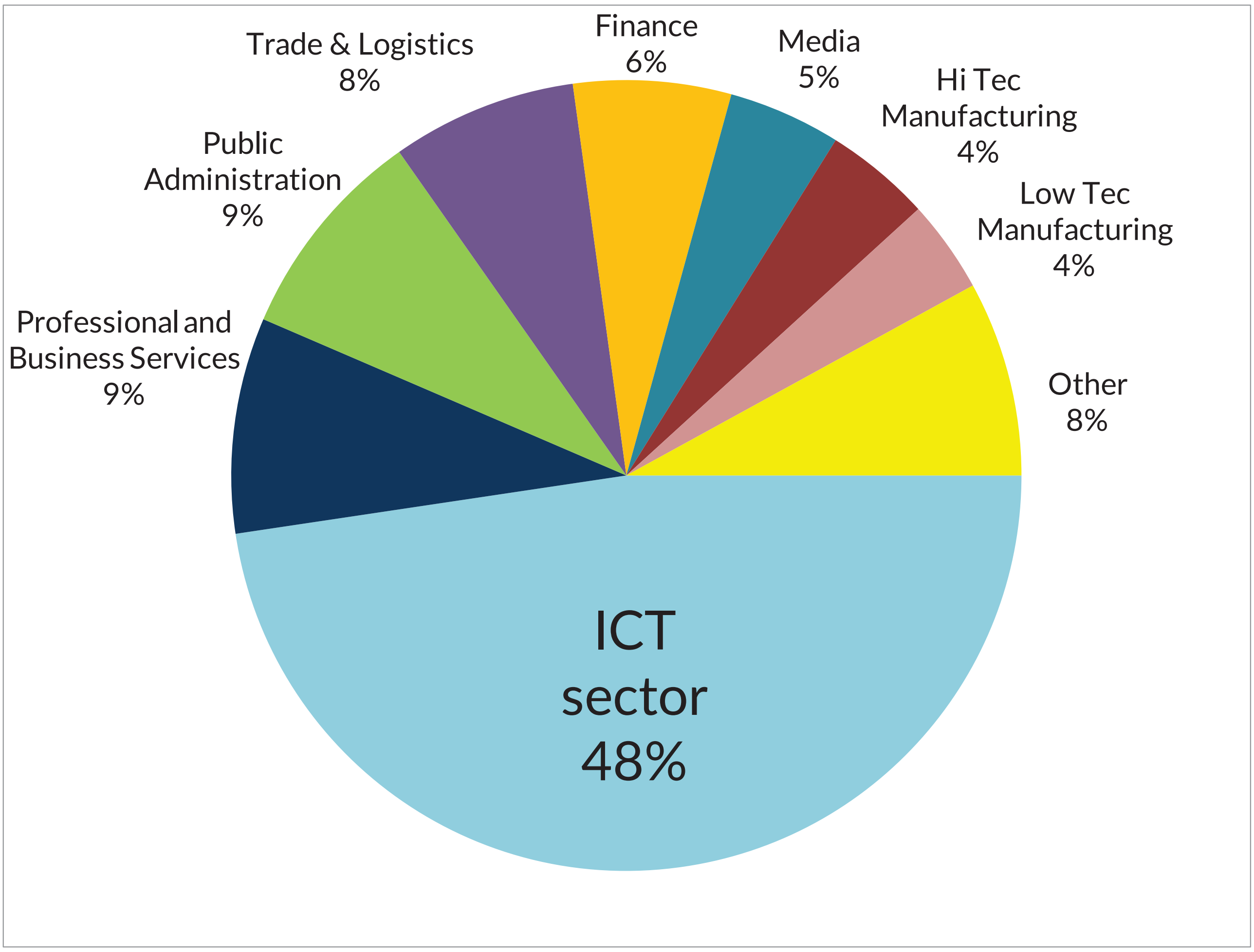
Table 2: ICT practitioner workforce in Europe 2014

	ISCO-08 code	Worker totals (EU28)
ICT practitioner workforce of which		**7,535,000**
Management, architecture and analysis		1,823,000
Information and communications technology service managers	1330	416,000
Management and organization analysts	2421*	661,000
Systems analysts	2511	746,000
Core ICT practitioners - professional level		2,710,000
Software developers	2512	821,000
Web and multimedia developers	2513	151,000
Applications programmers	2514	785,000
Software and applications developers and analysts n.e.c.	2519	342,000
Database designers and administrators	2521	85,000
Systems administrators	2522	380,000
Computer network professionals	2523	105,000
Database and network professionals n.e.c.	2529	42,000
Other ICT practitioners - professional level		615,000
Electronics engineers	2152	238,000
Telecommunications engineers	2153	235,000
Information technology trainers	2356	25,000
Information and communications technology sales professionals	2434	117,000
Core ICT practitioners - associate/technician level		1,293,000
Information and communications technology operations technicians	3511	396,000
Information and communications technology user support technicians	3512	658,000
Computer network and systems technicians	3513	181,000
Web technicians	3514	57,000
Other ICT practitioners - associate/technician level		1,095,000
Electronics engineering technicians	3114	208,000
Process control technicians n.e.c.	3139	208,000
Air traffic safety electronics technicians	3155	7,000
Medical imaging and therapeutic equipment technicians	3211	242,000
Medical records and health information technicians	3252	18,000
Broadcasting and audio-visual technicians	3521	212,000
Telecommunications engineering technicians	3522	200,000
ICT mechanics and assemblers (not part of the ICT practitioner workforce)		**1,393,000**
Electronics mechanics and servicers	7421	309,000
Information and communications technology installers and servicers	7422	461,000
Electrical and electronic equipment assemblers	8212	623,000

*Source: empirica calculations based on LFS retrieval by Eurostat. Some further estimates apply. * Note that ISCO group 2421 was multiplied by 50% in order to allow only for ICT (related) consulting.*

ICT practitioners are working in almost all industries of the economy and not just in the ICT industry sector.

Figure 2: ICT professional workforce in Europe 2013 by ICT and Non-ICT industry

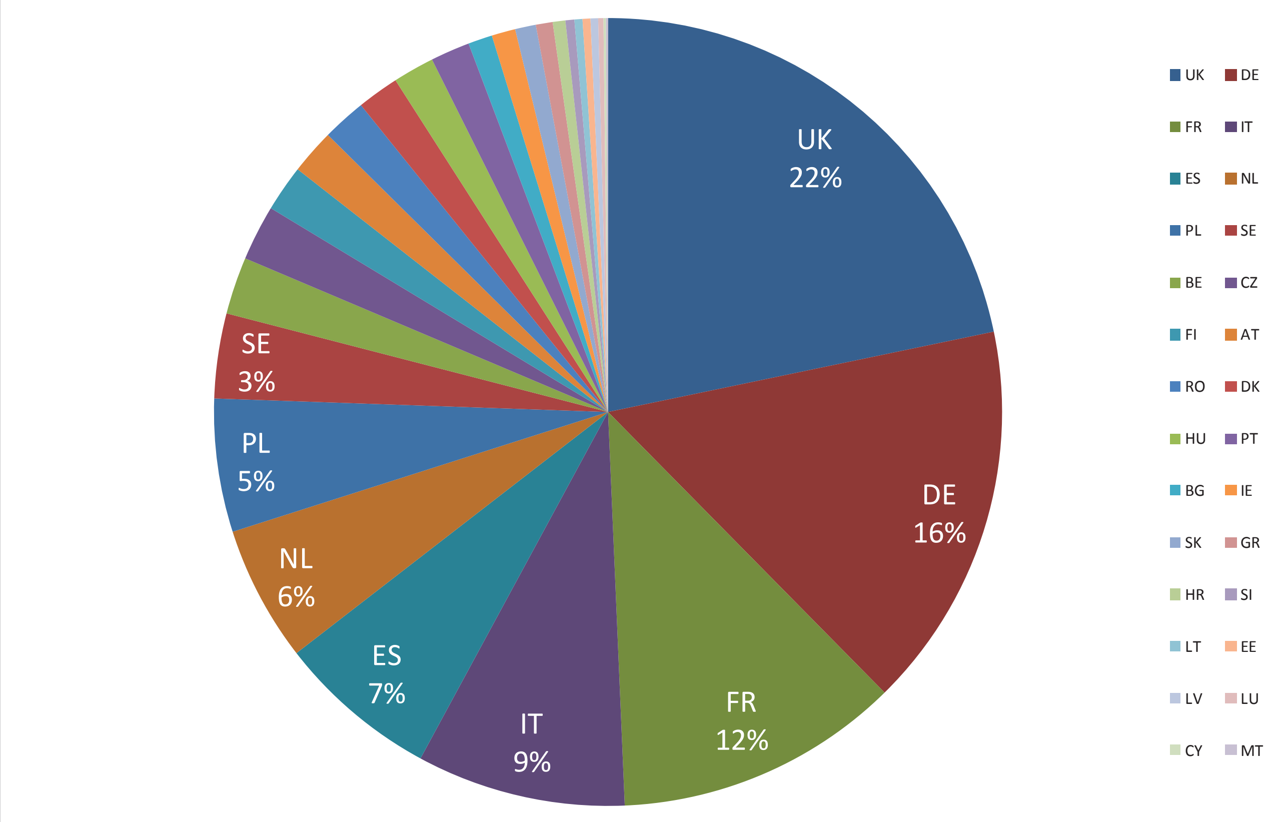


Based on ISCO-08 minor groups 133, 251, 252 and 351									
	ICT sector	Professional and Business Services	Public Administration	Trade & Logistics	Finance	Media	Hi Tec Manufacturing	Low Tec Manufacturing	Other
NACE rev. 2	26;61-63	68-74;77;78;82	84;85	45-53	64-66	58-60	20;21;27-30	10-19;22-25;31-33	1-9;35-43;55;56;75;79-81;86-99

Source: empirica calculations based on LFS retrieval by Eurostat.

Looking at the European ICT professional workforce as a whole, it becomes apparent that three countries already account for half of today's jobs, namely the United Kingdom, Germany and France. Adding Italy, Spain, Poland and the Netherlands already this group of seven would reflect already three quarters of the European ICT professional workforce.

Figure 3: ICT professional workforce in Europe 2014

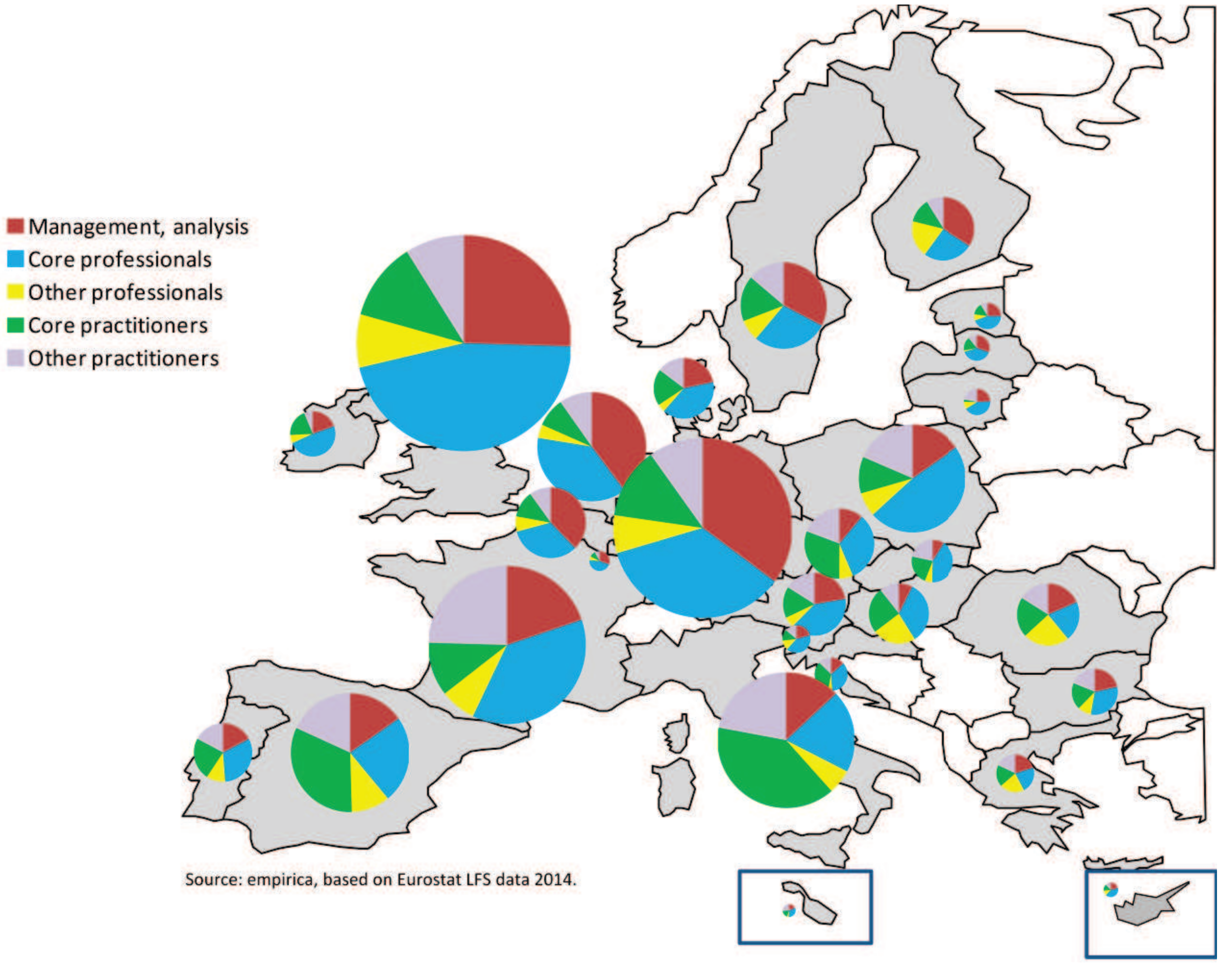


Source: empirica calculations based on LFS retrieval by Eurostat.

The share of the ICT professional workforce within the total workforce is 3.4% in Europe and varies significantly across the European countries. Sixteen EU Member States show shares below the EU-27 average with Greece, Lithuania, Romania and Cyprus below 2.5%. The other extreme includes the Netherlands, the United Kingdom, Sweden, Finland and Luxembourg with shares of above 5%.

There is a slightly positive correlation between the share of management levels skills among professionals and the share of ICT professionals in the workforce (r=0.52). While on average one in four ICT-professional jobs (24%) is in ICT management, architecture and analysis, countries with an overall large ICT workforce tend to have seen a trend towards higher-level skills in the ICT workforce, although some exceptions to this rule appear. In the Netherlands which features the largest share of management, architecture and analysis jobs, their share is 40%, followed by Belgium (38%), Germany (35%), Finland (34%), Sweden (33%), Luxembourg (31%), and Latvia (30%). Countries with a share below 15% are, in ascending order, the Hungary, Slovakia, Czech Republic, Italy and Croatia.

Figure 4: The Structure of the ICT Workforce in European Countries (EU27) in 2014



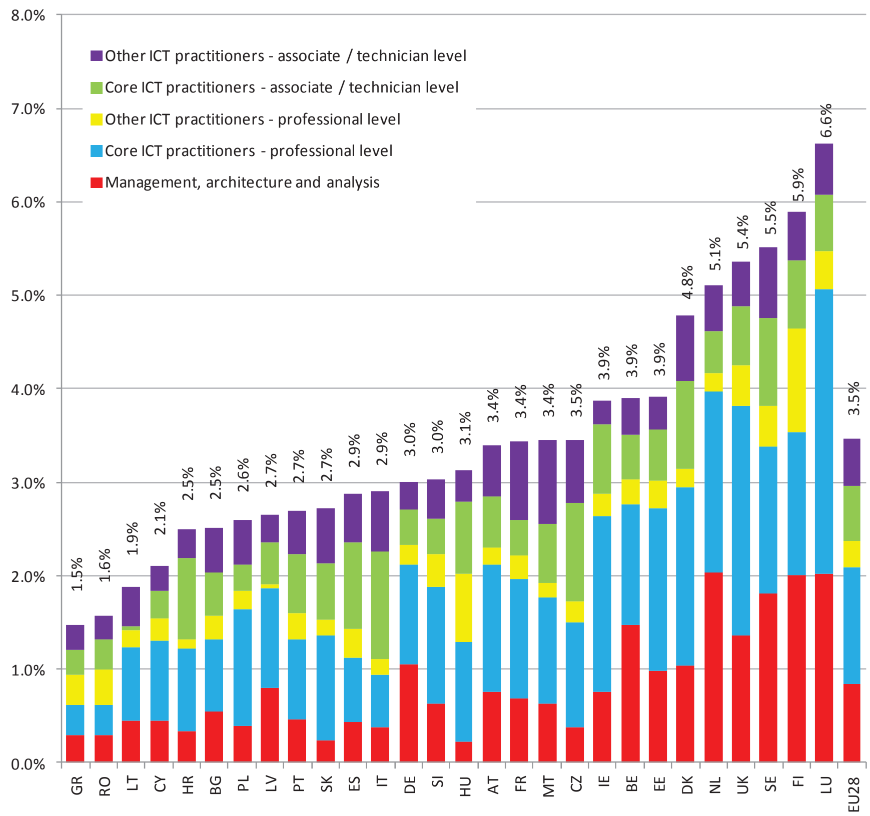
Source: empirica calculations based on LFS retrieval by Eurostat.

The size of the workforce is represented by the diameter of the country pie charts across job families.

The structure of the ICT workforce can be read from the segments of the pie charts. The largest share of management, architecture and analysis jobs can e.g. be found in the Netherlands, as mentioned before. The largest shares in the workforce as percent of the total workforce can be found in Luxemburg, Finland, Sweden and the UK.

Between countries one can see significant differences in the workforce structure. As for the seven largest ICT employing nations, there is an especially large share of top ICT jobs in the Netherlands and in Germany. The UK has the largest workforce, with a huge professional segment as well as management. France and Poland have a similar structure with many professional level workers. Spain and Italy on the other hand have far more associate level ICT workers and less highly skilled employees.

Figure 5: ICT professional workforce as share of employed Labour Force in Europe 2014

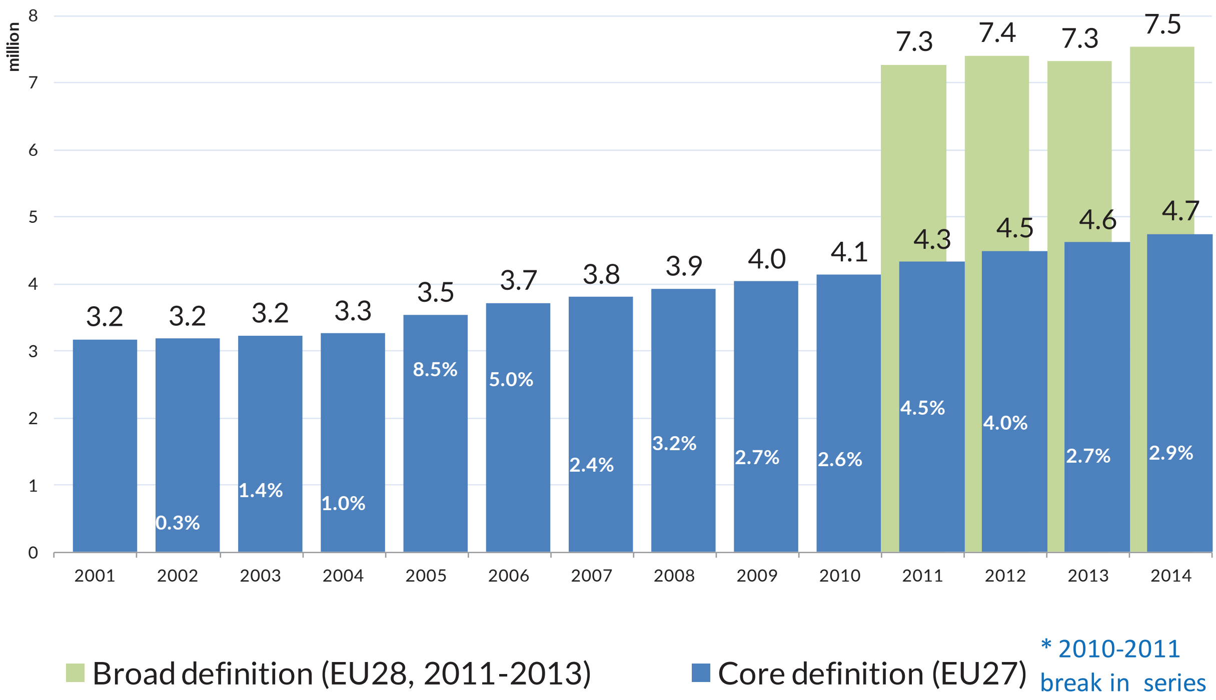


Source: empirica calculations based on LFS retrieval by Eurostat.

2.2 Developments

The development of the ICT workforce in Europe between 2000 and 2014 has been very dynamic. The size of "ICT workforce" naturally depends on the definition used. If using a minimum definition, that only includes a core set of practitioners, in the first decade of the millennium, from 2000-2010, we have seen an average compound growth rate of 4.3% and of 3.2% between 2011 and 2014 (with a break in series 2010/11).

Figure 6: Development of ICT employment and average annual growth rates in Europe 2000 – 2013



Source: Eurostat LFS. Narrow definition: 2000-2010 ISCO-88 groups 213, 312: "Computing professionals" and "Computer associate professionals". Break in series 2011: ISCO-08 groups 25 "ICT professionals", 35 "Information and communications technicians". Broad definition: see elsewhere in this document.

In a broader definition, today's ICT workforce in Europe amounts to 7.5 million workers[6], the growth of workforce according to this broader definition has however been on average 1.2% between 2011 and 2014[7].

It is notable that between 2008 and 2010, that is when the crisis hit most other labour markets, ICT employment increased by on average 2.65% per year. From 2011 on, when statistical institutes switched to a new taxonomy, we were able to produce a broader statistic of the ICT workforce, including many more ICT jobs, as is depicted by the „Broad Definition". In the broader definition there is more variance and less growth for the four years of measurement available.

In a more detailed breakdown of the data, one sees that massive changes in the structure of the workforce are happening right now. There is a surge in "Management" and "Plan/Design" positions: IS management and governance, architecture, analysis. Europe has added 459,000 jobs in this category in only three years.

There is also obviously a high demand for "core ICT jobs", such as Software and Application developers, Web and Multimedia experts, Database designers and administrators, system administrators and network and operations practitioners.

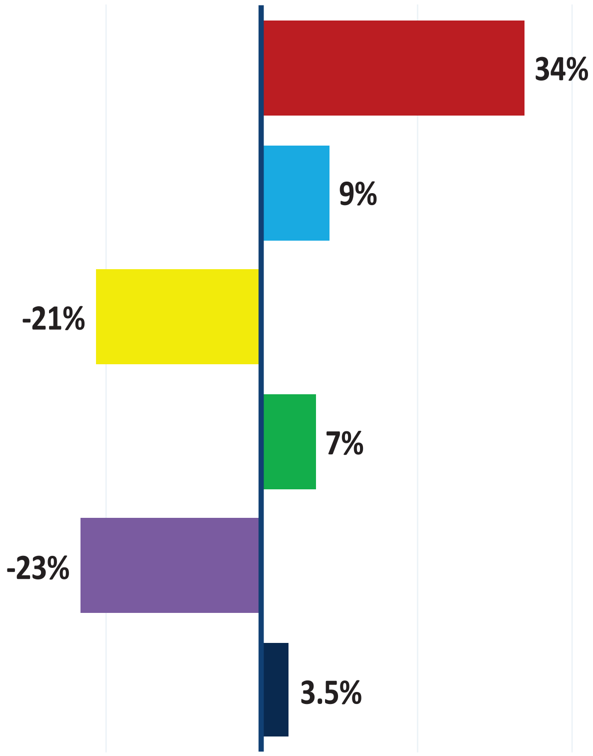
The open vacancy data that is available from different sources for several countries shows that there is also a severe excess demand for these core jobs. In vacancy data the most sought after IT positions currently are software engineering and web development jobs, and application administrators. These jobs are in high demand with many unfilled vacancies reported.

6 See definitions in the previous chapter.

7 There are no data available before 2011 for the broader definition.

At the same time we see a decrease in the number of jobs for some other jobs, such as peripheral, enabling and maintenance occupations, including telecoms and electronics engineers, sales and training professionals and technology specific maintenance and operation technicians.

Figure 7: Growth of ICT professional workforce (EU27) 2014 compared to 2011



Management, architecture and analysis	ICT managers Management and organization analysts (partly) Systems analysts
Core ICT practitioners - professional level	Software developers Web and multimedia developers Applications programmers Other software and applications developers and analysts Database designers and administrators Systems administrators Computer network professionals Other database and network professionals
Other ICT practitioners - professional level	Electronics engineers Telecommunications engineers IT trainers ICT sales professionals
Core ICT practitioners - associate/ technician level	ICT operations technicians ICT user support technicians Computer network and systems technicians Web technicians
Other ICT practitioners - associate/ technician level	Electronics engineering technicians Process control technicians not elsewhere classified Air traffic safety electronics technicians Medical imaging and therapeutic equipment technicians Medical records and health information technicians Broadcasting and audio-visual technicians Telecommunications engineering technicians

Source: empirica

2.3 ICT graduates

The major inflows into the ICT workforce would obviously come from the ICT graduates from Higher, and in some countries Vocational, Education. The e-skills supply in Europe in 2012 from ICT graduates from Higher Education can be estimated to sum up to 111,000 ICT graduates[8]. A closer look at the developments over the past 10 years shows a trend indicating decreasing numbers throughout Europe for the past years, but especially in the United Kingdom and Sweden. After a continuous increase and a peak of 129,000 ICT graduates leaving universities in 2006 the figures went down.

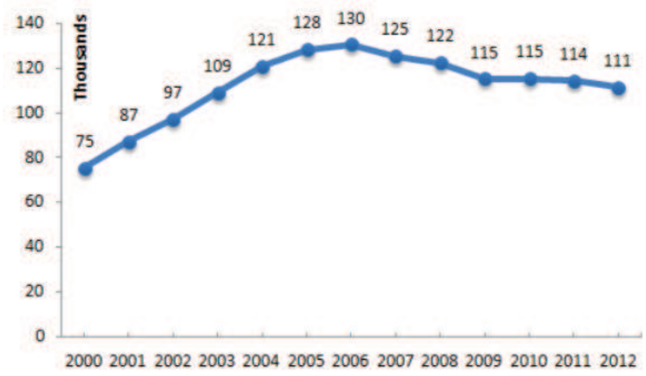
[8] This figure represents a count of first degrees in ISCED 5A and first qualifications in 5B. The number of students entering the labour force in a given year does not equal but is approximated by this number of graduates, as many will go on to second or further degrees (master, PhD). However, also counting second degrees would mean that every student is counted more than once, even if in different years.

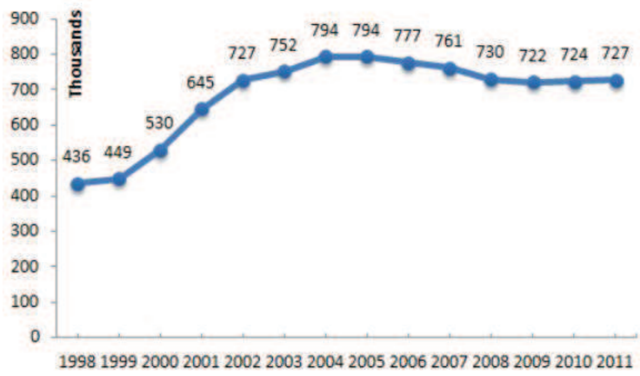
By counting only first degrees/qualifications, every graduate will be counted only once (except the supposedly very rare cases of doing both a 5A and 5B degree), even if labour market entry may be at a later point in time. However, there may be an issue of double counting with initial vocational degrees (ISCED 3 and 4), to which individual learners may later add an ISCED level-5 degree.

Another issue with this method lies in a poor representation of those graduates who earn a second (master's) degree but switch subjects. On the one hand, ICT related bachelors may switch to other subjects and not enter the workforce as ICT professionals, while on the other hand there are numerous ICT related masters that are addressed to non-ICT bachelors.

Figure 8: Enrolment in and Graduates from Computer Science studies (ISCED 5A and 5B) in Europe (EU28)

Computer Science graduates (first degrees / qualifications in ISCED 5A and 5B)	Enrolment in Computer Science (in ISCED 5A and 5B)





Source: Eurostat, some imputations and assumptions apply

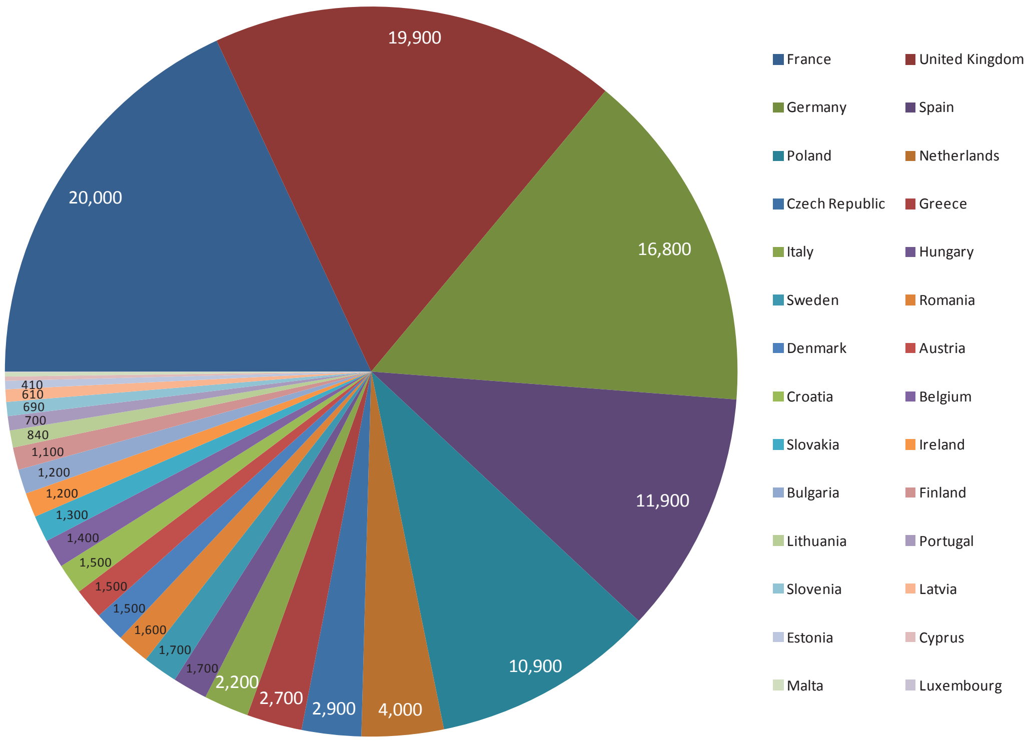
The interest in pursuing ICT careers seems to have been diminishing since the middle of the last decade, when the number of graduates had reached a peak. The number of computer science graduates grew even after the dot com bubble burst, but has been in decline in Europe since 2006.

The effect of the decrease in the number of graduate entrants to the ICT workforce is intensified in Europe by an increasing number of retirements and exits, as ICT practitioners leave the workforce. The most dramatic decrease of graduate numbers can be observed in the UK, where the number of graduates today is down to just 63% of the number it used to be in 2003. Decreases can also be observed in the other countries except Germany and France.

France has meanwhile overtaken the United Kingdom in terms of ICT graduates from university and now contributes 18% of all European graduates. The UK comes in second with 17%, and Germany third (15%) of the European computer science graduates to the labour market. The shares have changed dramatically, if compared to ten years earlier when the UK produced almost a third of Europe's Computer Scientists (30%) and Germany just 7%.

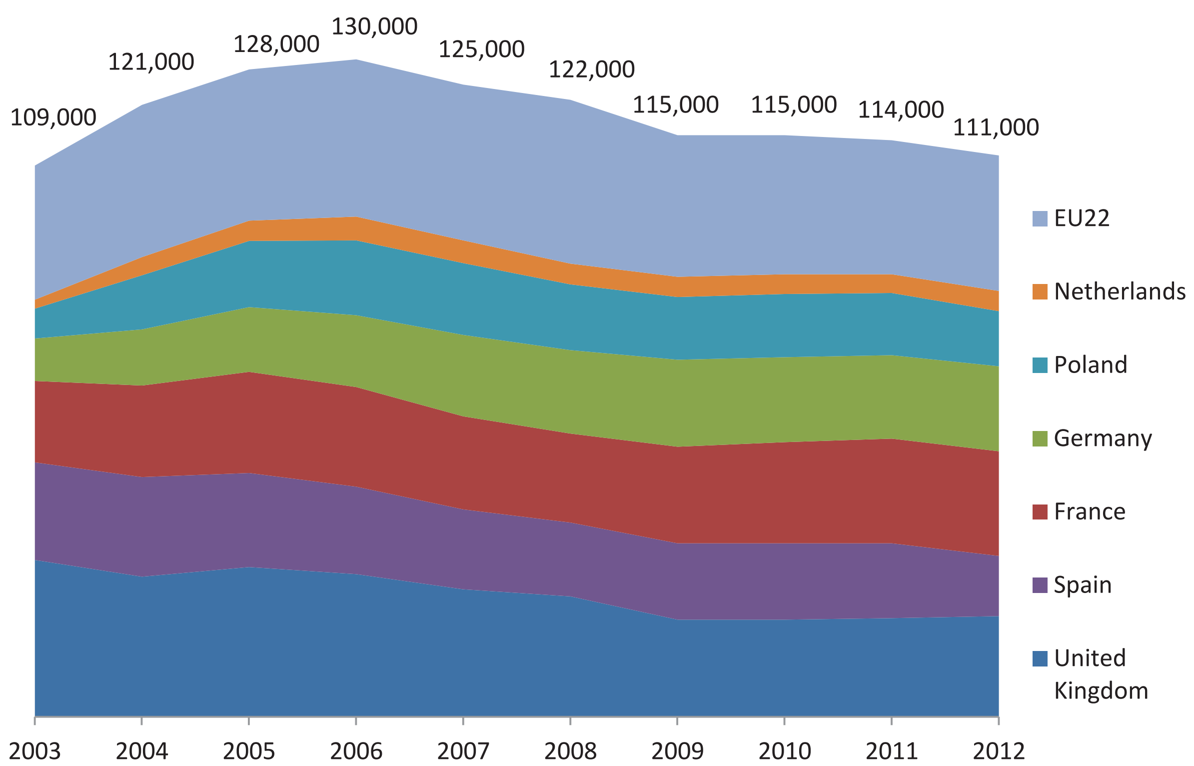
Enrolment has also reached a peak in 2004 and 2005, but figures have stabilised recently and a slight increase is visible since 2009.

Figure 9: ICT graduates (first degrees in ISCED 5A and first qualifications in 5B) in Europe 2012



Source: empirica, based on Eurostat educ_grad5

Figure 10: Tertiary level computer science graduates in EU28 countries in 2003 – 2012



Source: empirica, based on Eurostat educ_grad5

2.4 e-Skills demand

2.4.1 ICT skills shortages

What's new?

- Number of vacancies (2015) extrapolated from analysis of online job postings in five countries.
- Backcasting to 2014 to fit baseline (Eurostat figures are not yet available for 2015)
- Previously, this estimation was survey based: survey of CIOs / HR in three countries (2012) and extrapolation (2013)
- Online vacancy based estimation 2015: 373,000 (EU28)
- Compare: survey based estimation 2012: 274,000 (EU27)

Today, like in almost all recent years except for the aftermath of the dotcom-bubble bursting, the demand for ICT workers is outstripping supply. We have analysed online vacancy data provided through jobfeed (www.jobfeed.com) to estimate the number of open posts for ICT professionals. Jobfeed has been developed by Textkernel BV (www.textkernel.com/) as a Big Data tool for jobs and provides a database of real time and historical online job data. Together with Jobfeed we analysed the online job postings that mapped to the definition of ICT jobs presented in this paper. Jobfeed currently covers 5 EU Member States, but has plans for expansion so that future monitoring activities may well include further countries.

The table below provides the numbers of deduplicated job postings which are active on one specific day in October 2015 (i.e. they had to be not older than 8 weeks and be still online and not depublished or marked as expired).

For the five countries covered to a sufficiently mature degree for our research purposes, we can identify 205,000 ICT job vacancies. As a percentage of the most recent ICT job data (spring 2014[9]), there are on average 4.8 vacancies per 100 ICT jobs, or 3.2 per 100 management jobs and 5.4% per 100 practitioner jobs.

Table 3: ICT practitioner online vacancies in October 2015

	Vacancies Oct 2015 (jobfeed)			Jobs spring 2014 (LFS, Eurostat)			Percentage		
	Management	Practitioners	Total	Management	Practitioners	Total			
AT	931	4,521	5,452	31,116	108,270	139,386	3.0%	4.2%	3.9%
DE	13,355	59,891	73,246	420,881	776,218	1,197,099	3.2%	7.7%	6.1%
FR	10,791	39,593	50,384	174,859	707,240	882,099	6.2%	5.6%	5.7%
NL	3,455	23,146	26,601	166,889	252,652	419,541	2.1%	9.2%	6.3%
UK	10,048	39,632	49,680	417,083	1,220,450	1,637,532	2.4%	3.2%	3.0%
Total (5)	38,580	166,783	205,363	1,210,828	3,064,831	4,275,658	3.2%	5.4%	4.8%

Source: jobfeed

How representative can these countries be for the rest of Europe? The five countries account for almost 60% of the European workforce. In terms of GDP growth over the last two years, which is a major predictor of ICT job growth, the five countries come in at ranks 8, 14, 18, 19 and 21 among the EU28. We decided therefore that it is not out of the range of possibilities that vacancy rates in the rest of Europe average at the 5 country average of 4.8% as well. Applying this figure, we estimate that there are currently 373,000 open positions for ICT professionals in Europe.

Among these, 16% (58,000) are vacancies for highly qualified positions in ICT management, architecture and analysis and 84% (315,000) are vacancies for all other ICT professionals. This is a rather surprising finding, given the dynamics of the number of highly qualified positions and deserves some further research in the future.

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[9] It would be correct to use the current number of jobs as denominator, but this data is not available. We are aware that the actual number of ICT jobs is quite probably higher in October 2015 and therefore the actual percentage of vacancies slightly lower. On the other hand, we might have used historical jobfeed data of 2014 to estimate the ratio, but we weighted higher the importance to have most recent vacancy data. Given the number of uncertainties in such a model, this inaccuracy is probably only a minor issue.

This is an increase compared to the survey-based estimate of 2013. The results of a representative empirica survey of CIO's and HR managers in eight European countries in 2012 showed a demand for e-skills at around 274,000 in 2012. This was then based on the numbers given by CIOs and HR managers in European organisations for the number of vacancies in ICT-related occupations. Among these, we estimated a demand of about 73,000 vacancies for ICT management, business architecture and analysis skills and about 201,000 for "Core ICT practitioners" and "Other ICT technicians" jobs.

While we estimate that the number of vacancies has increased by 99,000 between 2012 and 2015, at the same time we estimate that the number of ICT jobs has increased by 272,000 to a total of 7,674,000.

2.5 ICT professional workforce forecasts

The main forecast scenario represents the most likely future as we foresee it for the time horizon of 2014 to 2020. The forecasting models differentiate between stocks and flows, or between a baseline market and dynamic entries and exits. The baseline basically consists of a number of existing jobs, number of vacancies and number of unemployed ICT practitioners. Flows are modelled as entries of graduates and exits of professionals.

Supply side model and assumptions made

The availability of individuals with the different types of e-skills who are either gainfully employed or seeking employment is termed e-skills supply to the labour market. As mentioned above, the e-skills supply **stock** includes individuals in ICT practitioner positions and unemployed ICT practitioners. The scope of e-skills supply depends on the scope of the e-skills definition used and is obviously not static.

The supply total for 2014 is estimated at 7.75 million, of which 7.54 million are in employment and 210,000 unemployed.

What's new?

Supply forecast increased, for several reasons:

- Model assumptions about new talent available have increased – we learned that in the past more jobs were created (and filled) than we foresaw based on graduate figures, i.e. more lateral entries must have taken place.
- Higher share of STEM graduates go into ICT jobs
- More "outsiders" or lateral entries go into ICT jobs.
- More cross-border mobility

The result is an increased absolute supply figure

E-skills **inflows and outflows** to/from the labour market need to be identified and statistically measured and future developments modelled to gain a comprehensive and complete picture of e-skills supply in the market. To capture market dynamics, i.e. the inflows and outflows of individuals in the pertinent e-skills categories, specific approaches need to be developed.

New market entrants typically are **computer science graduates** of **tertiary education** entering the labour market. In many countries (Germany and Poland in particular) also (post-) secondary **vocational training** plays a major role as supply pool. Computer science graduates are modelled to flow into the ICT workforce entirely.

Anecdotal evidence supports the observation that the share of computer science graduates has increased in ICT recruitment over the last decade[10], yet **other graduates**, from mathematics, natural sciences, engineering or social sciences who possess the IT skills demanded still today fill ICT positions that would otherwise remain vacant. The number of non-ICT graduates to flow into the ICT workforce is modelled to

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[10] A UK study of 2001 still found that „the majority of graduates working in ICT jobs do not hold a degree in an ICT related subject. While the most common degree subject is maths or computing (40 per cent), others include engineering and technology (21 per cent), physical sciences (11 per cent) and business studies (nine per cent). Graduates employed as computer analysts/programmers display the greatest range of degree subjects. Also, female graduates working in ICT occupations are more likely to have degrees in non-ICT or non-technical subjects (e.g. social sciences). (THE INSTITUTE FOR EMPLOYMENT STUDIES (2001): An Assessment of Skill Needs in Information and Communication Technology.) http://dera.ioe.ac.uk/15250/1/An%20assessment%20of%20skill%20needs%20in%20ICT.pdf)

follow demand but the number is capped at 10% of the number of STEM graduates (Italy 20%). There are about 640,000 STEM graduates per year in Europe.

While it is relatively easy to approximate an adequately accurate annual supply of university leavers and vocational school leavers with a major in ICT, any attempt to estimate the supply pool from the official statistics about natural science, maths, or social sciences graduates has to rely on evidence based assumptions and auxiliary hypotheses about the share of outsiders entering the ICT workforce.

Also **career changers** originally coming from a non-ICT background may take on ICT positions, furthermore re-entrants who had been out of the labour market previously. While recent research (e-skills QUALITY study: www.eskills-quality.eu) shows that certification has become crucial for ICT practitioners across all backgrounds, it can be assumed that especially for "educational outsiders" certification and re-skilling programmes play a crucial role in adapting the workforce skills to the demand side requirements.

Certifications and re-skilling programmes play a crucial role in adapting the workforce skills to the demand side requirements.

As we have recently underestimated the ability to recruit outsiders from the labour market, the number of outsiders entering the workforce through qualification and up-skilling measures was set to 0.5% of the 2014 workforce, or 28,500 annually.

The pool for ICT Management recruitment[11] (ICT managers, enterprise architects, ICT consultants) was specified as a percentage of individuals from the ICT practitioner pool getting promoted to management level and as a percentage those coming from the business side (line management etc.) i.e. external entries.

Finally, **immigration** is a source of additional supply to the market. We have for the time being not included immigration from outside the EU into our model, as anecdotal evidence has shown that the absolute figures of immigration directly into the labour market (i.e. not through the national education systems) remain to be proven significant. This may change in the near future as recent new immigration from outside the EU begins to gain access to the ICT labour market.

Supply side **exits** may be due to **retirement, temporary leave** (e.g. parental leave) and **emigration** of ICT workers as well as promotion or other **career change** to non-ICT jobs (or jobs at least not statistically captured as ICT jobs). Replacement demand figures (subsumed under the supply side model here because in the model it lowers the supply) have been estimated at 2.5% for practitioners and 3.3% for management positions with some delay built in to allow for the fast growth of the workforce (which tends to lower the average worker age).

The necessary statistical data regarding university graduations is available from Eurostat (see annex and chapter 2.3). Further inflow indicators of relevance - which could be considered subject to availability of the necessary data - include data from immigration and career changers or market re-entrants.

Outflow data would mainly include statistics on retirements, emigration, career changers or re-entrants. This kind of data is hardly available across countries and estimates have to be based on analogies.

[11] Advanced positions, especially ICT managers, can be recruited from the pool of ICT practitioners or through side entries of non-ICT practitioners (e.g. managers from other departments). In both cases, there are no statistical concepts of the pools of suitable candidates available, as is the case with university or vocational graduates for practitioner labour market entries. Seasoned practitioners are an obvious source for management jobs, but both working experience and life-long learning credentials have to match with the position. While bottlenecks are reported to exist by employers who claim to have a hard time finding good e-leaders, it is hard to model exact evidence-based parameters for these bottlenecks into our labour market model. We finally resorted to assuming external side entries to be 33% of new demand for management positions (with an unlimited pool), and 67% to be tried to recruited from the existing practitioner pool. For practitioners, a bottleneck of no more than 2.0% of existing practitioner workforce annually was introduced into the model. The breakdown of total number of vacancies into management and practitioner positions therefore has to be taken with a pinch of salt, as may underreport or overreport management vacancies and vice versa for practitioner vacancies.

Demand side model

Conceptually, demand given as a specific figure, i.e. not as a function of wage (as in textbook economics), is the size of the workforce that the market would absorb shortly given that the current wage level prevailed. Markets tend to adjust via the price or quantity offered of the commodity. However, certain limitations apply in the labour market in the short term as regards the availability of skills, and obviously also with regards to the wages employers are willing to pay.

While a short-term demand can be computed by adding existing and open posts, future demand will be highly path dependent. A planned demand that cannot be satisfied today and over a longer period and where prospects of filling it are meagre will eventually lead to evasion on the demand side, i.e. changes in the production structure. Therefore it is crucial to understand the concept of future "**demand potential**" which will be a demand given the supply available is not actually too distant from the plans of the enterprises. It should therefore be noted that **an extremely high projected number of vacancies in a distant future will probably not actually be realised**, but derives from a demand potential for potential jobs which could be created if Europe manages to produce the skills needed for these jobs.

What's new?

- Total skills demand extrapolation (2016-2020) uses the same year-on-year growth rates as in previous forecast, but is based on an updated baseline (new Eurostat figures)
- Due to composition effects, the total demand growth rates are slightly lower
- Together with the new and more reliable vacancy data, the result is an increased absolute demand figure.

Demand potential up until 2020 is calculated and estimated using the following observations:

- The long term trend of ICT workforce growth over the past decade
- Annual growth of ICT employment has remained very robust throughout the crisis
- The correlations between the ICT workforce growth rates, GDP growth rates and IT investment growth rates have been disappearing somewhat during recent years
- There seems to be less influence of economic cycles and a stronger indication of a "mega-trend"
- Consequence for foresight: Heavier weighting of "trend" in favour of "economic situation".

The approach contains the following inputs:

- Market insight data on enterprise IT spending
- Market insight data on hardware, software, services: IT Budgets
- Market insight data on Consulting Budgets
- (Semi-) Official Statistics on IT spending / IT investment (EITO, Eurostat)
- An evidence based estimate on the split of IT budgets into hardware, software, services
- Estimation of Labour costs, internal and external
- Correlation with GDP growth, IT investment and IT labour market
- Scenario outputs on the assumptions of GDP growth, IT investment which leads to estimations of IT labour demand (costs)
- Assumptions on wage developments and IT labour costs result in an estimation of IT labour headcount.

Technological trends are included to take effect from 2015 on, together with a beginning maturity of some markets in terms of outsourcing and off-shoring. Other major markets yet are still catching up through this period.

Scenarios furthermore deliver assumptions on the distribution of IT labour costs into a) management / business architecture level, b) core ICT practitioners and c) ICT technicians. Technological trends mainly put pressure on lower skilled ICT practitioner demand, while lifting demand for management / business architecture type of skills. As is inherent in the concept of demand potential, adjustments to supply shortage need to be made in the scenario.

The main scenario features an economic growth scenario based on a slow recovery for the time horizon 2015-2020. GDP growth across Europe from 2015 to 2020 is assumed at an average of 1.7 % annually. We expect moderate IT investment growth up to 3 % per year in the period of 2015 to 2020. In the education domain we assume a slight increase in the number of ICT graduates (**1% increase per year on average**). We also assume labour mobility of ICT workers within the EU to increase from countries of low demand to countries with excess demand.

Table 4: 'Main forecast scenario': Real GDP growth

	2015	2016	2017	2018	2019	2020
France	1.4%	1.6%	1.2%	1.3%	1.5%	1.7%
Germany	1.5%	1.6%	1.3%	1.4%	1.6%	1.8%
Italy	1.0%	0.8%	0.8%	0.9%	1.1%	1.3%
Poland	3.8%	3.6%	3.5%	3.6%	3.8%	4.0%
Spain	1.5%	1.9%	1.2%	1.3%	1.5%	1.7%
UK	1.9%	1.5%	1.3%	1.4%	1.6%	1.8%
EU22	2.0%	2.1%	1.8%	1.9%	2.1%	2.3%
EU28	1.7%	1.7%	1.4%	1.5%	1.7%	1.9%

Source: IDC Europe

Table 5: 'Main forecast scenario': IT spending growth

	2015	2016	2017	2018	2019	2020
France	2.8%	3.0%	3.4%	3.8%	4.2%	3.8%
Germany	2.7%	2.8%	3.3%	3.6%	3.7%	3.7%
Italy	1.7%	2.2%	2.1%	2.8%	5.1%	5.1%
Poland	4.7%	4.9%	5.1%	5.2%	5.3%	4.6%
Spain	1.5%	1.9%	2.7%	4.3%	4.1%	3.1%
UK	2.3%	2.7%	2.5%	2.1%	1.7%	1.2%
EU22	4.4%	3.4%	2.9%	2.3%	2.3%	2.1%
Total	3.0%	2.9%	3.0%	2.9%	3.1%	2.9%

Source: IDC Europe

Results – the forecast

In the 'Main Forecast Scenario', the ICT workforce in Europe will grow from 7.5 million in 2014 to 8.2 million in 2020, of which 6.1 million will be ICT practitioners and 2.1 million ICT management and analysis level employees.

Table 6: e-Skills Jobs – 'Main forecast scenario': Development ICT Professional e-skills Jobs in Europe 2014 – 2020

EU28 (millions)	2014	2015	2016	2017	2018	2019	2020
ICT Management	1,823,000	1,840,000	1,852,000	1,912,000	1,986,000	2,065,000	2,149,000
ICT Practitioners	5,712,000	5,836,000	5,915,000	5,956,000	5,987,000	6,025,000	6,060,000
Total	7,535,000	7,676,000	7,767,000	7,868,000	7,973,000	8,090,000	8,209,000
% Growth	+2.9%	+1.9%	+1.2%	+1.3%	+1.3%	+1.5%	+1.5%

Source: empirica model forecast.

Demand is increasing despite the modest economic circumstances, to over 8 million in 2015 and 8.9 million in 2020.

Table 7: e-Skills Demand Potential - 'Main forecast scenario': Development of ICT Professional e-skills Demand Potential in Europe 2014 – 2020

EU28 (millions)	2014	2015	2016	2017	2018	2019	2020
ICT Management	1,880,000	1,898,000	1,994,000	2,092,000	2,189,000	2,284,000	2,375,000
ICT Practitioners	6,020,000	6,152,000	6,244,000	6,352,000	6,452,000	6,529,000	6,589,000
Total	7,900,000	8,049,000	8,239,000	8,444,000	8,641,000	8,812,000	8,964,000
% Growth	+4.0%	+1.9%	+2.4%	+2.5%	+2.3%	+2.0%	+1.7%

Source: IDC Europe

The **excess demand** or shortage (calculated as the number of open posts)[12] amounts to **365,000 in 2015** and **756,000 in 2020**. This figure can best be described as **'demand potential' or 'job potential' for ICT jobs**. It should be seen as a (theoretical) figure describing the demand potential for new ICT jobs which – under the above assumptions – could theoretically and additionally be created in Europe due to an e-skills demand likely to occur especially in the years closer to 2020.

Recalling the definition of demand potential, by 2020 the labour market would be able to absorb **756,000 additional workers, if demand is not hampered by supply bottlenecks.** Of these 756,000 there are 530,000 potential additional jobs in ICT practitioner occupations and around 226,000 at ICT management level.

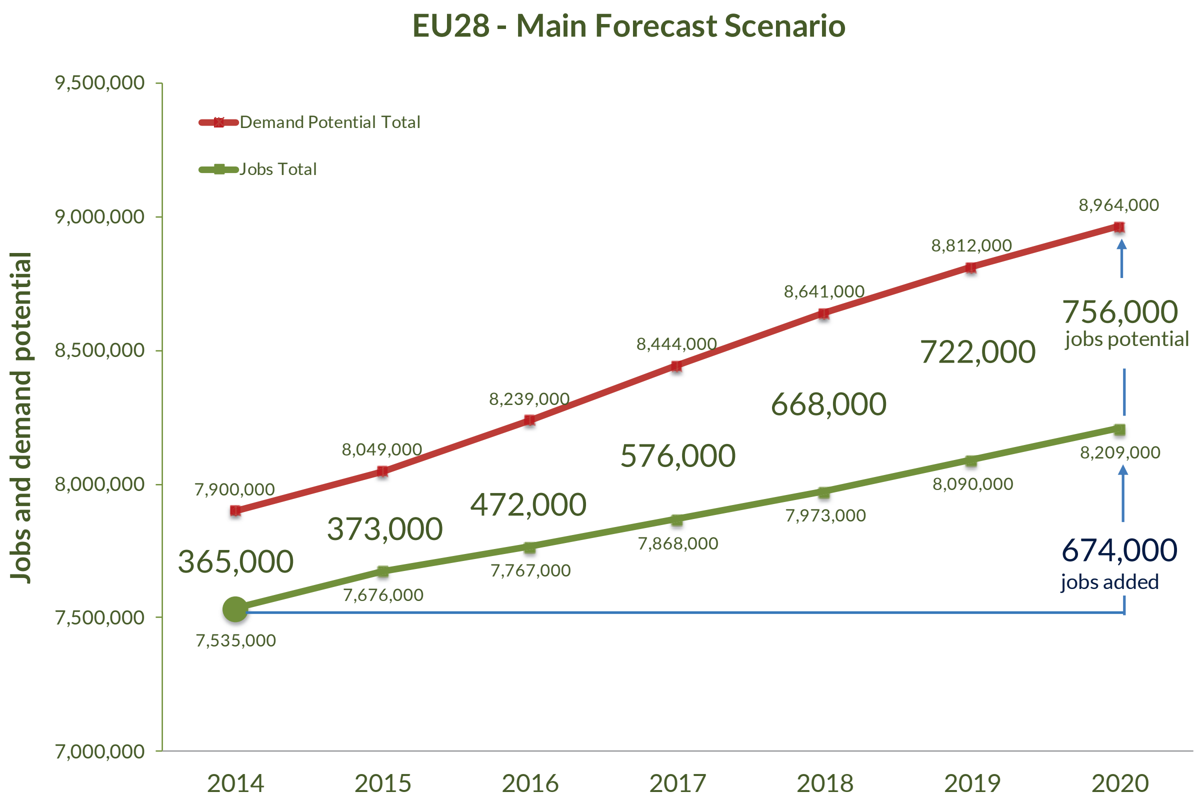
12 This model simply adds up the national balances of supply and demand, but only where they reveal an excess demand. It should be noted that this is still a very conservative estimate, as within countries a perfect geographical match is assumed. Mismatches thus only occur between countries. Migration, which alleviates the geographical mismatch, is already built into the model, as described in the assumptions section. Apart from geographical mismatches, skills mismatches only exist between management and practitioner level skills, but the assumptions on management level recruitment out of the pool of practitioners are also conservatively estimated, rather overestimating the mobility between these categories.

Table 8: e-Skills Vacancies Estimate- 'Main forecast scenario':
Summing-up of National ICT Professional Excess Demand in Europe 2014 – 2020

EU27	2014	2015	2016	2017	2018	2019	2020
ICT Management	57,000	58,000	143,000	180,000	203,000	218,000	226,000
ICT Practitioners	307,000	315,000	329,000	396,000	465,000	504,000	530,000
Total	365,000	373,000	472,000	576,000	668,000	722,000	756,000
% Growth	+35.2%*	+2.2%	+26.5%	+22.0%	+16.0%	+8.1%	+4.7%

*Source: empirica model forecast. Note: this is a summing up of national excess demand figures, not balanced with oversupply in other countries, but after migration. *: Interpolation*

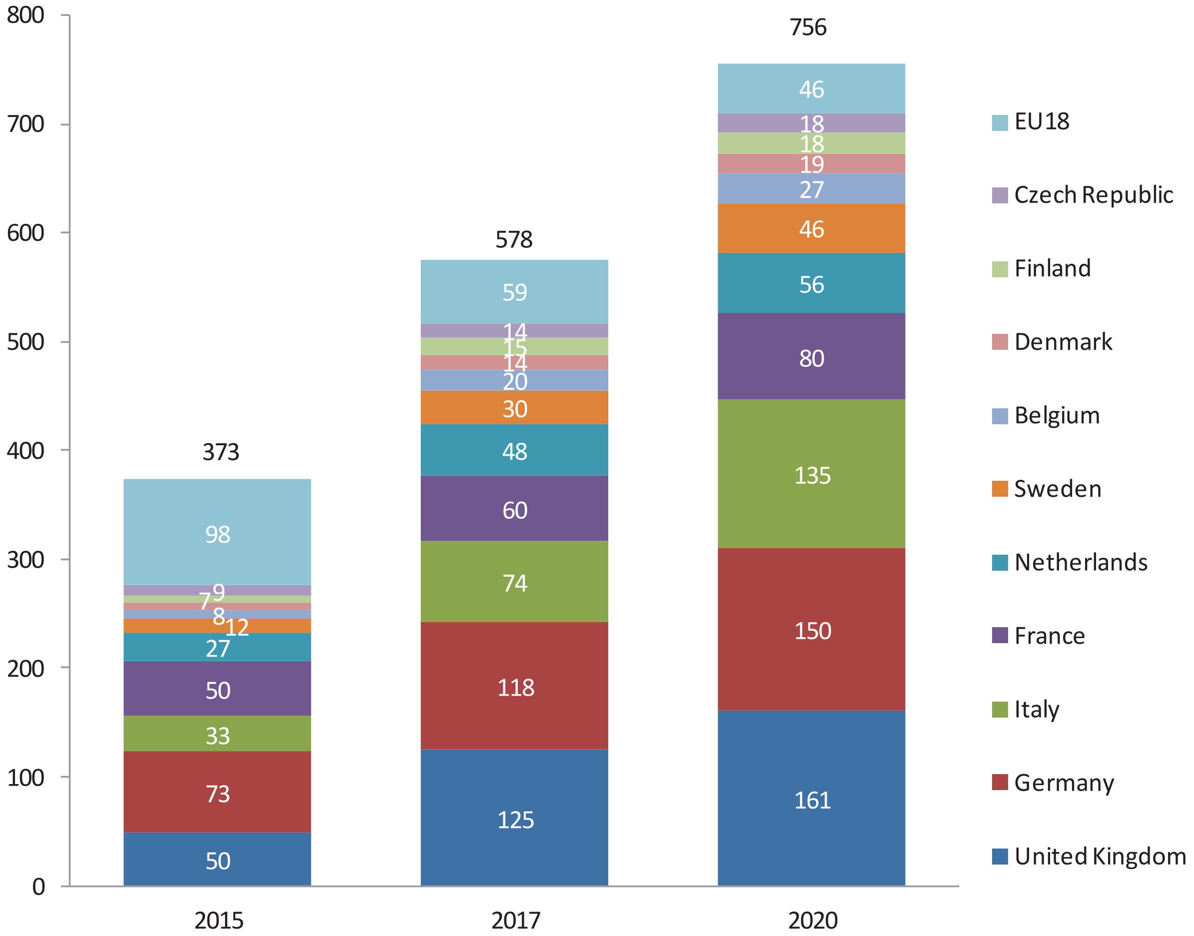
Figure 11: Main Forecast Scenario: ICT Professional Jobs and Demand in Europe (EU-27) 2014 – 2020



While currently a relative majority of vacancies exists in Germany, the comparably lower graduate figures in the United Kingdom and in Italy suggest that the problem of skills shortages will severely aggravate in these countries. While in absolute figures increasing from 73,000 (2015) to 150,000, the share of German vacancies in the European will remain at 20%. By contrast, the number of vacancies grows immensely in the UK from 50,000 to 161,000 (13% to 21%). In Italy, the number of vacancies is expected to rise from 33,000 to 135,000 (9% to 18%).

This figure of course strongly depends (of course among other factors) on the cross border mobility of IT workers into countries of highest demand.

Figure 12: e-Skills Vacancies Estimate- 'Main forecast scenario': Distribution of vacancies per country ('000s)



Interpreting the results

The Main Forecast Scenario features a modest but steady job growth of on average 112,000 ICT workers per year until 2020, a figure which is curbed by supply. More than 750,000 more jobs could be created if the skills were available. The bottlenecks are largest in the UK and Germany, but also Italy. Taken together, these three countries will account for almost 60% of all vacancies in Europe.

In 2013, we "predicted" a shortage of 510,000 ICT skilled specialists in 2015. Today, we estimate that there are 373,000 open posts, so the actual shortage is not as massive (-137,000) as feared two years ago. At the same time, we foresaw e-skilled occupation to grow to 7,503,000 in 2015. In fact, in 2014 we report an e-skilled workforce of 7,535,000, projected to grow to 7,676,000 in 2015. That would mean a positive deviation by 173,000, or 173,000 more jobs than anticipated.

There is thus reason to believe that the supply situation of e-skills has improved over the years. This improvement is probably at least in part also a merit of an increased policy effort to set the right framework conditions, give support and incentives to develop digital skills. As one example, the average policy score that Member States got for the e-skills improved from 2.37 in 2009[13] to 2.87 in 2013[14] (scale 0-5).

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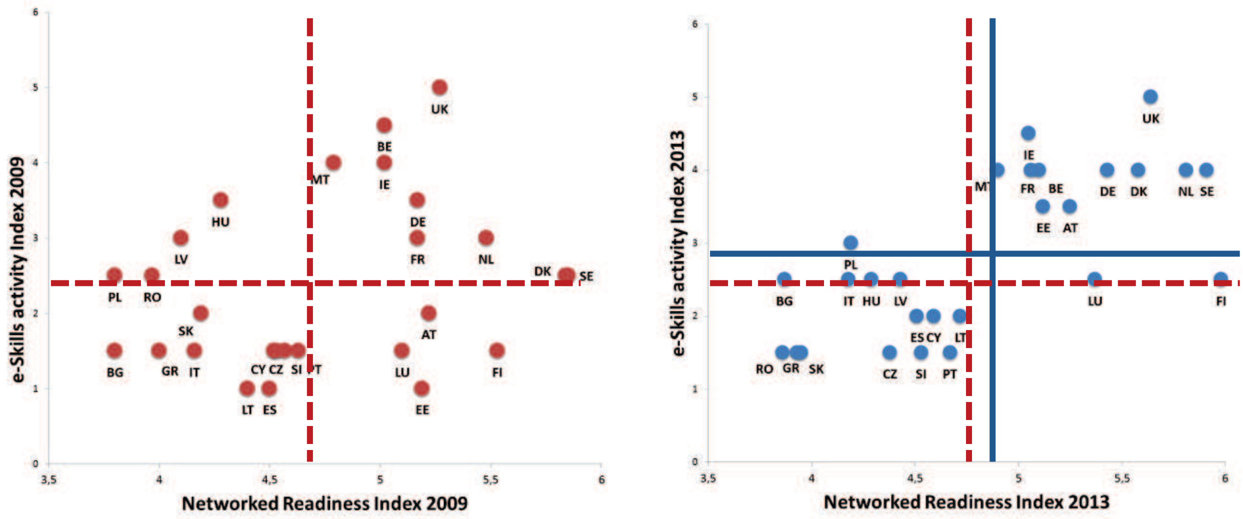
[13] Hüsing, T. and Korte, W.B. (2010) "Evaluation of the Implementation of the Communication of the European Commission 'e-Skills for the 21st Century'"

Figure 13: Increase of average e-Skills policies scores between 2009 and 2013



Source: Gareis, K. Et al.: E-SKILLS FOR JOBS IN EUROPE: MEASURING PROGRESS AND MOVING AHEAD. FINAL REPORT Feb 2014

Some caveats need to be formulated when interpreting these results. The **first one** concerns the notion of **demand *potential***. The projection is about a demand potential and actual future demand of organisations will be informed by the actual supply situation at a given point in time. Vacancies that cannot be filled year after year will go away – projects cannot be realised, tenders not submitted, innovations will simply not be made. The effects of a persisting skills shortage will probably include

- increased outsourcing and off-shoring
- untapped innovation potential
- unwanted/enforced productivity gains but also
- wage increases
- changes of the production structure.

The **second caveat** concerns the workarounds that have existed in IT as long as the sector and occupations exist. Our approach is prudent insofar as that it accounts for **a limited number of lateral entries & non-ICT graduates**. In the Main Forecast Scenario, 866,000 lateral entries and non-ICT graduates over the six years enter the workforce, compared to 1.13 million graduates.

In recent years, however, the number of new jobs was up to more than twice as high as the number of available graduates. Assuming this ratio to pertain, the number of vacancies could be lower – and the number of jobs to materialise higher. We have already adapted the model assumptions to allow for more lateral entries, bearing in mind, however, that CIOs we have talked to in the process of modelling have told us that lateral entries at the entry level happen much less recently than it used to be for example in the Nineties.

The **third caveat** is that, quite obviously, the **demand estimate is a forecast** relying on a relation of ICT workforce growth and GDP/IT spending growth of the 1990's and the first decade of the 2000's, with different economic climate, but also concerning a different set of workers, i.e. the "core definition". The core workforce increased significantly even through the crisis years 2008-2012. The level of ICT workforce growth in 2011-12 has been much stronger than expected. On the other hand, the larger aggregate of workers, the "broad definition", has seen only 1.2% growth between 2011 and 2014. We forecast demand growth of annual rates between 2.5% and 1.7% between 2015 and 2020.

[14] Gareis, K. Et al.: E-SKILLS FOR JOBS IN EUROPE: MEASURING PROGRESS AND MOVING AHEAD. FINAL REPORT Feb 2014

A **fourth caveat** concerns new and emerging jobs which are not part of the forecasting model yet. There are and will be numerous jobs around third platform technologies that have not yet appeared in job statistics – or if they have, as people on these jobs will for sure be counted in the statistical systems, it is not yet clear where in the existing categorisations they would appear. Big Data, cloud computing, social media, mobile platforms and other megatrends will deliver new capabilities and jobs – and taken together this "3rd technology platform" will require new skills.

Many third platform jobs that are not genuinely IT jobs will be at professional level, for instance in finance, marketing, or consulting. New business processes need to be defined and implemented as the third platform is adopted, and many people engaged in these tasks will never appear in statistics as “ICT workers”.

2.6 Outlook

Demand for ICT skills keeps growing at a tremendous pace. The trend in core IT jobs has been up to 4% growth p.a., the growth in management jobs up to 8% growth p.a. However, demand for medium level skilled associate and technician jobs is declining. In total, despite the crisis, we have seen new jobs being created in Europe continuously. There is thus a need to continuously increase the quality and the relevance of e-skills. At the same time, although graduate figures seem to stabilise, supply from universities does not seem to keep pace.

Job growth is largest in highly skilled jobs, such as management, architecture and analytics positions, and this reinforces the need for more and better e-Leadership skills. The fact that these positions are usually recruited from the pool of seasoned practitioners and other (non-ICT) managers, together with a presumed lack of entry level jobs at medium level skills may evolve into recruitment bottlenecks in the longer term.

However, at the same time the pace of change seems to be still increasing in ICT jobs, and new job profiles pop up which naturally cannot yet be fully covered in statistical classification, such as Big Data and Cloud computing specialists. Many of these jobs are not genuinely ICT jobs but will be at a professional level, for instance in finance, marketing, or consulting – helping new business processes be defined and implemented.

This is a huge opportunity for creation of new jobs generated in all industry sectors, beyond the traditional pathway of ICT studies, but with a strong imperative for ICT to permeate other and new educational trajectories.

ICT has traditionally been a field in which outsiders – in terms of formal education or career trajectory – play a crucial role. However, recently increased endeavours are made to reach a higher level of professionalization of the profession, which increasingly includes formal education requirements. These are not necessarily to be sought in a traditional first university or vocational education, but may still be acquired later in the career, a workaround that the ICT profession has maintained like perhaps no other profession for decades. Nevertheless, increasing requirements of formal education make continuous professional education, lifelong learning and executive education even more important. There is an immense opportunity today for new education approaches, new modes of delivery, better curricula and learning outcomes.

3 Quantification of the e-leadership workforce

Previous estimates[15] at e-leadership demand and supply in Europe came to the conclusion that Europe sees a demand of about 683,000 e-leaders and a supply of 661,000. Demand estimation was based on the sector

[15] Hüsing, Tobias et al (2013).: e-Leadership: e-Skills for Competitiveness and Innovation Vision, Roadmap and Foresight Scenarios. Final Study Report http://eskills-vision.eu/fileadmin/eSkillsVision/documents/VISION%20Final%20Report.pdf

and size structure of businesses in Europe, simply assuming that an enterprise of a certain size and in a certain, more or less ICT intensive sector needs on average a certain number of e-leadership skilled employees. Supply estimation was based on occupational data and assumed that a certain percentage of several occupations (such as ICT and R&D executives) are e-leaders.

While the estimations presented a reasonable stab at establishing an order of magnitude of e-leadership in the workforce, its weakness lies in the fact that some of the assumptions made simply rely on educated guesswork. They were discussed at various workshops with experts and stakeholders, but not empirically tested.

To amend this shortcoming, empirica undertook to survey enterprises of the business economy and public sector with the intention to estimate the number of employees that could be seen as e-leaders.

A survey of CIOs carried out in the summer of 2013 was used to pilot methods for exposing e-leadership problems in today's organisations, i.e. a focus on an organisation's competence in identifying and addressing opportunities for business innovation using ICT.

As a yet not fully defined phenomenon, e-leadership had to be operationalised so as to be able to communicate to survey respondents whom we look for. Operationalization of e-leadership was decided to follow the proposition that e-Leadership manifests in successful innovation.

The survey was carried out in the UK, Germany and the Netherlands – the first being the two biggest economies in Europe with the largest ICT labour markets, the Netherlands as regionally close and with a high level of educational activity in the e-leadership domain. Together, these three countries account for 38% of the business economy employment in the EU.

In total 901 interviews were carried out, across the three countries and across sectors and size classes. The respondent was the head of the IT function in the organisation, in larger organisations usually a CIO. The following tables show the composition of the sample:

Table 9: Sample e-leadership survey

		Sample	Percent
Sector	Manufacturing and Construction	220	24%
	Distributive services	231	26%
	Other services incl. Finance	240	27%
	ICT	138	15%
	Public sector	72	8%
	Total	**901**	**100%**
Size of firm	10 – 19	73	8%
	20 – 29	67	7%
	30 – 49	92	10%
	50 - 99	96	11%
	100 - 249	142	16%
	250 - 499	151	17%
	500 - 999	116	13%
	1000 - 2499	88	10%
	2500+	76	8%
	Total	**901**	**100%**
Country	Germany	300	33%
	The Netherlands	301	33%
	United Kingdom	300	33%
	Total	**901**	**100%**

The methods were directed at organisations employing ICT staff. Therefore an interview was only carried out if at least one ICT practitioner was employed in the organisation. Incidence of ICT employment is shown in the following table.

Table 10: Incidence rate in e-leadership survey

	Incidence Rate
Sample Total	18%
Sample Germany Total	19%
Sample Netherlands Total	16%
Sample UK Total	19%
Sample Total 10 to 49	9%
Sample Total 50 to 249	20%
Sample Total 250 plus	34%

Though incidence rates appear low, these levels were reconfirmed by the survey organisation as being in line with results from other surveys.

3.1 Addressing innovation opportunities

Key questions in the survey address an organisation's success in detecting innovation opportunities, both by ICT staff and by business staff. The main issue was whether overall CIOs thought their organisation was performing well in addressing innovation, and whether innovation projects were allocated sufficient resources. Some reports suggest that business innovation projects are left to the IT department, with the implication that these suffer from lack of access to resources in user departments. Furthermore, since many opportunities for innovation require understanding of both business and ICT, innovation opportunities could be detected by business executives, if these have enough understanding of ICT. Two questions therefore looked at the CIO's view of the innovation capabilities of their organisation as a whole and as identified by their fellow non-IT executives in particular.

Though most CIOs (77%) report that the opportunities for IT-based innovation open to their organisation are being addressed in time and with appropriate resources, a significant minority report that this is not the case. Problems are somewhat more acute in smaller organisations, though the difference perhaps surprisingly small: the proportion of organisations experiencing problems drops from over a quarter of the smaller organisations to under 20% in the largest enterprises.

A significant part of the problem in grasping ICT based innovation opportunities appears to be due to skills deficits in business departments. From the perspective of their CIO, only about half of organisations today have business executives who have a level of understanding of IT sufficient to identify innovation opportunities in their sector or area of activity. This is more or less constant across all size categories – there is just as large a proportion of the largest enterprises organisations reporting this problem as among quite small organisations.

3.2 e-Leadership roles in innovation

Ensuring ICT-based innovation opportunities are identified, grasped and guided to fruition requires e-leadership at the different stages in the innovation life cycle. It is seen as particularly critical not only to be able to envision an innovation, and to assess its likely success in the organisation, but also to communicate this vision to executive colleagues controlling the resources impacted by the proposed organisational change. This was operationalised as the performance of two key component e-leadership roles. The first is the role of proposing an innovation project. The success of a proposal was conceptualised as an innovation project resulting from the proposal. Making proposals not leading to a project can be taken as an indicator of failure in e-leadership, having arisen either from inability to assess business outcome appropriately or inability to persuade business colleagues of the probability and value of the business outcome.

A second key component of an e-leadership role is seen as that of guiding an innovation project to success. This is not implementation of an IT solution, nor even managing its implementation, but acting as the client for the innovation project - assessing proposals, monitoring conformance to requirements, accepting results etc., including acting as client for delivery of solutions from outside organisations.

Both these e-leadership component roles are required ensure that innovative IT applications and services are identified and successfully deployed to improve performance and competitiveness.

To investigate this complex, it was first necessary to ask the respondents to report on recent ICT-based innovation. CIOs were asked about the number of such innovation projects their organisation had engaged in in the recent past, phrased for simplicity as "innovative IT projects".

Of the organisations surveyed, nearly three quarters reported having initiated / carried out at least one innovation project within the previous year. A further 10% had at least one such project within the last five years. Those unable to report on a project - 7% reported no project at all, while 11% were unable to tell – had to be excluded from further questions and analysis, due to the methodological focus adopted. The average number of innovative ICT-based projects in the previous year is 5.1, the median is 2.

Table 11: Staff involved in proposing and as clients of IT projects

		Innovative IT projects have been proposed by staff from ...			Number of persons involved in proposing innovative projects using IT in ...			Number of persons acting as project clients in ...		
Size of enterprise	Average number of employees	IT depart-ment	other business units	external organi-sations	IT depart-ment	other business units	external organi-sations	IT depart-ment	other business units	external organi-sations
10 - 19	13.8	51%	54%	39%	1.5	2.1	1.6	1.3	1.4	0.8
20 - 29	23.2	59%	52%	21%	2	1.8	1.3	1.3	1.3	0.4
30 - 49	37.3	58%	60%	25%	1.4	2.1	4.4	1.4	1.4	0.8
50 - 99	69.2	53%	65%	12%	1.9	2.5	0.7	1.5	1.8	0.5
100 - 249	153	56%	64%	22%	1.9	2.9	1.1	1.4	2	0.5
250 - 499	342	65%	76%	24%	2.9	5	0.7	1.7	2.7	0.4
500 - 999	667	72%	73%	27%	3.9	4.5	0.8	2.4	3.6	1.1
1000 - 2499	1420	65%	83%	14%	4.9	5.5	1.5	2.3	4.3	0.5
2500+	9633	75%	77%	34%	5	13.7	7.3	4.2	8.7	1.2
Total	**1030**	**62%**	**68%**	**23%**	**2.7**	**4**	**1.8**	**1.8**	**2.7**	**0.7**

The second feature addressed was the locus of proposed innovation. Are successful innovation proposals flowing in from business units – a sign of at least adequate understanding of the options for ICT exploitation alongside business understanding – or are such proposals mainly generated from the CIO or IT staff working under the CIO? Or does the organisation respond to vendor proposals, proposals coming from outside without direct access to organisation-specific demand detail

The picture is surprisingly mixed. Successful innovation project proposals are balanced in origin between business and ICT executives. Successful proposals have been proposed equally from within and outside the IT department. About two thirds of organisations with recent ICT-based innovation state each origin. Vendor or other external impetus is also very prevalent, being mentioned by about a quarter of innovative organisations.

The number of persons involved increases only slightly with enterprise size, so that a much higher share of employees in the enterprises are actually involved in smaller enterprises(up to 25% in the smallest class), while larger ones have a specialised innovation labour force:

Table 12: Staff involved in proposing and as clients of IT projects

Enterprise size class	% of staff involved in proposing IT projects	% of staff involved as project clients
10 - 19	25.4%	19.5%
20 - 29	16.5%	11.5%
30 - 49	9.6%	7.5%
50 - 99	6.3%	4.9%
100 - 249	3.1%	2.2%
250 - 499	2.3%	1.3%
500 - 999	1.3%	0.9%
1000 - 2499	0.7%	0.5%
2500+	0.2%	0.1%
Total	**0.6%**	**0.4%**

It is interesting to see that the relation between IT staff and non-it staff involved in driving IT based innovation is rather constant at 40/60, both in terms of initiation (proposing, 2.7 IT staff and 4.0 Non-IT staff) and implementation (acting as client, 1.8 IT staff and 2.7 Non-IT staff).

While the survey only addressed three countries, we experimentally applied the results of the three countries to the known business structure according to size class (but not industry) of the whole of Europe (EU28)[16]. The following e-Leadership quantification emerges from grossing up from DE, NL and UK to EU28.

Table 13: e-Leadership quantification 2013

Size of enterprise	Total number of employees business economy	e-Leaders: Number of persons involved in proposing innovative projects using IT, which have been successful	Number of persons acting as project clients in
10 - 19	12.6 M	176,000	229,000
20 - 49	15.0 M	108,000	147,000
50 - 249	23.0 M	140,000	188,000
250 +	44.2M	145,000	239,000
Total	**94.8M**	**568,000**	**802,000**

EU28 estimation based on data in NL, DE and UK

The order of magnitude of the European e-Leadership workforce can thus be estimated to be around 570,000. Those 800,000 workers acting as "project clients", i.e. taking care of the successful roll-out and implementation might be included in a broader definition of e-leadership but we have decided not to, in order to keep the notion of ideation and finding opportunities. The previous estimate of 660,000 to 680,000 e-leaders has not been out of range.

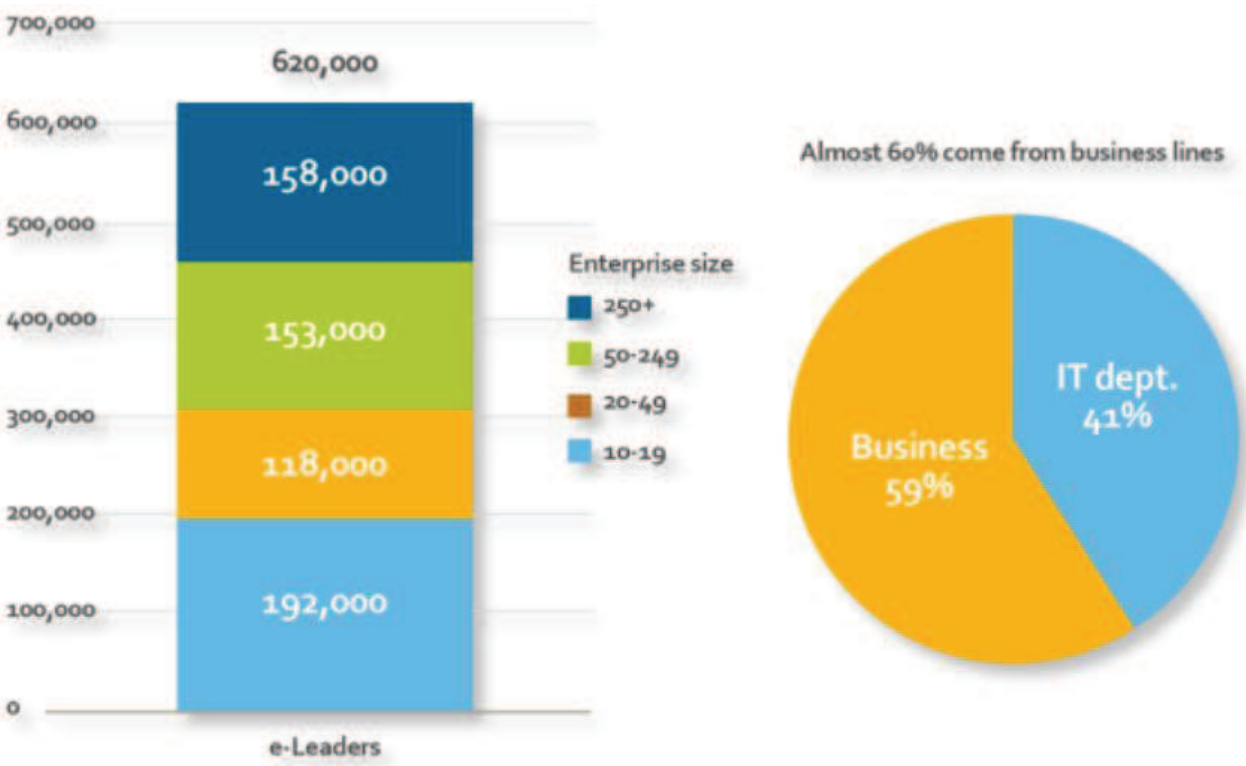
It has to be noted that SMEs are overrepresented among e-leaders. The ICT innovation in larger enterprises (250+ employees), according to this estimation, relies on less than 150,000 e-leaders in Europe.

3.3 e-Leadership Quantification 2015 and forecast

Extrapolating from the 2013 result, applying a 4.6% growth trend to today, 2015, there are probably 620,000 innovation e-Leaders in Europe. It is assumed that the distribution across size classes and business units has not changed significantly since then. A majority of almost 60% comes from the business units in companies and not from IT departments. 158,000 e-leaders are found in large enterprises.

[16] The countries in the survey account for 38% of the employment in the European Union. Scaling up the result to the European Union should also require taking account of sector differences between these countries and the remaining 25 Member States but due to the limited number of cases and inconclusive variance between sectors and it seemed reasonable to restrict adaptation to size class structure only. Given the sector structure difference between the whole of Europe and the countries covered, the true value might be somewhat lower.

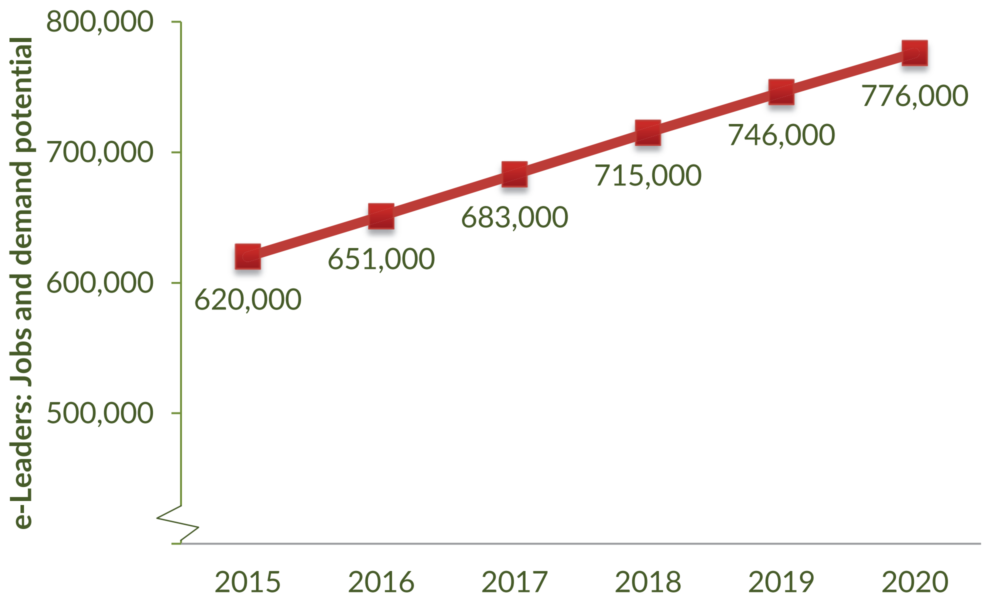
Table 14: e-Leadership quantification 2015



IDC and empirica have forecast demand for highly skilled ICT occupations[17] to rise by on average 4.6% until 2020. It seems reasonable to assume that demand for e-leadership is closely coupled with highest skilled ICT jobs. Applying a 4.6% growth rate to the above mentioned 568,000 e-leaders, results in a demand potential for 776,000 e-leaders in 2020.

[17] ICT management, architecture and analysis skills. Demand for these jobs is forecast to rise from 1.94 million (2013) to 2.65 million (2020).

Figure 14: e-Leadership forecast



Europe will thus need increase the number of e-leaders by 156,000 until 2020. Taking account of expansion and replacement demand, Europe will so need 200,000 to 250,000 additional innovation e-leaders by 2020, or 40,000 to 50,000 per year.

3.4 Summary and Outlook

Experts agree that for effective e-leadership, people need very strong ICT skills and must lead qualified staff from ICT and other disciplines towards identifying and designing business models and exploiting key innovation opportunities. Their success is defined as making best use of developments in ICT and delivering value to their organizations.

Recent research - further described in the document - demonstrates that there is a significant demand of e-leaders in Europe. First attempts to quantify the existing e-leadership workforce based on company's involvement in ICT based innovation activities result in some 620,000 e-leaders in European enterprises. Around 70% of e-leaders are found in SMEs and interestingly enough, we see 59% of e-leaders outside the IT department, coming from lines of business, and 41% being IT department inhabitants.

When coupling the e-Leadership demand and supply with the known demand and supply of ICT management, architecture and analysis skills with an average rise of 4.6% we can assume the Europe would need to increase the number of e-leaders by more than 150,000 until 2020. On top of that, replacement demand has to be catered for.

In order to compensate for this, organisation internal talent pipelines but also the European higher and executive education system and other training and education providers need to be capable of supporting 40,000+ seasoned ICT practitioners and business managers to be turned into new e-leaders each year which constitutes a huge challenge.

It is against this background that the European Commission e-Leadership initiative aims to support the development of e-leadership skills through the strong practical instrument of a curriculum profile and the development of quality criteria that evaluate the programmes provided by higher educational institutions matched to curriculum profiles and demonstrate these at different business schools and universities in Europe. This should lead to encouraging the development of attractive, adapted, up-to-date educational offers able to increase the supply to the economy of experienced and highly qualified leaders in ICT-based innovation

Closing this skills gap requires an ecosystem perspective, connecting the demand and supply side stakeholders of e-leadership skills. Responding to the inadequacies in the skills market flagged by stakeholders across the EU, the European Commission has launched the "e-skills strategy" and the "Grand Coalition for Digital Jobs". After responding to requirements for increased professionalism among ICT practitioners, and developing strategies and instruments to bridge the gap between e-skills demand and supply at that level, the new focus is on the skills gap in the e-leadership domain. The first pan-European initiative on e-leadership was launched in 2013 (www.eskills-guide.eu) followed by the 2014 European e-Skills conference on 'e-leadership and ICT professionalism' (http://eskills2014conference.eu) and the European e-leadership and key enabling technologies conference in 2015 (http://leadership2015.eu).

In order to close this skills gap, the e-leadership initiative has applied an ecosystem perspective and identified techniques to improve information flows between demand and supply side stakeholders in e-leadership skills. The improved transparency and timely flow of knowledge about developing skills requirements will enable institutions of higher and executive education to respond. A key practical instrument in communicating skills requirements are the new e-leadership curriculum profiles, which specify core skills, learning outcomes, understanding and competences required by e-leaders today, whether they lead innovation teams bringing specialist understanding of topics such as enterprise architecture or take full responsibility for enterprise innovation at C level.

A key element of these curriculum profiles and the guidelines is the requirement for mapping existing programmes onto the skills and competences of the e-Competence Framework (www.ecompetences.eu). The e-leadership curriculum profiles and guidelines use and applicability has been demonstrated by the universities and business schools directly participating in this initiative in several European countries. Response by the education community is picking up with already more than 20 universities and business schools having evaluated their programmes against the new e-leadership profiles. Further dissemination and substantial stakeholder engagement was achieved through 10 regional cluster events throughout Europe reaching out to more than 1200 stakeholders and experts. The initiative continues to be open to education institutions, industry and associations understanding e-leadership skill requirements in the workplace.

The European Commission launched the complementary e-Leadership Skills for Small and Medium sized Enterprises action in January 2014. This Commission initiative is complementary to the above one on 'New Curricula for e-Leadership' and focusing on entrepreneurs, managers and advanced ICT users in SMEs, start-ups and gazelles (www.eskills-lead.eu). This initiative has developed guidelines for designing e-leadership training and education for SMEs and start-up companies. It has shown the divers pathways to e-leadership for SMEs and demonstrated how five pioneering European universities and business schools have addressed the lack of appropriate e-leadership education through developing and teaching innovative short and longer-term e-leadership courses for this target group

Annex

Comparing current forecast to previous forecasts

2014 Forecast

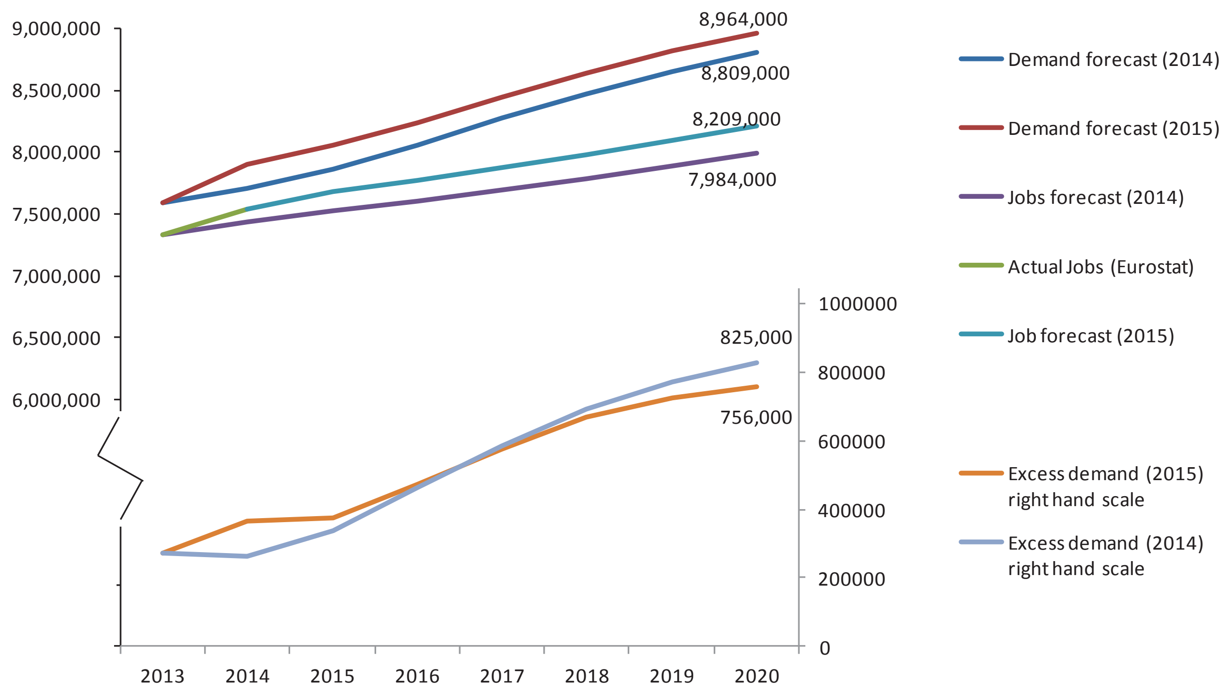
Compared to the forecast of last year, the two major differences are the unexpected large increase in number jobs from 2013 to 2014 (98,000 more jobs were created than we foresaw) and the new method of estimating the number of vacancies, which resulted in an estimated figure of 373,000 vacancies for 2015, which we had to back cast to get a new baseline for 2014 (the year where job data are available).

Table 15: 'Main forecast scenario' 2014 and 2015 compared

	2013	2014	2015	2016	2017	2018	2019	2020
Demand forecast (2014)	7,594,000	7,700,000	7,866,000	8,060,000	8,270,000	8,471,000	8,650,000	8,809,000
Demand forecast (2015)	7,595,000	7,900,000	8,049,000	8,239,000	8,444,000	8,641,000	8,812,000	8,965,000
Jobs forecast (2014)	7,325,000*	7,437,000	7,529,000	7,598,000	7,686,000	7,780,000	7,881,000	7,984,000
Jobs forecast (2015)	7,325,000*	7,535,000*	7,676,000	7,767,000	7,868,000	7,973,000	8,090,000	8,209,000
Excess demand potential (2014)	270,000	262,000	337,000	462,000	584,000	692,000	769,000	825,000
Excess demand potential (2015)	270,000	365,000	373,000	472,000	576,000	668,000	722,000	756,000

* Actual number of ICT jobs based on Eurostat data

Figure 15: 'Main forecast scenario' 2014 and 2015 compared



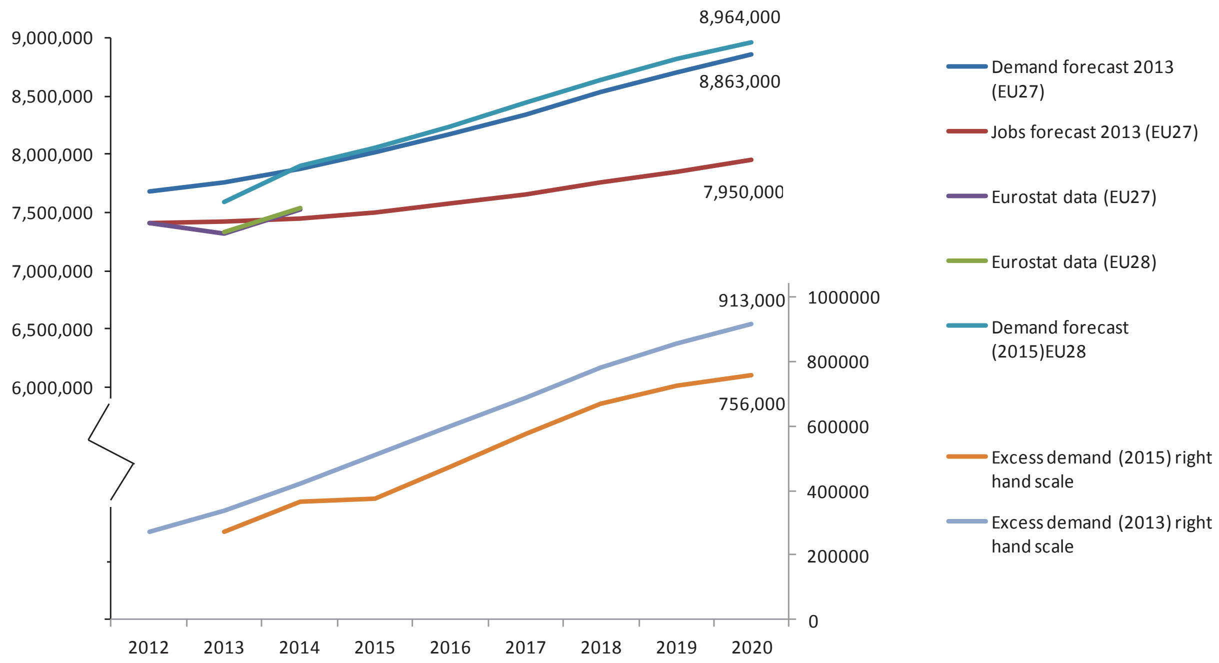
2013 Forecast

As the 2013 and 2014 forecast was largely built on the same methodology, the differences to today's forecast are similar. In 2013 the main forecast scenario saw the excess demand *potential* for 2015 at 510,000, and at 913,000 for 2020. As described we today estimate an excess demand (*actual*) of 373,000 in 2015 and 756,000 for 2020. Note that an *actual* excess demand of today is not at all contradictory of a higher *potential for today (which was the future)* in the past.

Table 16: 'Main forecast scenario' 2013 and 2015 compared

	2012	2013	2014	2015	2016	2017	2018	2019	2020
Demand forecast 2013 (EU27)	7,677,000	7,757,000	7,873,000	8,013,000	8,169,000	8,343,000	8,532,000	8,703,000	8,863,000
Demand forecast (2015) EU28		7,594,000	7,900,000	8,049,000	8,239,000	8,444,000	8,641,000	8,812,000	8,964,000
Jobs forecast(2013) EU27	7,403,000	7,419,000	7,451,000	7,503,000	7,571,000	7,657,000	7,752,000	7,848,000	7,950,000
Jobs forecast (2015) EU28		7,325,000	7,535,000	7,676,000	7,767,000	7,868,000	7,973,000	8,090,000	8,209,000
Eurostat data (EU27)	7,403,000	7,316,000	7,528,000						
Eurostat data (EU28)		7,325,000	7,535,000						
Excess demand potential (2015)		270,000	365,000	373,000	472,000	576,000	668,000	722,000	756,000
Excess demand potential (2013)	274,000	338,000	422,000	510,000	598,000	686,000	780,000	855,000	913,000

Figure 16: 'Main forecast scenario' 2013 and 2015 compared



2009 Forecast

In 2009, the forecast was still built on a baseline that was 2 years old and consisted only of the narrow definition of e-skills. At that time the impression of the 2008 financial turmoil were still very fresh and the widely shared opinion on the future outlook was rather bleak. This certainly has contributed to strongly underestimating the robustness of ICT and e-skills demand at the time. Even the most optimistic scenario of 2009 ("Turbo Knowledge Economy") foresaw a demand development that was significantly below the actual market outcome that later came to be. We hence underestimated significantly both the supply and the demand.

Table 17: 2009 Forecast, 2007 baseline - Scenarios "Back to normal" and "Turbo Knowledge Economy" and actual job development

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Demand e-Skills - back to normal	3,944,805	3,954,954	3,868,263	3,880,438	3,931,381	4,000,589	4,076,470	4,211,197	4,352,485
Jobs forecast - back to normal	3,793,081	3,829,605	3,864,632	3,880,438	3,926,679	3,958,663	3,987,518	4,013,842	4,038,308
Demand e-Skills - turbo knowledge economy	3,944,805	3,954,954	3,888,189	3,918,228	4,006,762	4,114,028	4,232,092	4,474,847	4,738,502
Jobs forecast - turbo knowledge economy	3,793,081	3,829,605	3,864,632	3,899,163	3,943,007	3,996,265	4,059,877	4,125,665	4,194,843
Actual number of jobs	3,803,497	3,925,531	4,030,853	4,136,174	4,322,814	4,493,837	4,616,979	4,748,612	

(Note: Core ICT job definition of workforce)

Figure 17: 2009 Forecast, 2007 baseline - Scenario "Back to normal" and actual job development

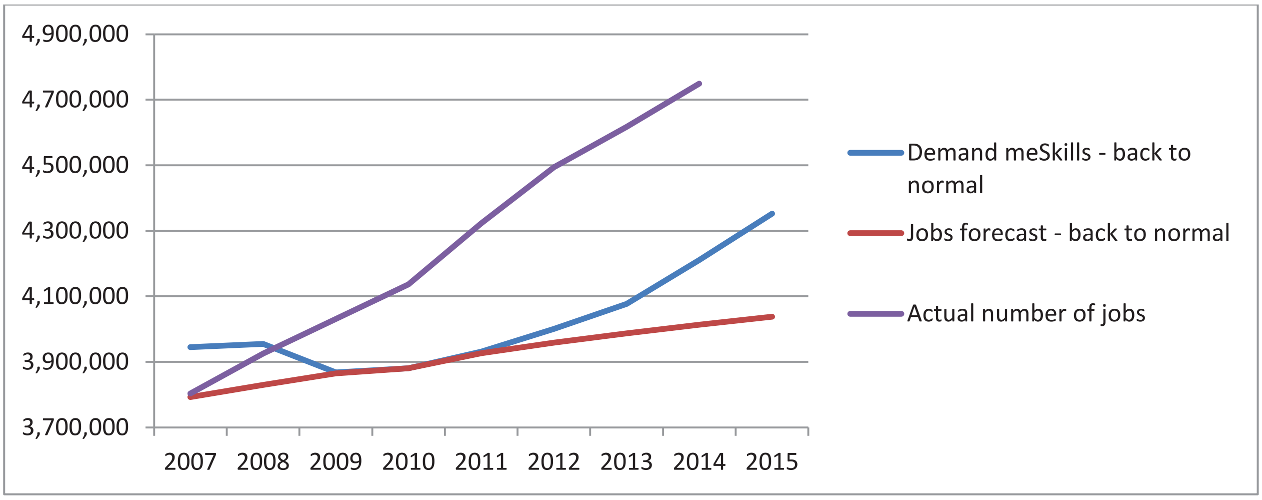
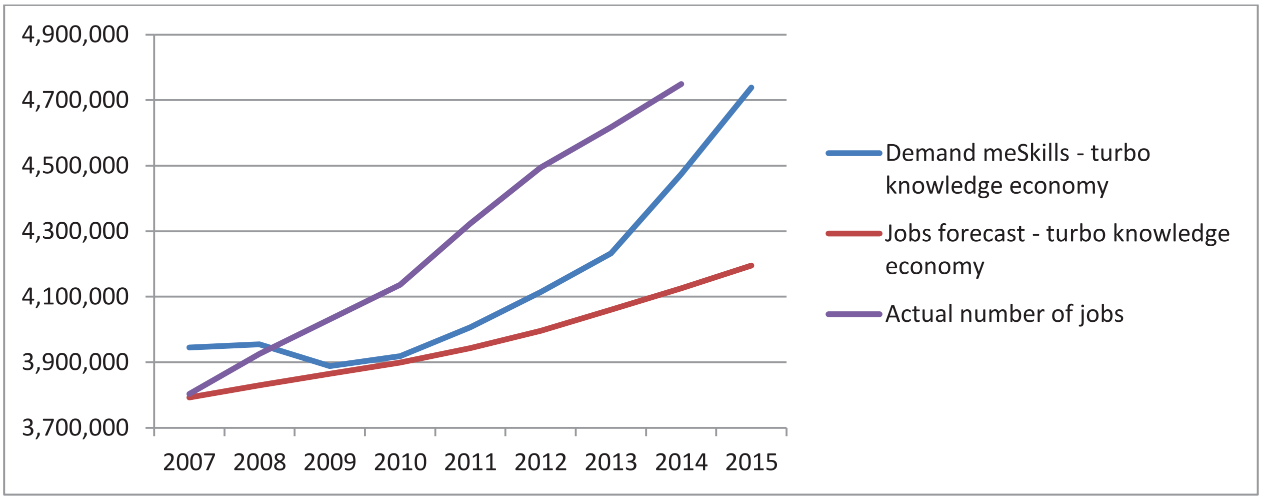


Figure 18: 2009 Forecast, 2007 baseline - Scenario "Turbo Knowledge Economy" and actual job development



Comparison of OECD ICT specialist occupations and coverage by "our" definition.

Table 18: OECD ICT specialist occupations and coverage by "our" definition

	OECD definition	ISCO	Covered by "our" definition
1	Information and communications technology operations and user support	351	100%
2	Engineering professionals (excluding electrotechnology)	214	not
3	Software and applications developers and analysts	251	100%
4	Information and communications technology service managers	133	100%
5	Database and network professionals	252	100%
6	Physical and earth science professionals	211	not
7	Electrotechnology engineers	215	~ 60%
8	University and higher education teachers	231	not
9	Mathematicians, actuaries and statisticians	212	not
10	Architects, planners, surveyors and designers	216	not
11	Vocational education teachers	232	not
12	Telecommunications and broadcasting technicians	352	100%
13	Physical and engineering science technicians	311	~ 5%
14	Electronics and telecommunications installers and repairers	742	In "very broad" definition only
15	Blacksmiths, toolmakers and related trades workers	722	not
16	Life science professionals	213	not
17	Metal processing and finishing plant operators	812	not
18	Administration professionals	242	~ 20%
19	Sales, marketing and public relations professionals	243	~ 5%
20	Process control technicians	313	~ 30%

Some data tables.

Table 19: ICT workforce in Europe in 2014

	Management, architecture and analysis	Core ICT practitioners - professional level	Other ICT practitioners - professional level	Core ICT practitioners - associate/ technician level	Other ICT practitioners - associate/ technician level	TOTAL	Share of workforce
UK	417,000	751,000	131,000	192,000	146,000	1,638,000	5.4%
DE	421,000	422,000	82,000	153,000	118,000	1,197,000	3.0%
FR	175,000	329,000	65,000	97,000	217,000	882,000	3.4%
IT	84,000	125,000	37,900	256,000	143,000	646,000	2.9%
ES	76,000	118,000	53,000	161,000	91,000	499,000	2.9%
NL	167,000	159,000	17,000	36,100	41,000	420,000	5.1%
PL	63,000	197,000	30,000	44,900	76,000	412,000	2.6%
SE	86,000	75,000	21,100	44,600	36,200	262,000	5.5%
BE	67,000	59,000	12,500	21,500	17,600	177,000	3.9%
CZ	19,000	56,000	11,200	52,000	33,200	172,000	3.5%
FI	49,000	37,300	27,100	17,600	12,800	144,000	5.9%
AT	31,100	56,000	7,800	22,200	22,400	139,000	3.4%
RO	24,900	28,000	32,700	28,100	21,800	136,000	1.6%
DK	28,200	51,000	5,600	25,300	19,200	130,000	4.8%
HU	9,400	43,100	30,200	31,500	13,600	128,000	3.1%
PT	21,000	38,300	12,800	28,400	20,900	121,000	2.7%
BG	16,100	23,400	7,200	14,000	14,200	75,000	2.5%
IE	14,400	35,700	4,500	14,300	4,700	74,000	3.9%
SK	5,700	26,600	3,700	14,300	13,900	64,000	2.7%
GR	10,500	11,500	11,100	9,600	9,300	52,000	1.5%
HR	5,300	13,800	1,700	13,400	5,000	39,100	2.5%
SI	5,700	11,300	3,200	3,500	3,900	27,500	3.0%
LT	6,000	10,300	2,300	600	5,500	24,800	1.9%
EE	6,100	10,800	1,900	3,400	2,200	24,400	3.9%
LV	7,100	9,300	400	4,000	2,600	23,400	2.7%
LU	4,900	7,400	1,000	1,500	1,300	16,200	6.6%
CY	1,600	3,100	900	1,100	1,000	7,700	2.1%
MT	1,100	2,100	300	1,100	1,600	6,300	3.4%
EU28	1,823,000	2,710,000	615,000	1,293,000	1,095,000	7,535,000	3.5%

Source: empirica calculations based on an LFS data retrieval done by Eurostat.

Table 20: ICT graduates (first degrees in ISCED 5A and first qualifications in 5B) in Europe 2012

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
EU28	109,000	121,000	128,000	130,000	125,000	122,000	115,000	115,000	114,000	111,000
France	16,100	18,100	20,000	19,700	18,400	17,600	19,100	20,000	20,700	20,000
United Kingdom	31,000	27,700	29,600	28,200	25,200	23,800	19,200	19,200	19,500	19,900
Germany	8,400	11,100	12,800	14,200	16,100	16,500	17,200	16,800	16,500	16,800
Spain	19,300	19,700	18,600	17,300	15,800	14,600	15,100	15,100	14,800	11,900
Poland	5,900	10,700	13,100	14,800	14,200	13,000	12,400	12,500	12,300	10,900
Netherlands	1,770	3,600	4,000	4,700	4,500	4,100	4,000	3,900	3,700	4,000
Czech Republic	1,220	1,500	1,640	2,100	2,400	2,900	3,000	2,900	2,800	2,900
Greece	1,210	1,330	2,900	2,000	1,100	2,200	2,200	2,300	2,300	2,700
Italy	2,800	3,200	3,500	3,500	3,400	2,900	2,900	2,800	2,400	2,200
Hungary	640	1,290	1,330	2,900	3,000	2,600	2,200	2,200	1,970	1,670
Sweden	2,200	2,200	2,100	2,000	1,630	1,430	1,360	1,400	1,620	1,660
Romania	3,800	4,400	4,400	4,500	4,400	4,600	2,800	2,100	2,000	1,600
Denmark	1,390	1,520	1,220	1,000	840	870	900	1,240	1,430	1,540
Austria	560	1,080	1,500	1,970	2,000	1,820	2,000	1,630	1,560	1,520
Croatia	460	360	450	470	630	1,150	1,250	740	1,120	1,500
Belgium	2,700	2,800	2,700	2,500	2,600	1,840	1,140	1,340	1,370	1,380
Slovakia	960	1,100	1,060	1,090	1,370	1,480	1,580	1,500	1,380	1,270
Ireland	4,000	3,400	1,080	1,160	1,240	1,330	1,410	1,630	870	1,250
Bulgaria	640	730	710	760	750	760	800	980	1,100	1,240
Finland	1,610	1,780	1,810	1,720	1,750	3,000	1,060	1,230	1,120	1,110
Lithuania	610	780	910	1,200	1,160	970	910	970	820	840
Portugal	890	1,030	1,100	910	1,180	1,240	1,010	770	780	700
Slovenia	120	140	180	200	270	290	340	430	540	690
Latvia	520	540	560	610	610	600	580	580	620	610
Estonia	300	360	540	500	560	380	380	400	410	410
Malta	40	50	50	130	90	150	150	150	230	210
Cyprus	190	210	210	180	230	220	190	180	300	210
Luxembourg	60	110	110	140	70	30	30	30	30	30

Source: Based on Eurostat, some estimates.

Table 21: ICT graduates (Higher Secondary vocational ISCED level 3) in Europe 2012

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
EU28	11,477	5,610	64,026	43,921	35,999	33,583	36,412	44,295	:	59,383
Poland	258	314	18,051	255	363	1,237	8,997	13,498	16,283	17,706
Spain	:	28	898	3,335	4,387	3,955	7,011	9,814	11,088	11,525
Germany	19,114	19,955	17,867	17,605	17,227	14,513	9,591	9,704	9,481	8,740
Portugal	:	:	:	:	:	:	:	:	:	6,378
Netherlands	6,532	7,919	8,078	6,175	5,371	5,430	5,495	5,523	5,830	5,509
Greece	:	8,159	8,985	:	:	:	:	:	:	3,320
Finland	2,299	2,479	2,175	2,024	1,950	1,766	1,696	1,636	1,496	1,482
Bulgaria	240	301	360	433	569	517	665	701	755	1,019
Belgium	1,444	:	834	764	791	692	745	1,061	1,045	930
Austria	:	:	:	:	516	546	621	840	892	872
Slovenia	189	334	248	373	423	589	605	590	615	594
Latvia	:	325	444	515	506	511	436	535	525	521
Estonia	110	172	166	137	139	72	89	152	237	303
Malta	:	:	:	47	364	571	363	175	227	227
Czech Republic	:	:	:	:	:	:	:	:	:	148
Luxemburg	:	56	70	46	66	37	50	46	58	56
Lithuania	:	:	:	:	:	:	:	:	:	30
Hungary	568	332	338	613	674	965	:	:	:	19
Sweden	:	4	203	22	28	5	5	19	19	4

Source: Eurostat educ_grad5

Table 22: ICT graduates (Post Secondary vocational ISCED level 4) in Europe 2012

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
EU28	23,053	16,967	31,424	31,188	26,128	16,214	24,159	17,757	:	12,565
Poland	17,305	15,900	16,019	16,559	11,705	3,759	8,332	6,343	4,191	3,517
Germany	3,437	4,045	3,733	3,031	3,801	3,239	7,258	4,729	4,688	3,028
Hungary	4,566	4,799	4,818	4,148	3,704	2,977	2,171	2,313	2,529	2,460
Austria	:	:	:	:	1,269	1,251	1,015	1,018	1,019	963
Greece	:	3,604	5,355	2,753	3,745	3,330	:	1,246	:	691
Portugal	:	:	:	81	:	279	427	437	284	623
Romania	1,089	975	804	684	363	141	374	449	384	400
Sweden	:	15	:	33	29	84	:	175	247	224
Malta	:	:	:	256	200	:	:	186	212	212
Estonia	540	304	325	207	146	116	123	121	146	161
Lithuania	:	:	28	46	45	46	73	77	124	134
Belgium	285	:	79	86	231	218	227	245	245	66
Netherlands	:	:	:	427	438	344	338	183	157	23
Latvia	12	39	26	22	:	:	:	:	:	12
Slovenia	:	:	:	:	:	15	30	18	5	8
Bulgaria	5	:	43	69	27	48	47	47	1	6
Finland	39	27	10	23	7	17	4	12	3	6

Source: Eurostat educ_grad5