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Insight into ICT professional skills and jobs in the Candidate Countries

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The production and use of Information and Communication Technologies (ICT) is recognized as a key factor in analysing the prospects and needs of the EU to become the most dynamic knowledge-based economy in the world by 2010. IPTS has launched a number of studies focussed on the socio-economic impact of ICTs in the frame of a project on Foresight on Information Society Technologies in an Enlarged Europe (FISTE). This study on ICT professional skills and employment in the acceding and candidate countries has been produced within that frame.

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Executive Summary

Introduction

On their accession to the EU, the Candidate Countries (CCs) will fully participate in the Lisbon strategy, which aims to make the EU the most competitive knowledge-based economy in the world. This raises the issue of how well the labour force in these countries is equipped with the skills necessary to develop, apply and work with new technology. In particular, the introduction of information and communication technologies (ICTs) has rapidly changed production and management processes in the CCs, possibly even faster than in the EU member states, and this has many consequences for the workers. Hence, the main objective of this paper is to highlight ICT job trends and the prospects for the preservation and supply of highly-skilled professionals in the medium and longer term in CCs, focusing in detail on a few countries – Bulgaria, Estonia, Hungary and Poland.

ICT job trends in the candidate countries

The diffusion of ICTs in all sectors of the economy requires highly-skilled professionals to develop, support and maintain them. The availability of knowledgeable individuals in the CCs – researchers, engineers, ICT professionals, etc. – contributed to the initial restructuring and modernisation of ICT industry. It was also an important factor for attracting foreign companies to establish ICT subsidiaries or to outsource software development and support in a number of CCs.

In the last few years the ICT sector in the CCs has experienced deep changes, influenced by some major factors, such as economic restructuring and modernisation, foreign direct investment, new regulatory environments and government emphasis on the Information Society. Hence, ICT employment growth corresponds to the expansion of new market segments related to the Internet, e-commerce and information and communication services.

Most CCs have recorded a rise in the number of employees in software industry and IT-related services. At the same time, despite the expansion of many market segments, the total telecommunications employment in many countries (Hungary, Poland, Baltic states) has decreased. A closer look at telecom data shows decreasing employment in 'fixed telecommunications', while employment in 'mobile communications' shows more than 30% annual growth in many countries.

Trends appear to be different in ICT manufacturing where severe job cuts have been observed in a number of CCs in the last decade (e.g. Bulgaria, Romania, Lithuania). Other CCs (Hungary, the Czech Republic, Estonia), however, succeeded in creating new jobs in 'manufacturing of radio, television and communication equipment'. Hungary is an exception, with high employment growth in computer manufacturing. Moreover, Hungary (along with Japan, Mexico and South Korea) is among the few OECD members with a higher number of workers in ICT manufacturing than in ICT services. Turkey is another exception among CCs as more than 50% of its ICT employees work in the telecommunications industry. Compared to total employment, ICT sector employment in CCs accounts for a much smaller percentage than the EU average. Among CCs, Hungary and the Czech Republic have highest ICT employment share, even higher than some EU members (e.g. Greece, Portugal).

Rapidly changing technology and the growth of ICT-related activities in all sectors have led to shortages of highly-qualified ICT professionals. Unfilled vacancies are found at all levels – IT technicians and managers, programmers, systems analysts, network and systems support engineers, application developers, business software implementation consultants, graphics designers, etc. As in the US, there is a specific demand for technical skills in Java, C++, Oracle, HTML programming. IT trainers and lecturers are also needed, and central administration and local governments face serious problems in finding appropriate IT staff. Thus, the growing labour shortages are acknowledged as a serious bottleneck for ICT-related development in many CCs.

The emerging recruitment difficulties also indicate imbalances between existing skills and company demands. Many jobs are vacant due to the lack of specialists with the business and management skills combined with ICT skills required by companies. As in many developed countries, the highest demand is found in companies in industrial sectors, where IT jobs are related to support functions or salaries are not attractive enough. For these companies outsourcing is the preferred solution to solve e-business issues. Generally, with the development of ICT applications and services and the increase of the population's ICT knowledge and skills, the demand for ICT specialists will grow faster. It is therefore expected that ICT skills needs in CCs will increase considerably over the next few years, as has happened in Greece, Portugal and Spain.

Building and preserving ICT skills in the candidate countries

ICT skills may be obtained through formal education and training or more informally through using ICTs and gaining experience with them. Following EU Information Society initiatives, all CCs have acknowledged ICT as an enabling technology, and necessity for all. The e-Learning concept has been embedded in their educational policy and action plans and many efforts are devoted to building large school networks in order to develop educational content and tools necessary for provision of ICT education for all.

As the process of building ICT capabilities and skills is a long one, the focus on mathematics and science in the early educational phases in addition to the integration of ICTs in education is especially important for future ICT specialists. High standards in mathematics, science and informatics in most CCs are promising for the supply of highly-skilled professionals in the future. Secondary students from countries such as the Czech Republic, Slovakia and Hungary achieve better results in international tests (e.g. PISA, TIMSS) than the students of some EU member states. In addition, the gold medals won by students from a number of CCs at International Olympiads in informatics (e.g. Poland, Slovakia, the Czech Republic, Romania, etc.) and in mathematics (e.g. Romania, Bulgaria) over the last few years indicate excellent traditions in these subjects.

The medium and longer-term supply of ICT professionals is associated generally with trends in higher education and vocational schools. At present, increasing numbers of young people are studying beyond secondary level. As a response to the demand for management and business skills, relatively high numbers of students are choosing business-related subjects. A strong tradition in the past in engineering in most Central and Eastern European CCs still leads to relatively high numbers of students in engineering subjects – significantly higher than in many EU member states. These numbers, however, are progressively decreasing (except in Romania and Turkey).

A closer look at ICT-related subjects in Hungary shows that in 1993-2000 the number of students enrolled in 'computertechnics' and 'computer and mathematical programming' almost doubled, whereas the number of students in traditional subjects like 'telecommunications', 'microelectronics', 'control and system engineering' declined sharply. The high number of students in 'technological and economic informatics' reflects the extent of business demand for interdisciplinary skills.

As far as studies in 'computing' are concerned, an increase in enrolments can be observed in most CCs (except Slovakia and Lithuania) over the last few years. This contrasts with trends in the EU member states where industrial actors and educational authorities are discussing measures to make the ICT profession more attractive and to fill the vacancies in university ICT programmes. In the CCs, the ICT sector growth and the high salaries of ICT workers have influenced many students in choosing communications or computers-related subjects. However, despite the overall growth in enrolments, it is estimated that the number of ICT graduates is insufficient to meet growing demands. As a result, many IT students (e.g. in Estonia and Bulgaria) are responding to industrial demands and leaving universities before graduation.

Vocational education and training is particularly important for the creation of middle and lower-skilled ICT specialists. In Hungary, for example, the number of ICT students in vocational schools has constantly increased since 1993, reaching 7% of all students enrolled in 2000. Moreover, though the highest number of vocational students at secondary level is enrolled in 'engineering and engineering trades' in Estonia, Hungary and Poland, this tends to shift to 'computing' or 'business and administration' at post-secondary level.

The concept of 'lifelong learning' implies that skills, knowledge and competencies need to be continuously updated in order to enable citizens and employees to meet new challenges. In the CCs, ICT skills shortages prompt many companies to provide specialised training to their employees. Companies in CCs, as compared with those in EU countries, spent less time on computer-related training for their employees, but more time on language courses and courses in 'engineering and manufacturing'. Companies in the ICT industry place a high priority on employee certification according to internationally recognised standards. Multinational IT companies such as Microsoft, Oracle, Cisco, IBM have focused on training ICT professionals by launching special programmes and certification courses as they do world-wide.

The increasing participation in ICT higher education in all CCs could contribute to solving employment imbalance in the future. However, in most cases the rising number of students has not led to a corresponding increase in the numbers of teaching staff. The ageing of academic staff has raised concerns on how to preserve present achievements. Promising are the indications that the ageing trend has stopped or even reversed in many CCs (e.g. Estonia, Poland), although the number of PhD students in ICT-related subjects is still not sufficient to meet future teaching staff needs.

Analysis of the prospects for preserving and building ICT capabilities and skills in the CCs is complicated by the mobility of the highly-skilled professionals. However, though the immigration policy of many developed countries facilitates mobility, there are expectations that the stabilising policy and economic environment and increasing quality of life, as well as the attractive working conditions in the ICT sector will keep the specialists in the CCs. Bulgaria and Romania run the highest risk of losing their skilled IT workforce, scientists and engineers, whereas in Latvia, Lithuania and Slovakia the risk is only average.

Some implications for research and policy action?

This paper highlights the demand and supply of ICT-skilled workers in a number of CCs. Analysis of skills and jobs trends in the CCs indicates that:

- The size of the mismatch between the demand for workers with ICT skills and the available supply is difficult to establish, given the lack of precise and up-to-date data. If such a skills gap persists, however, it is due to a lack of staff with technology specific and interdisciplinary skills and management abilities.
- There are indications that the labour market is providing incentives for ICT specialists. In fact, there are worries that IT professors leave their universities for highly paid jobs in industry. These jobs are mainly in financial services, networking and software development, rather than the traditional industries. This suggests that the critical mass of ICT skilled labour needed to support ICT applications in other sectors of the economy is still missing.
- Although a number of CCs score well in international scientific tests and Olympiads on mathematics and informatics, at the moment there is insufficient rejuvenation in the teaching of these subjects. This may be one reason why the most promising students are moving to universities abroad and others are choosing more business-oriented studies. In time, however, the inflow into the labour force of professionals equipped with ICT, business and interdisciplinary skills and the return of students from abroad could have beneficial effects on the growth potential of the CCs.

As the topic on ICT professional skills and jobs is not fully exhausted, many issues for further research or action can be indicated:

- First, the integration of the CCs into the EU calls for an early assessment of the problems these countries will face in the future on the ICT labour market. The provision of reliable and comprehensive data on ICT professionals supply, demand and mobility will allow better understanding of labour dynamics and future requirements and hence considering policy actions.
- The second issue is the qualitative assessment of the available skills and their relation to company demands and educational supply. Here CCs need to consider their specific realities and to take part in a Europe wide dialogue on future ICT skills demands and appropriate university curricula.
- The problems following contemporary technological trends and the corresponding skills mismatches necessitate a broad partnership approach, based on analysis of existing collaboration and initiatives in CCs and EU best practice.
- Another issue is to consider how to create conditions for preserving and facilitating the development of young talent and excellent traditions in CCs, while implementing

strategic common objectives for educational quality, effectiveness and compatibility, mutual recognition of qualifications and training, etc.

- The only sustainable solution to the brain-drain is the creation of high quality opportunities. This has already been recognised at EU level and many actions are underway. In the CCs the answer is partly seen in the ERA and the Bologna processes. However, it is important to go beyond collaboration at individual or department level and to foster long-term institutional co-operation.
- Outsourcing and production integration are possible ways to keep ICT specialists in their home countries or attract them back. To which extent building new ICT clusters in new and old member states could contribute to strengthening the competitiveness of ICT industry in the enlarged EU could be further explored.

1. Introduction

Background and objectives

The European society and economy have undergone major changes in the last few years. Some of these changes are related to the enlargement of the European Union (EU), others are defined by technological, social and economic trends that affect many regions of the world. The rapid pace of change world-wide has faced the EU with the need to take corresponding action in order to benefit from the opportunities presented. Hence, the Lisbon Council set the ambitious strategic goal of making the EU the most dynamic, competitive, sustainable knowledge-based economy, enjoying full employment and strengthened economic and social cohesion.

In order to achieve this goal, high importance has been given to human resources and the provision of new basic skills. IT skills, foreign languages, technological culture, enterpreneurship and social skills have deserved special attention in education and employment agendas. Furthermore, greater labour force mobility, both between jobs and within and between European countries is considered important for 'enabling the European economy, employment and labour force to adapt to changing circumstances more smoothly and efficiently, and to drive change in a competitive global economy'[1].

Particular attention has been paid in EU member states to the availability of skilled ICT professionals. Despite the burst of the Internet bubble and the downturn of the ICT industry, ICT skills have remained an essential issue. This was highlighted in EU action lines on skills and mobility and at the European e-skills Summit of October 2002). Well-educated and highly-skilled people are seen as vital for taking maximum advantage of new technologies and implementing the vision for e-Economy in Europe.

Taking into account all past and on-going actions focused on ICT skills in the EU, on the eve of the enlargement it is important to also look at trends and challenges in EU CCs[2]. For the CCs, the world-wide technological trends and globalisation processes, as well as their commitment to become EU members, have determined some common features in their economic, social and political development[3]. Other factors such as their history, traditions or geography have contributed to large differences between them. The Central and Eastern European countries (CEEC10), for example, have followed quite a specific development path marked by large changes in governance, economy and society[4]. The opening of the market to competition, the privatisation process, the collapse of traditional export markets in Eastern Europe and the disappearance of state support, have all constituted a dramatic shift in the business environment. The process of economic transformation has had various consequences for domestic enterprises and the labour force. Many enterprises have gone bankrupt or lost their market position while a new enterpreneurship mindset has flourished. Many workers now face the problems of unemployment and skills mismatch.

[1] High Level Task Force on Skills and Mobility, 14.12.2001, Final report.
[2] Ten of them, the Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia, will become soon EU members, while Bulgaria, Romania and Turkey will keep their status as CCs for a longer period.
[3] See for more details 'Futures' and 'Enlargement Futures' projects of IPTS, http://www.jrc.es.
[4] Systematically considered in the research of EBRD, World Bank, etc.

Today, the CCs' EU membership ambitions clearly determine their policy direction towards a knowledge-based economy and focus their attention on relevant knowledge and skills. The availability of human resources with the required knowledge and skills is considered to be a determining factor in the prospects for economic development and competitiveness. This has become a central issue in the process of 'capacity building' needed for implementing the enlargement agenda.

In addition to general skills requirements, the rapid technological change and the CCs commitment to the eEurope+ Action plan raise a wide range of issues related to ICT capabilities and skills. First, there is demand for leaders and managers able to develop and implement strategies targeted at ICT development at national, regional, institutional or company level. Additionally, a critical mass of skilled labour is needed to supply ICT applications, provide support and disseminate relevant technical knowledge. Finally, digital literacy of the whole population is required in order to use the new electronic services and applications for work, business, social life or entertainment.

As capabilities and skills are generally associated with a wide range of issues, the scope of this paper is rather limited. Its main objective is to highlight ICT job trends in the CCs and the prospects of keeping and supplying highly-skilled professionals in the middle and longer term. At the centre of the debate, therefore, are ICT professionals – workers possessing skills to create, develop, maintain and use advanced ICT tools.

When the scope of this paper was considered, it was taken into account that the developed countries have faced serious difficulties in measuring ICT jobs and skills. It is equally difficult in the CCs to find comprehensive and comparable data on ICT skills and jobs. Therefore, this paper will provide only an insight into ICT professionals in the CCs, focusing in detail, where possible, on a few countries (e.g. Bulgaria, Estonia, Hungary and Poland). Thus, this study may serve as an input to a future more comprehensive survey of ICT skills demand and supply in the CCs.

Monitoring of ICT professional skills

Meeting the stated objectives requires qualitative and quantitative assessment of ICT skills and jobs in the CCs. However, one of the most difficult issues is how to measure them. In the case of ICT professionals, many sources[5] highlight the measurement problems encountered by assessing the availability and supply, on the one hand, and the industrial demand for ICT skilled professionals, on the other.

First, the problems are related to the different conceptual and practical approaches followed at national and regional levels, as well as the insufficiently sophisticated classification systems. In fact, it is difficult to measure skills, and normally some proxies are used, such as educational qualification and jobs requiring a given set of skills. In order to measure the wider group of highly-skilled professionals Eurostat and OECD have developed the 'Canberra Manual', using educational/occupational classifications, - both the International Standard Classification of Occupations (ISCO) and the International Standard Classification of Education (ISCED).[6] IT professionals according ISCO are included as sub-categories of 'other department managers' (ISCO 1236), 'Physical,

[5] OECD (2002a), ICT skills monitoring group, etc.
[6] OECD (2001a).

mathematical and engineering science professionals' (ISCO 213) and 'Physical and engineering science associate professionals' (ISCO 312).

Some examples of the classifications/definitions used in the US and EITO for ICT skills and related jobs are given in Tables 1 and 2.[7] The ICT skills/jobs definitions given by EITO comprise the whole range of professionals required for the development of the new economy. The classification of the US Department of Commerce focuses only on ICT-related occupations. However, it specifies in detail the different skills levels and the job descriptions used. The US classification explicitly includes electrical and electronics engineers, as well as technicians fulfilling many support tasks for networking and IT production. In the EITO classification technical skills are required from all workers within the category of 'ICT professionals', while for the category 'e-business professionals' mainly non-technical skills such as marketing, management and organisational skills are needed (with the exception of the last two sub-categories where programming skills are required). As the last group maintains contacts with the customer, communication skills and knowledge of languages are necessary.

Table 1: Classification of ICT-related occupations by the US Department of Commerce

high skilled IT occupations	Computer support specialists Computer software engineers, applications Computer systems analysts Computer programmers Computer software engineers, systems software Computer and information systems managers Network and computer systems administrators Engineering managers Electrical and electronic engineering technicians Network systems and data communications analysts Database administrators Electrical engineers Electronics engineers, except computer Computer hardware engineers Computer and information scientists, research
medium skilled IT occupations	Data entry keyers Electrical and electronic equipment assemblers Telecommunications line installers and repairers Computer, ATM, and office machine repairers Electrical power-line installers and repairers Telecommunications equipment installers and repairers, exc. line installers Electrical and electronics repairers, commercial and industrial equipment Semiconductor processors Electromechanical equipment assemblers
low skilled IT occupations	Billing and posting clerks and machine operators Switchboard operators, including answering service Mail clerks and mail machine operators except postal service Computer operators Office machine operators, except computers Telephone operators

Source: OECD(2002a)

[7] More systematic data are available in the report of the ICT skills monitoring group, http://europa.eu.int/comm/enterprise/ict/policy/ict-skills/wshop/synthesis-report-v1.pdf.

OECD[8] also distinguishes the characteristics of three different IT skills sets:

- *professional* defined as 'the ability to use advanced IT tools and/or to develop, repair and create them';
- *applied* – 'the ability to apply simple IT tools in general workplace settings (in non-IT jobs)';
- *basic* – 'the ability to use IT for basic tasks and as a tool for learning'.

For the purposes of this study, the focus will be limited to ICT professionals – staff employed at IT services, products and telecoms companies providing technology design, development, implementation, operation and support.

Table 2: Definition of ICT jobs and skills used by EITO

profession	content	sub-segment (examples)
ICT professionals	Employed at the IS department of companies or other type of ICT user organisations, staff employed at IT services, products and telecoms companies providing technology design, development, implementation, operation and support.	▪ Applications (C++/ Unix/ Java specialists) ▪ Internet working (WAN manager, e-business implementor, call centre integrator) ▪ Distributed computing (Unix/NT administrator, PC desktop support) ▪ Host-based computing (Systems developer) ▪ Technology neutral (CRM/ERP consultant)
E-business professionals	Employed in business positions, intensive logical/physical use of the Internet, require a wide range of non-technical skills.	▪ Internet Business Strategists (IBS): online marketing professionals ▪ IBS: online sales professionals ▪ IBS: Internet product or online service designers ("Internet Economy Architects") ▪ IBS: online business unit managers ▪ IBS: online product managers ▪ IBS: online organisation experts ▪ Internet Business Operations Staff ▪ CIOs (Internet technology/product design) ▪ Internet technology specialists
Call centre professionals	Manage phone contact with customers or prospects to promote sale or to provide support.	(e.g. telesales account manager; information broker; online customer support)

Source: EITO(2002)

For the core ICT sector monitoring difficulties also come from the rapid changes in technologies and respective occupations, as well as the mobility of workers within the sector or to other sectors or abroad. Furthermore, the wide range of ICT workers in all industrial sectors makes it almost impossible to use traditional statistical methods to measure their availability or shortage. Therefore, the surveys carried out by industrial associations or researchers are, in most cases, based on questionnaires, interviews or expert estimates. However, the small sample size and the ambiguity of the questions are often associated with high deviations in the results. Mathematical modelling is another

[8] OECD (2002a), p. 157.

approach used for estimating and forecasting the availability of ICT workers, their distribution by sector and activity (occupation), and growth and market dynamics[9].

At EU level, Eurostat is making systematic efforts to overcome these difficulties and to integrate IS aspects into existing surveys and statistical databases of EU members and the CCs. However, as noted by a Eurostat official[10], it is very difficult to survey the demand as it is 'not fixed and function of price' and the statistical offices do not provide data on 'Number of vacancies for IT expertise' or data on e-skills demand.

For the CCs the situation with IS measurement is more difficult than in the Member states, since systematic work with Eurostat on IS statistics only started in 2002. Rapid change in the ICT sector and the growth of ICT-related activities in all sectors present statistical institutions with serious difficulties in responding to the rapid changes related to the emerging new economy and with providing quality statistical services. At present, official statistical data for employment in the CCs are available either for the industry and services sectors in general or for some categories of services, e.g. financial, transport and communication, etc.

In addition to the ICT-related problems of the official statistics in the CEEC10, many other factors impinge on the data gathering process, some to do with the structural and institutional changes, including the establishment of a large number of micro firms, others with the labour force mobility and self-employment. The presence of an informal economy, employing in some CCs[11] (e.g. Bulgaria, Baltic countries) up to 30% of the working age population, also needs to be considered. Therefore, the data presented below should be assessed carefully, taking into account the probable ambiguity of the available ICT statistics.

[9] International Co-operation Europe Ltd. (2001).
[10] Deiss, R. (2002).
[11] Data for 1998/99 in Schneider, F. (2002).

2. ICT skilled Human resources in Candidate countries

ICT skills have been a 'hot topic' in the last few years world-wide. The overall growth of the ICT industry and the ICT-based services and applications have triggered industry concerns about severe difficulties in finding skilled workers in the future. The recent burst of the Internet bubble and the downturn of the ICT industry have slightly changed the overall picture. Nevertheless, ICT skills remain an essential issue and this has resulted in corresponding policy actions and common initiatives by public and private actors to solve expected skills shortages and train the future labour force and ICT users in general.

The CCs have been also affected by global technological trends. Although many CCs claim to have highly-skilled professionals and have devoted efforts to develop a national ICT industry, the skills issue is emerging. Global assessments and competition results paint a diverse picture in most CCs. However, what is the real situation of the ICT work-force in the CCs? Are there sufficient ICT skilled specialists to meet the company demands? Are ICT jobs attractive to the highly-skilled specialists? How does industry respond to ICT skills shortages? These are some of the research questions which this chapter will try to highlight as far as the existing measurement problems allow. At the same time, it will provide an insight into the overall capabilities and skills needs in the CCs.

2.1. Capabilities and skills in the candidate countries

Insight into skills availability and demand

Global trends towards a knowledge economy are influencing the size and composition of the workforce, and the knowledge and skills required for success. The competitiveness of companies appears increasingly dependent on the ability to develop, recruit and retain a technologically sophisticated workforce. At regional and national levels, the availability of highly-skilled professionals is considered as an essential factor for success.

Concerning the CCs, contradictory views are provided on the ability of the workforce to meet market demand for skilled and knowledgeable workers. A preliminary view of indicators such as literacy rates and qualification levels gives the impression that the relatively high educational levels provide a good basis for future development. For example, the UNDP Technology achievement index[12] paints a positive picture, suggesting that many of the CEEC10 can be considered to be potential leaders. Other more practically oriented studies, however, give different results. For example, a survey of EBRD indicates[13] that foreign investors in the CEEC10 consider lack of adaptability and flexibility to be the main deficiency of workers. Their experience shows that, on average, workers in transition economies need around 6 months longer to achieve the same level of productivity as in Western Europe. This is one of the reasons why investors remain hesitant about using the most modern production processes in Eastern Europe.

[12] The UNDP's technology achievement index aims to capture how well a country is creating and diffusing technology and building a human skill base - reflecting its capacity to participate in technological innovations of the network age. This index is a composite of four dimensions including technology creation (patents granted to residents; receipts of royalties & license fees), diffusion of recent innovations (internet hosts; high & medium tech. exports), diffusion of old innovations (telephones, electricity consumption) and human skills (years of schooling; output level of skills & qualification, tertiary professional and scientific education enrolment and graduates' ratio). UNDP (2001a).

[13] EBRD (2000).

Other authors[14] consider that the good educational achievements in the CCs (e.g. CEEC10) have not sufficiently contributed to a stock of human capital which is economically relevant today and suggests that these countries should ‘increase the human capital of their workforce in order to achieve the average EU productivity level’.

These problems are partly related to the middle- and low-skilled workers coming out of secondary vocational education in most CEEC10. Their skills reflect the past dependence of these schools on the technology and production processes used in the enterprises linked to them. In a situation of deep structural changes in the economy, the mismatch between skills supply and demand in different areas is generating either a shortage of specialists or unemployment and underemployment. Subsequently, on-the-job training and learning by doing are crucial in resolving skills problems, as many lower level vocational qualifications and practically acquired skills become obsolete. In the CCs more attention needs to be paid, therefore, to multifunctional and transferable skills, and stimulating dynamic and autonomous learning capabilities, analytical ability, creative thinking, communication and co-operation skills. Here, there is considerable scope for various types of joint public-private initiatives to resolve skills problems.

Large-scale reforms in the CEEC10 have also seriously affected the highly-skilled workforce, the opportunities for many scientists to undertake top-level research, and the provision of high-quality education and training in educational institutions. Many researchers and professors have been ‘brain-drained’ to better paid jobs in industry or have started their own businesses, and young people have not been attracted to research or university careers. In addition, the insufficient resources for research and development (R&D) can be related to a shift towards more theoretical and less technology and capital-intensive research areas, and innovation and technology potential is not sufficiently exploited.

Management skills and business culture are other important issues. Though the Mediterranean countries have market economies with longer histories, the CEEC10 are faced with the challenge of preparing managers able to raise the competitiveness of their companies and adapt them to the rapidly changing technological and market conditions after the transition decade. As the EBRD pointed out in the 2000 Transition report, foreign investors have experienced more difficulties in finding good managers than IT or financial staff. Another study reaches similar conclusions for six CCs[15], where there is a serious need for development of more forward-looking attitudes, and the introduction of innovation management techniques in company practice would be relevant. A cross-country survey[16] of the European Training Foundation in Slovenia, Romania and Poland indicates that the great majority of managers still see themselves primarily as functional specialists and professionals while strategic thinking seems to be underdeveloped. It is promising that the survey has found considerable managerial and leadership potential within the non-managerial groups of young talent and professionals, though this is still under-utilised. Subsequently, many courses on management of change, quality management, etc. have been provided separately in order to complement traditional degree programmes or as a part of special programmes developed jointly by universities and companies according to management needs. Moreover, initiatives for education and

[14] Gundlach (2002).
[15] Cyprus, the Czech Republic, Estonia, Hungary, Poland and Slovenia, European Commission, DG Enterprises (2001).
[16] Gudic, M. (2000).

training for enterpreneurship have been launched in all CCs, in order to 'nurture entrepreneurial spirit and new skills from an early age'.[17]

Are ICT competencies and skills strength of candidate countries?

The ICT sector is not isolated from overall country development and general skills needs. However, there are many specific issues related to ICT competencies and skills in a dynamic and strongly competitive environment which require a closer look.

It is acknowledged in many studies that the past educational systems in the CEEC10 have produced a large number of highly-skilled specialists, including computer engineers. Central and South Eastern European countries have 'traditionally a very high R&D potential in the fields related to the IS. These highly qualified researchers have attracted IBM to establish an R&D centre in Prague and Nokia, Ericsson and Xerox to do the same in Budapest.'[18] Similarly, due to their high educational standards, the Czech Republic, Hungary and Poland are very popular for outsourcing of software development and support, as well as for establishment of subsidiaries of large foreign ICT companies.[19]

Lack of enterpreneurship and aversion to risk are often claimed to be weaknesses of businesses in the CEEC10. It has also been argued, however, that individual enterpreneurship has driven the start-up of many economic activities.[20] The emergence of a large number of small and medium enterprises (SMEs) in the ICT sector, for example, is actually due to individual entrepreneurs able to start business from scratch and find a market niche for growth. Many successful businesses have developed in an environment of uncertainty and risk, unattractive to foreign investors. Individual knowledge and skills have been an important factor for the success of many ICT companies. Domestic software firms in many CCs have shown high competence in ICTs and many of them have provided successful services to US and EU companies for design, testing, maintenance or support. Software firms in Bulgaria, Poland and Romania, for example, have shown high expertise in complicated tasks such as developing fully integrated systems or system components.[21] Western partners and consultants believe, however, that Central and Eastern European firms 'need to change quickly to meet international standards for quality, speedy communications, dependability and adaptability' if they are to be successful in the future.

Some international assessments highlight the ICT skills level in the CCs (Table 3). The World Bank Development Data Group[22] uses ratings from 1 to 7 to measure the availability of highly-skilled technology workers in the industry. Poland has achieved the highest ranking for highly-skilled IT job market among the CC11[23], followed by the

[17] European Commission, SEC(2003)57.
[18] Antelope Consulting (2000).
[19] STAR (2001).
[20] McMillan et al. (2002).
[21] In Romania, the competencies of most companies are in the development of specialised applications and databases, but fewer companies have expertise in the areas of CAD/CAM software, programming languages and expert systems. Polish software producers have focused on domestic demands and their software accounts for 80% in banking/finance sector, 90% in administration, 84% in manufacturing, and 45% in CAD/CAM. Software companies in Bulgaria are involved in various projects: customisation of database systems, integrated system video quality control, business software, multimedia, etc. Mroczkowski et al. (2002).
[22] These data are based on the Global Competitiveness Report 2001 of the World Economic Forum, as stated in the methodological notes to the ICT at a Glance tables (9.9.2002), http://www.worldbank.org/data/countrydata/ictglance.htm.
[23] Malta and Cyprus not included.

Czech Republic, Estonia and Turkey. Bulgaria and Romania are considered to have less skilled IT markets. As compared with EU members, the US and Japan, all CC11 have lower ratings. Only Poland has a higher rating than Greece (which has a similar rating to the Czech Republic and Estonia).

Table 3: International ratings related to ICT skills and training

	highly-skilled IT job market	Readiness for the Networked society		
		Networked Learning	ICT opportunities	Social capital
BG	2.5	3.13	2.50	5.53
CZ	5.2	4.97	5.15	6.21
EE	5.2	5.00	4.80	5.98
HU	4.8	5.07	4.40	5.99
LV	4.1	4.23	3.70	5.77
LT	3.6	3.27	3.45	5.73
PL	5.3	4.00	4.60	5.92
RO	2.2	2.23	2.75	5.54
SI	4.9	4.70	4.55	6.05
SK	4.8	4.53	4.10	6.47
TK	5.1	4.00	4.55	3.57
A	6.2	5.27	5.70	6.44
EL	5.2	3.93	4.85	5.29
FIN	6.6	6.23	6.35	6.66
I	5.9	3.97	5.00	5.48
UK	6.3	5.60	5.55	5.69
India	4.4	4.43	3.65	2.83
Japan	5.9	4.40	5.75	6.27
US	6.7	5.97	6.65	6.04

Source: World Bank Development Data Group(2002), CID(2002)

Some indications on ICT skills, brain-drain of the highly-skilled and literacy level of the population are provided in the micro-indexes of the Networked society[24] (see Table 3). Hungary, Estonia and the Czech Republic have achieved higher assessments for the quality of their IT training and e-Learning opportunities. They also invest more in the IT skills of their employees and subsequently rank among the first 25 countries in the world, even higher than many OECD members (e.g. France, Spain, Japan, etc.). In this category most CC11 (except Bulgaria, Romania and Lithuania) rank higher than Greece and Italy. In the micro-index on social capital all CEEC10 rank relatively high, among the top 32 countries in the world. Turkey, however, has a long way to go to reduce illiteracy and the polarisation in educational opportunities. Slovakia is a leader in the group for these criteria, ranking 4th after Finland, Norway and Switzerland. The micro-index on ICT opportunities, however, indicates that most CCs (except the Czech Republic) have suffered higher brain-drain of their IT workers, scientists and engineers than the EU members, which has subsequently reduced ICT opportunities.

Publications and surveys which focus on 'core' ICT professionals give slightly different results. Countries like Romania and Bulgaria with lower results in global surveys are better positioned, for example, in ICT certification tests. In Brainbench's Global IT IQ

[24] The Network Readiness index is composed of two components – Network Use and Enabling Factors. The Enabling Factors include Network Access, Network Policy, Networked Society and Networked Economy. The Networked Society sub-index from its side includes the Networked Learning, the ICT opportunities and the Social capital micro-indexes with ratings from 1 to 7., CID(2002).

Report[25], based on on-line tests and certification results obtained by more than 3.5 million IT professionals in the world, Romania is among the leaders (i.e. the US, India, Russia, Ukraine, Canada, the UK) according to the absolute number of IT certified professionals. Highest concentration of IT certified professionals is found in Latvia and Estonia, followed by Bulgaria, Singapore, Lithuania and Romania. These practical results are also supported by other sources (e.g. press releases, country reports, company surveys) which show that there is a good stock of IT labour in Romania, Bulgaria and the Baltic countries.

These various ratings highlight only the average achievements of a given country, and other factors should also be taken into account such as the positioning of the ICT industry, or the economic and social development of the country[26]. Subsequently, CCs, which are quite advanced in their economic reforms, have achieved a more balanced development in ICT education and training, and thus rank higher. The low ranking of Romania and Bulgaria is not surprising, therefore, as these countries have delayed their economic reforms (with some negative consequences on social capital) and have experienced a large brain-drain of their highly-skilled professionals. Furthermore, IT professionals in less developed countries are probably better motivated to pass IT certification tests as these could help them get better jobs and improve their quality of life. On the other hand, IT specialists in countries with higher living standards and/or better developed ICT industries and services are probably not interested in such on-line tests, which do not offer them any significant advantages for their future work and life.

2.2. ICT professionals in the candidate countries

ICT employment trends

Considering employment trends in the ICT industry, OECD notes[27] that Hungary is among the few member states (also Japan, Mexico, Korea) with a higher number of workers in ICT manufacturing activities than in ICT services. Other OECD-based data for employment in the ICT sector (Table 4) show that the telecommunication industry makes up over 70% of ICT sector employment in Turkey, while in the Czech Republic and Hungary ICT manufacturing and services dominate.

Of the CCs that are members of the OECD, the only country in which the ‘manufacturing of office machinery and computers’ takes higher share in the total ICT manufacturing employment is Hungary (in 1999 it reached 20%). In the period 1995-2000 its share slightly increased in Poland (from 8.52% to 13.23%), the Czech Republic (from 3.77% to 6.3%) and Turkey (from 1.57% to 3.96%), while in Slovakia it dropped from 7.3% to 6.3%[28]. It is also interesting to note that IT manufacturing employees in Hungary are mainly employed by foreign-owned affiliates, whereas in Poland more are employed by domestic companies. In Hungary, Poland and the Czech Republic, government procurement policy has made it possible to retain employees in the domestic telecommunications manufacturing and to attract foreign investors.[29]

[25] Quoted by the Bulgarian Foreign Investment Agency (2002) and in Mroczkowski et al. (2002).
[26] In support of this consideration is the low position hold in many international ratings by India, whose software industry (based on highly-skilled IT professionals), however, is broadly recognised as a success story.
[27] OECD(2002a).
[28] Based on country ICT sector data of OECD(2002b), Measuring the information economy 2002.
[29] B.Sadowski (2000).

Table 4: Employment in ICT sector in selected CCs

	Employment in ICT sector in 1997 (1)				Employment by ICT-sector affiliates in 1998 (2)	
	ICT[30] manufacturing	Telecommunications	Other ICT services[31]	Total ICT	IT equipment	Communication equipment
CZ	54000	33000	65000	152000		7000
HU	53071	23690	80674	157435	4158	14574
PL		73100			381	12946
TR	23615	72926	3026	99567	:	6049

Source: (1) OECD(1998), (2) OECD(2002a)

A study[32] by the Deutsches Institut für Wirtschaftsforschung observed a serious fall in employment in 'manufacture of office machinery and computers' in the Czech Republic and Lithuania in the period 1992-1998 (Table 5). Other countries were more successful in local hardware manufacturing activities, e.g. in Poland and Romania the number of employees slightly increased, and in Hungary it almost doubled. This study does not provide employment data for Bulgaria, however the steep decline in local EDP production observed there corresponds to a serious decline in employment. [33]

Table 5: Employment in 'manufacture of office machinery and computers' in selected CEEC10

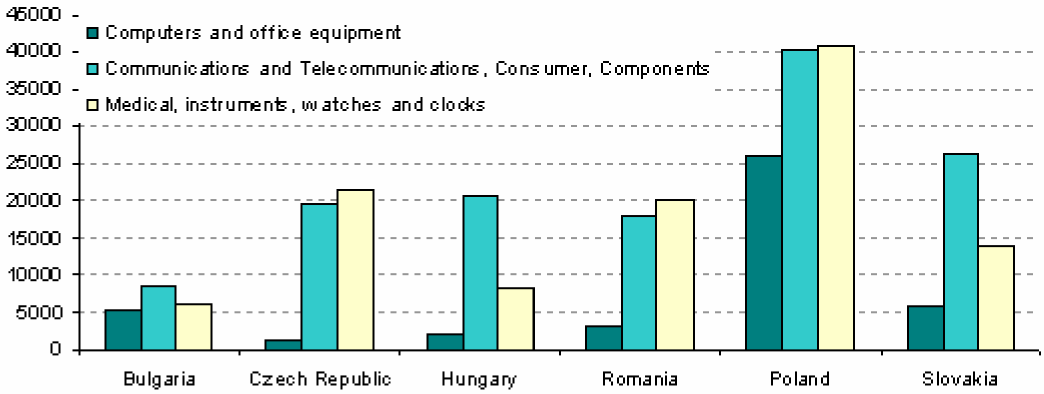
	1992	1993	1994	1995	1996	1997	1998
CZ			2213	2378	2442	1411	1424
HU			2140	1815	3830	5907	4089
LT	6400	4400	3000	1800	1500	1100	:
PL				4200	4100	4500	4500
RO	2570	3417	2214	3331			

Source: Bitzer (2000)[34]

An important ICT sub-sector for many CCs is the 'manufacturing of radio, television and communication equipment'. Reed Electronics data suggest that communication and telecommunication equipment and components manufacturing provides employment to a large number of people in many CCs (Figure 1). In the last few years the employment in 'manufacturing of radio, television and communication equipment' in Hungary and the Czech Republic has increased. Similarly, in Estonia[35] in the period 1994-1997 there was 22% employment growth in this sector, whereas in Romania[36] in the period 1990-2000 the number of employees decreased from 40,000 to 9,000. Similarly, in Bulgaria recent data indicate[37] that in the period 1997-2000 the number of employees in the 'manufacture of radio, television and communication equipment and apparatus' industry decreased by more than 30%.

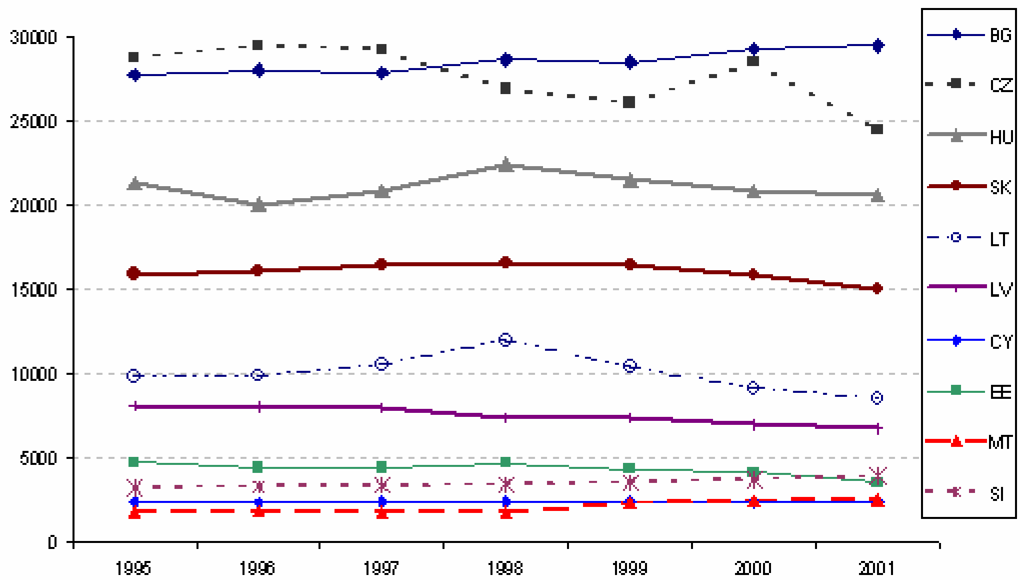
[30] ICT manufacturing includes manufacturing of 'office, accounting and computing machinery', 'insulated wire and cable', 'electronic valves and tubes and other electronic components', 'television and radio transmitters and apparatus for line telephony and line telegraphy', 'television and radio receivers, sound or video recording or reproducing apparatus, and associated goods', 'instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process equipment', 'industrial process control equipment' according International Standard Industrial Classification (ISIC).
[31] Include for Hungary and the Czech Republic 'computer and related services' and 'wholesale of machinery, equipment and supply', for Turkey only the first one.
[32] Bitzer (2000).
[33] As it is indicated in the study, in 1997 local production at Bulgarian EDP market was 5 million USD or 4.8% of the market size. During the period 1994 to 1997 local production decreased strongly – its share in the market size dropped from 13.9% to 4.8%. Bitzer (2000).
[34] As a remark on the data sources used, the author notes that the size of the reported employment figures depends on the enterprises covered by the national statistical offices, and many enterprises of 1-2 employees are not covered.
[35] Hernesniemi, H. (2000).
[36] Reed Electronics Research(2001).
[37] Bulgarian Ministry of economy(2002).

Figure 1: Employment in electronic manufacturing in selected CCs, 1997



Source: calculations based on Reed Electronics (2001)
data for Hungary and Romania from 1995

Figure 2: Employment in 'telecommunication services', 1995-2001



Source: Eurostat

The overall changes in telecommunications in all CCs have also affected employment in 'telecommunications services'. Over the whole period 1995-2001, a slight decline in employment can be observed in many CCs (Baltic States, Hungary, the Czech Republic), while in others (e.g. Bulgaria, Cyprus, Malta and Slovenia) total employment in the sector is increasing (Figure 2). Of the countries not indicated in the Figure 2, Poland and Turkey are characterised by a decline in the numbers of telecom employees, though in Romania their numbers are growing. A closer look at telecom data shows decreasing employment in 'fixed telecommunications', while the numbers employed in 'mobile communications' has seen more than 30% annual growth in many CCs. The excess of personnel and the lack of adequate management skills are considered to be major challenges to the transformation of incumbent operators. In fact, employment is expected to decrease as the ratio 'main lines per employee' in many CCs is still much lower than in EU15, and this implies lower revenue per employee[38]. The digitisation of networks and the introduction of new services could also contribute to job losses among those workers who are not flexible enough in the changing environment. The issue here is to what extent the expansion of new segments in the telecom market can balance job cuts in the incumbent operators, and what kind of new jobs will be created in the sector.

Table 6: Employment in 'computer and related activities' in selected OECD countries (in 1000)

	1996	1997	1998	1999	2000
CZ	10.7	14.6	15.2	16.8	
HU	:	:	10.7	12.1	14.8
TR	2	2.4	2.7	:	:
EL	3.2	3.5	3.8	3.9	:
P	9.4	11.8	12.2	:	:
D	15.8	21.8	23.6	25.4	27.6
FIN	18.7	20.8	25.9	31.2	35.3
UK	293	340	388	427	:
US	1217.1	1397.4	1601.6	1861.8	2082.4

Source: OECD (2002a)

A closer look at 'computer and related activities' shows constant employment growth over the last few years (Table 6). For many CEEC10 these data correspond to a shift in industry observed over the last few years where domestic enterprises have moved towards applied software development and away from technology and capital intensive areas. The growth rates in Turkey are close to those in Greece and Portugal, and very modest compared to employment growth observed in the US, Finland, the UK and Germany.

Table 7: Employment and wages in IT and software-related industry in selected CEEC10 (2000)

	BG	CZ	HU	PL	RO	SK	SI
Total employment (in 1000) (1)	2872.4	4675.1	3806.6	14517.6	10897.6	2083.4	893.6
IT industry total	7290	34964	26635	81679	26679	9780	3995
Software industry[39] direct employment	3208	22405	21308	27362	5869	5288	2160
Software industry indirect downstream employment	8112	85609	82228	101569	13235	15864	7478
Software industry indirect upstream employment	3759	20568	18709	27034	7407	5262	1765
Average annual country wages, USD	1540	4680	3718	5400	1285	3260	11741
Average IT annual wages, USD	2695	9562	5979	9450	2366	5705	14819
Average software annual wages, USD	2830	10380	6278	9923	2484	5990	15335
Corporate revenues per software employee, USD	8728	11397	10047	12862	5521	15240	31075

Source: Datamonitor (2001) (1) Eurostat

Datamonitor provides further insight into the structure of IT industrial employment in some CEEC10 (Table 7). In 2000, software sector employment reached around 0.50% of

[38] IT Task Force, Romania: Internet for Economic Development Assessment, 18.09.-2.10.2000.
[39] software employment is defined as 'software consultancy and supply services'.

total employment in the Czech Republic and Hungary, while in Slovakia, Slovenia and Poland it was close to 0.20%. The software industry in Bulgaria and Romania accounts for a very small share of total employment – 0.11% and 0.06% respectively. Hungary (0.75%) and the Czech Republic (0.70%) are also ahead of the other CCs in total IT employment, while in Romania and Bulgaria it remains lower than 0.30%.

Table 8: ICT sector employment in Estonia and corresponding educational level, 1999/2000

ICT sub-sector	Employment	Education level (in %)		
		Master and/or Doctor	diploma and/or Bachelor	other
Telecom services	4500	5	32	63
Telecom equipment	3850	5	36	59
Computers and office machinery	1100	3	42	55
Industrial automation	600	4	35	61
Components of electronics	850	1	11	88
Software	1200	17	45	38
Consumer electronics	150	3	30	67
Multimedia and content	100	0	15	85

Source: Kalvet et al. (2002)

The data above provide an insight into ICT sector employment trends, but they do not indicate the percentage of highly-skilled workers among ICT employees. The statistics on R&D employees provide some indication of the availability of R&D intensive activities in the ICT sector. In many CCs (the Czech Republic, Hungary, Poland) software development and support is related to highly qualified work and more R&D staff are employed in this sub-sector than in IT manufacturing, for example[40]. Similarly, the sectoral employment data for Estonia show that a higher concentration of highly-qualified specialists is found in the software sub-sector, where many enterprises employ people with above Bachelor degree level qualifications than in other sub-sectors (Table 8).

Table 9: ICT occupations and total employees in the ICT sector in Hungary

Sector	**1998**		**1999**	
	ICT Occupation	**Total Employees**	**ICT Occupation**	**Total Employees**
Hardware consultancy	189	711	193	681
Software consultancy & supply	2669	7543	3374	8960
Data processing	1497	3903	1487	3662
Data base activities	185	605	192	643
Maintenance and repair of office, accounting and computing machinery	182	1785	176	2080
Other computer related activities	1057	2727	923	2858
Telecommunications	1427	24824	1256	24248
Production of computers and electronic processing equipment	373	7843	406	9126
Production of electronic capital goods	273	5413	338	4682
Production of electronic consumer goods	117	14380	128	11110
Total	**7969**	**69734**	**8473**	**68050**

Source: Hungarian Statistical Office (2001), quoted in STAR (2001)

[40] Bitzer(2000).

The data for ICT job distribution in Hungary (Table 9) show that ICT occupations[41] in reality represent less than 15% of total ICT employment. Bearing in mind that ICT occupations require higher qualification, the table above shows a similarity with the Estonian case – in Hungary higher numbers of highly-skilled people are occupied in 'software consultancy and supply' and significantly lower numbers in 'production of electronic consumer goods'.

ICTs have affected every activity and aspect of people's work and lives. The diffusion of ICTs in all sectors of the economy requires the availability of highly-skilled professionals to develop, support and maintain them, to build corporate networks and databases or design and maintain web-sites. Thus, ICT skilled workers can be found in all sectors of the economy – from large banks and hospitals to small enterprises in various sectors (Box 1).

Box 1: ICT employment in other industrial sectors

Banks are among the biggest users of ICTs and need many employees to support and develop special banking applications and databases, banking networks, etc. In Estonia, for example, the IT divisions of the two largest banks, Hansabank and Estonian Union Bank, are considered to be two of the largest "software companies" in the country. Their IT personnel amount to around 610 employees and corresponds to almost 5% of ICT sector employees. As IT divisions of banks have no serious problems with financing, they can buy state-of-the art technologies and support programming novelties, and this attracts many highly educated employees to the banks.

The development of e-commerce affects employment in industry differently. As a survey in Hungary indicates, some companies in the automotive industry use web-applications mainly for advertising and they outsource these activities as they do not justify hiring new staff. However, the use of Enterprise Resource Planning (ERP) and Electronic Data Interchange (EDI) systems to handle orders from important suppliers and/or customers requires appropriate staff. More active involvement in B2C e-commerce activities, as in the case of publishing sector companies (e.g. book publishers, distributors, electronic bookstores), requires internal employees to update the sites and handle orders. Here more complicated tasks like web-site design and hosting activities are outsourced.

Source: Tiits(2002), STAR(2001)

As it is difficult to provide exact data for ICT employees in corporate or public sector IT departments, estimates are used instead. For example, Datamonitor[42] estimates indirect employment related to the software industry in upstream (e.g. manufacturing, printing and packaging, logistics) and downstream (e.g. training, retailing, reselling, consultancy, distribution, etc.) industries. It is interesting to note that software industry indirect jobs in the Czech Republic (2.27%) and Hungary (2.65%) account for a much higher share of total employment in these countries than equivalent jobs in Romania (0.19%) and Bulgaria (0.41%). Countries like Slovenia and Slovakia, less involved in the software industry, also show a more modest job creation in other industries (around 1% of total employment) compared to Hungary and the Czech Republic. This indicates partly the impact of the software industry on employment in other sectors.

The data provided here, though not comprehensive and too aggregate, confirm some assumptions about employment in CEEC10, namely that increasing numbers of people

[41] The following occupations have been included: Computing services managers, computer and electronic data processing professionals, computer associate professionals, electronic data processing administrative occupations. STAR (2001), p. 21.
[42] The data provided in the study are compiled from national and international sources, including company estimations. The authors explicitly underline the methodological problems related to the lack of data and the grey economy. Datamonitor (2001).

are employed in the software industry and ICT-related services. In ICT manufacturing only a few 'champions' able to attract foreign investors and create new jobs exist. Most frequently, many hardware engineers have lost their jobs and have had to retrain due to the downturn of ICT manufacturing during the transitional period. As some experts[43] indicate, the lack of ICT manufacturing and highly-skilled jobs for hardware specialists in the country is a factor behind the professional brain-drain (e.g. from Slovakia, Bulgaria, Romania, etc.). At the same time, universities continue to prepare these specialists although the demand is not high and local production has collapsed.

An important question arising from the above issues is whether the employment figures in the CCs will ensure ICT market growth and, in particular, growth of IS-related activities, or whether they will be a handicap for IS development. The size of ICT industry and ICT employment indicate that the CCs are lagging behind the developed countries and the leaders. For example, in 2000 the entire IT workforce in the US was more than 6.5 million with almost 60% of employees in highly-skilled jobs[44]. In 2001 the whole IT workforce rose to 10.4 million, of which software programmers and engineers (more than 2 million) were 'the single largest category of IT worker, constituting almost 21% of the total workforce'[45]. Figures for employment by sector in the US show that 92% of IT workers were employed in non-IT companies in 2001, and were therefore less affected by the job cuts.

In the EU about 6.5 million ICT jobs were reported[46] in 2001, representing 3.9% of total employment. Around 40% of IT workers were employed in the ICT supplier industry, whereas the largest ICT job concentration was in the software and services industry. However, ICT jobs are not equally distributed. In many countries (Finland, Sweden, Netherlands, Denmark) ICT jobs represent a higher percentage of total employment – almost twice the EU average (1.6%), while in others (Greece, Spain, Italy, Portugal) ICT workers constitute less than 1%, actually less than some CCs.

Growing demand for ICT professionals

The shortages of ICT workers are estimated mainly on the basis of company demand, e.g. job vacancies announced. As these data are not generally available in CCs, some assessments of the shortages and indications on the labour conditions and the company employment strategies may throw some light on the situation. High wages and low unemployment figures also suggest a tight labour market.

In the first years of the transition in most CEEC10 the availability of highly skilled researchers and engineers, including ICT professionals, contributed to the initial restructuring and modernisation of the ICT industry, and the growth of IS-related services. However, rapid technological change and the overall growth of ICT-related activities in all sectors have led to some shortages of highly qualified ICT professionals. National or international research about the ICT industry or ICT-related developments provides an insight into the stock of ICT labour in some CCs (see Box 2). The availability of highly-skilled professionals is considered as an important national strength

[43] Workshop "IS development strategies in candidate countries" (Seville, 23-25 February 2003).
[44] OECD (2002), p. 159.
[45] ITAA(2002).
[46] International Co-operation Europe Ltd. (2001).

for most of the countries (except Turkey). However, growing ICT labour shortages are acknowledged as a serious threat for the future ICT-related developments in a number of CCs.

Box 2: Country estimation of ICT labour shortages

In *Bulgaria* the availability of 'large numbers of highly qualified and experienced IT professionals, with expertise in practically all areas of ICT' is considered to be an important strength. The main threats, however, come from the decreasing quality of education and the brain-drain of young specialists. According to Alpha Research, in the last quarter of 2000 alone, 43% of IT firms experienced brain-drain problems, and only 3% of IT specialists returned to the country. More recent assessment of the situation in Bulgaria suggests a 'stagnancy in young IT skilled people, both in the educational system and on the labour market. Although there are signs of recovery and reversal of the brain-drain, the still limited IT funding does not significantly support future changes'.

In *Hungary* the strong tradition in engineering is regarded as one of its assets. Many employees' engineering backgrounds have facilitated their movement into the ICT sector. Highly-qualified labour is one of the factors that attracts foreign companies to open subsidiaries or R&D centres in Hungary. However, some shortages are also expected there. ICT firms are seeking software developers, web programmers and system integrators, and telecom software developers for the Nokia and Ericson centres in the country. It is estimated that a further 4,300 network specialists will be needed in 2002.

In *Estonia,* human capital is the major factor determining the future competitiveness of the ICT sector. The 'well educated, skilled and cheap workforce' is considered to be an important strength of Estonia's IT industry. However, shortages of qualified personnel have already been observed and the lack of skilled workers may turn into a serious obstacle to further ICT development. In 2001, 56% of companies needed specialists for specific products or technologies, while 39% wanted project managers and sales staff. On the basis of trends and enrolments, the Estonian IT Society estimated a shortage of about 6,000 IT specialists in 2002. Furthermore it is considered that 'if the number of highly literate (bachelor degree level) computer specialists entering the job market is maintained at 2,500 each year, the potential need for such staff will not be fully covered until 2020, meaning a time lag of at least 10 years behind market demand'.

In *Poland* modest shortages of trained professional network technicians were reported in 2000, when the supply of skilled network administrators was estimated by industry sources at 18% below the demand. Although this gap is narrower than in most EU countries, shortages are expected to grow to 40% by the end of 2003. Furthermore, the Polish Chamber of IT and Telecommunications raised some concerns (not fully shared by companies) that the 'brain-drain' of young specialists might increase the shortage of personnel, especially in the central administration and local government institutions where salaries in IT departments are lower than those in industry.

Turkey traditionally has a good technical educational system. However, an assessment of the available human resources found skills shortages in web designers and network-literate employees, both critical for the development of e-commerce. Limited salary budgets are a serious problem for public bodies. Generally, human resources are considered to be the principle bottleneck for Internet and e-commerce growth.

Sources: UNDP(2001b), ISIS(2002), STAR(2001), Estonian eVikings (2002), Lewis (2000), Wolcott (1999)

The available estimates need to be considered in relation to current market trends in the CCs and globally. The ICT sector downturn and the corresponding slowdown of the new economy resulted in a decrease in IT investments and a reduction in ICT job demand in, for example, the EU and other developed countries. ICT market growth in Western

Europe[47] in 2001 was 5.1% instead of the 11% that EITO forecasted. As a consequence of these trends, many employees have lost their jobs, thus reducing the size of the supply-demand mismatch. Although the skills shortages are no longer so critical, they remain an issue to be dealt with. EITO[48] considers that there are skills shortages in the area of networking, integration of applications in the front and back office and in deployment of e-business strategies. In general, EITO concludes that "demand for skilled professionals will remain high for the years to come, but will change from being pervasive to being selective". In absolute numbers, ICT skills shortage in EU in 2002 was about 1.2 million. This is expected to grow to 1.7 million in 2005, if the demand for ICT skilled labour of 10-12% remains constant between 2000 and 2005 (Table 10). As the ICT skills monitoring group indicates[49], in EU members the demand for ICT professionals remains the highest in the ICT services sector (telecommunications, computer services) and the financial sector (credit and leasing institutes and insurance companies). Other sectors with a strong demand for ICT specialists are the 'electrical machinery and electronics' and the 'transport equipment manufacturing' sectors. EU companies with less then 50 employees have the greatest difficulties in recruiting appropriate staff, but bigger companies have also reported some problems.

Table 10: Western European Total ICT Skills Shortage, 2002-2005

	2002	**2003**	**2004**	**2005**
Demand	11,837,533	12,874,484	13,614,357	14,302,430
Supply	10,580,954	11,288,395	11,974,980	12,634,371
Shortage	1,256,579	1,586,089	1,639,377	1,668,058
% Shortage	11%	12%	12%	12%

Source: IDC, 2002, quoted by ICT skills monitoring group (2002)

In the United States in early 2002 a net loss of more than 500,000 IT jobs was observed, and over 12 months the IT workforce fell by 5% to 9.9 million workers[50]. Although the demand for IT workers was down significantly between 2000 and 2002 in the US (68% drop in Midwest and 71% in the West), it is estimated that the vacancy rate will remain constant at around 50% of total demand. Technical support workers were the worst hit by job cuts, while professionals with skills in C++, Oracle, SQL, Java and Windows NT continue to be most in demand in the US.

Despite the recent slowdown of the new economy in the EU and the US, the ICT sector in the CCs is still trying to bridge the technological gaps and catch up with the most advanced countries[51]. The new regulatory environment and the privatisation and modernisation of the economy are important factors for continuing technology diffusion and ICT market growth in CEEC10. Government emphasis on IS is another driver of advanced information and communication technologies and services development, contributing to ICT market growth and low sectoral unemployment. ICT employment growth corresponds mainly to the expansion of new segments related to the development of Internet, e-commerce and IS applications and services, while in ICT manufacturing the situation is quite different, as indicated above.

[47] Includes EU15, Norway and Switzerland.
[48] European Information Technology Observatory (2002).
[49] ICT skills monitoring group(2002).
[50] ITAA(2002).
[51] See for details EITO(2002).

The demand for ICT specialists is determined by the level of usage of ICTs at work, at home or in public places. With the development of ICT applications and services and the increase of the population's ICT knowledge and skills, it could be expected that the demand for ICT specialists will grow at higher rate. Present trends in some EU members (Greece, Portugal, Spain) suggest that with the growth of ICT supply and usage, the skills shortages might reach higher levels in the CCs too. As an example, a growing number of public Internet access points (PIAP) in most CCs has been observed, but a PIAP with 10 computer places needs at least one ICT specialist to support and maintain the service. If more sophisticated services are foreseen, additional personal could also be needed. Similarly, the introduction of computers in all schools and the development of e-business strategies by companies will increase demand for personal to support networks, web content, specific applications, etc.

In addition, the implementation of e-Government plans in the CCs does not only require IT specialists for local networks and systems in state institutions but also, more importantly, individuals able to provide online public services to meet the demand of citizens and businesses at national or inter-regional level, and able to put recent information for the public institutions and their activities on the Internet. A frequent problem, not only in the CCs, is that specialists do not have enough time to manage their institution's information systems and to update the web-pages regularly. Therefore these services (e.g. web-design, maintenance and upgrade) often have to be outsourced. In small villages especially, the availability of a person 'full of local pride, who can collect historical, cultural, environmental, demographic and economic data on the settlement and has the necessary knowledge to put this on the web[52]' might be an important condition for public web-site development. It is not surprising, therefore, that in Hungary[53], for example, less than 25% of local administrations are accessible on the web. These sites provide mainly general information - 20% update weekly and 30% monthly. Thus, there is a long way to go before the administration is able to establish two-way interaction with citizens and business, not to mention full on-line transactions and public procurement in municipalities.

According to some on-line recruitment sites or country survey data[54], a growing number of unfilled vacancies exists at all levels of ICT professions – IT technicians and managers, programmers, systems analysts, network and systems support engineers, application developers, business software implementation consultants, graphics designers, etc. Besides demand for specific technological skills (e.g. Java, C++, Oracle, HTML programming, etc.), there is increased demand for IT trainers and lecturers.

These unfilled vacancies suggest a possible mismatch between available skilled workers and company demand. For example, in Bulgaria[55] many jobs are not filled due to the lack of specialists with the skills companies require – business and management skills in addition to the ICT skills. Generally, companies are seeking a combination of three types of skills – technical (e.g. IT, technical writing), business (e.g. marketing, strategy, project management) and personal (e.g. communication, leadership, teamwork, problem-

[52] Istvan, Tozsa - Balazs, Budai (2002).
[53] Schneider, M.(2002).
[54] E.g. for Hungary STAR (2001); for Cyprus http://www.ccs.org.cy/JOBS/vacancies.htm; for Bulgaria http:/www.idg.bg; for Latvia http://www.dtmedia.lv/raksti/en/bit/200010/00101102.stm.
[55] The Bulgarian IT specialists are returning from America, Computerworld/Bulgaria, 8, 2002.

solving). The greatest demand is found in companies in industrial sectors, where IT jobs are related to support functions. In many cases these companies are not in a position to offer the skilled workers they seek attractive salaries and job opportunities. Thus, recruitment difficulties are often a reason for outsourcing web design and e-commerce activities, especially by SMEs (Box 3).

Box 3: Outsourcing – a preferred solution for skills shortages in SMEs in Hungary

In Hungary, outsourcing is the preferred solution for companies outside the 'core' ICT sector, as a STAR consortium survey indicates. Outsourcing is considered by many SMEs involved in various e-commerce activities in the automotive and publishing sectors to be less costly than in-house development and easier to manage. Besides, SMEs do not have in-house resources for web development and the workload does not justify an extra job. At the same time, people with ICT skills demand relatively high salaries, and companies often experience difficulties in finding creative people to solve unexpected problems, or in deciding what skills will be needed. In some cases, when all e-commerce related activities are carried out in-house, extensive on-the-job training is a way of providing existing employees with the skills they need. In general, however, SMEs can avoid any problems related to ICT or e-business skills by the extensive use of outsourcing.

Sources: STAR(2001)

For ICT companies world-wide, time is one of the critical competitive factors today. Faced with very short project deadlines and rapid technological and market changes, high-tech companies in the developed countries are hiring experienced workers who are specialised in particular technical skills. It is less expensive for companies to attract workers from other companies or even migrant workers than to train new staff on-the-job. In order to keep their qualified staff, companies are increasing wages or providing non-wage benefits (flexible work schedule, holidays, additional social services, etc.).

In most CCs the overall changes in the economy and the emphasis on ICT infrastructure and services have affected working conditions in the ICT sector, making ICT-related jobs more attractive. In general, the period after 1989 was marked by substantial growth in wage differentiation, between regions, between sectors, and between occupational groups in most CEEC10. Some sectors such as education, health and science were very seriously hit by the reforms. Budgetary restrictions and low rates of pay in these sectors have caused a major long-term 'brain-drain' to other sectors of the economy. As a result many scientists and engineers have moved to banks or foreign affiliates, and government IT departments are having recruitment difficulties. Good employment conditions in foreign-owned companies have attracted the best-trained specialists. Furthermore, company training has upgraded their skills and technological knowledge. It is not surprising, therefore, that the labour productivity in foreign-owned enterprises varied in 1998 from 150% (in Estonia) to almost 300% (in Hungary) of the productivity in domestic companies.[56]

According to Antelope Consulting, 'most Central and South Eastern European countries report shortages of ICT qualified labour, a fact which is reflected in higher salaries in the ICT sector – 2-4 times the national average'. As indicated in Table 8 above, the average wages of software specialists are around twice as high as the country average wages in many CCs. In Estonia[57], IT experts in the private sector are paid salaries at least 4 times higher than those in R&D institutions.

[56] European Commission, DG Enterprise (2001).
[57] Marek Tiits (2002).

A survey[58] indicates that salaries in the IT sector in Bulgaria increased by more than 30% between 2000-2002. Higher IT salaries are offered in capital cities, foreign-owned companies, software companies or banks. 48% of the survey respondents earn around 250 Euro a month, however 9% earn more than 1,000 Euro (5% in 2000), and 3% - more than 1,500 Euro. IT directors and team managers get the highest salaries, but attractive wages are also offered to experienced programmers, web designers, network engineers or system administrators.

Despite the growth of wages in domestic companies, the conditions offered to ICT professionals by foreign-owned companies and in the developed countries are more attractive. Compared to wages in the ICT sector in OECD countries, the average monthly wages in most CCs are considerably lower[59]. In many countries (e.g. Bulgaria, Poland, Hungary, Romania, Baltic countries) this is regarded as one of the reasons why young specialists migrate. In Poland, for example, the threat of brain-drain was considered[60] to be a serious weakness for the IT industry in 2000, as the average IT salary ranged from $450-$600/month, as compared to $5,000/month in the US.

2.4. Summary

After considering many views on the availability of ICT professionals in the CCs, it is possible to offer a cautious assessment of the ICT skills and jobs issues.

The availability of skilled engineers, technicians and researchers is obviously an advantage for the take-up of ICTs. Local enterpreneurship and capabilities have driven the early phases of ICT development in the CCs and the growth of this market. However, the development of an IS requires much more. In the process of catching-up with the EU15, the CCs follow similar trends in IS developments, but with a slight time delay. Therefore, the development of e-commerce and Internet connectivity, as in other countries, will increase the demand for IT specialists to build and support networks, administrate databases, ensure information and network security or design company web sites.

In the short term, the indications are that there will be shortages of particular categories of IT workers – IT managers, network and system support engineers or Java, C++, Oracle or HTML programmers – on the labour markets. Small domestic companies experience more difficulties, especially in non-ICT industries. The public sector also has problems finding appropriate staff for IT departments, IT trainers and lecturers. By offering better paid jobs or providing company training, companies could overcome present jobs shortages.

However, the main concerns are related to future gaps due to ICT development. Therefore, a middle- and long-term strategy for the supply of ICT professionals is very important. This requires, however, robust data on demand and supply and a broad partnership approach in order to overcome the skills imbalance and recruitment gaps.

[58] N.Krasteva, Computerworld/Bulgaria, Nr. 26, 2002.
[59] OECD(1998).
[60] J.Lewis (2000).

3. Building and Preserving ICT capabilities and skills

The picture of ICT professionals in the CCs needs to be completed with some data on their supply. Generally, ICT skills may be obtained through formal education or training, or in a more informal way through using ICTs and gaining experience with them. As the informal ways of obtaining skills are difficult to measure, the focus of similar studies is on the outflow of ICT graduates from educational institutions and on the initiatives towards qualification upgrade and certification of present labour force.

In most CCs, the issue of building ICT capabilities and skills has recently been placed high on national agendas. In the process of European integration most of them have launched wide reforms in education in order to adapt learning programmes to the needs of economy and society, and to facilitate the future mobility of students and workers in the enlarged EU.

Following the attempt made in the previous chapter to highlight ICT skills and jobs in the CCs, this chapter focuses on issues related to the medium and longer-term supply of highly-qualified ICT professionals. It intends to go beyond the standard focus on higher education supply of ICT graduates and engineers by also exploring the integration of ICT in compulsory education and the focus on mathematics and science in early educational phases as they are especially important for future ICT-savvy employees. Similarly, continuous learning provides many opportunities to bridge the ICT skills gaps of present workers and to raise the quality of work. Further factors affecting the future ICT labour force are the decline and ageing of researchers and professors, and the mobility of the highly skilled.

3.1. Building ICT capabilities and skills in the candidate countries

Providing ICT skills bases in schools

As a result of EU Information Society initiatives, all CCs have acknowledged the role of ICT as an enabling technology and necessity for all. The e-Learning concept has been embedded in their educational policy and action plans. However, faced with large economic reforms and increasing social disparities, the governments of most CCs lack resources to meet the related educational challenges. The emergence of private schools and various bottom-up initiatives from schools and local authorities have further widened the differences in the e-Learning environment, and generally contributed to increasing polarisation in the educational opportunities for students with different social backgrounds.

The level of initial ICT education is important for ICT professionals. As Eurydice indicates in its study,[61] lower and upper secondary ICT education in European countries focused on developing four categories of skills: programming, using word processors and spreadsheets, searching for information on a CD-ROM, networks, etc., and communicating via a network. As early as 1997/98, all CC11[62] introduced requirements for obtaining the skills to use IT tools and search for information in the school curricula at both secondary levels.

[61] Eurydice (2000).
[62] Malta and Turkey not included in Eurydice data.

The ICT educational focus in most CCs is on development of new methodologies, programmes and educational content, supply of equipment and networking of schools. The availability of computers connected to the Internet is considered essential for the ICT-based learning process. Thus, the first phase of e-Learning developments in CCs was dominated by the introduction of technology in educational institutions. However, even where technologies are available, the integration of ICTs in the learning process has been hampered by the lack of appropriate electronic books or multimedia tools in the local language, and the ability of teachers to adapt effectively to the new technologies in the learning environment. Therefore, recent national programmes related to ICT education (Box 4) focus on 'soft' factors and the effective use of ICT in education. More attention is also paid to teachers' and school managers' ICT skills and the regular monitoring of educational attainment.

Box 4: 'Tiger Leap' programme in Estonia – measures for promotion and implementation during the period 2001-2005

• development of a systems for appraising the ICT skills of teachers (1 March 2001);
• in-service training of teachers in ICT and the establishment of certification (up to 2005);
• introduction of courses on the methodology of ICT applications in classes for teachers in basic and upper secondary education (1 September 2001);
• reference to the level of ICT skills requirements in the job descriptions of school heads (1 June 2001) and training of school heads (up to 2002);
• inclusion of ICT as a school subject in national curricula (1 June 2001);
• identification of the content, aims and expected results of teaching ICT in school subjects; schools may supplement or amend ICT content provided this is done in a way consistent with the subject concerned (up to 2005);
• preparation of a particular system for assessing pupil skills in the 3rd and 4th stages of study, and annual inspection of the system (2001/2002);
• introduction of a pilot examination concerning ICT skills in the 9th and 12th grades (spring 2002);
• introducing assessment of pupil ICT skills in all schools (1 September 2003);
• take-over by the State of responsibility for the financing and administration of connecting schools to the Internet with connections established on the basis of needs (1 September 2001);
• production and transmission of teaching and instructional materials – along with international cooperation projects and scenarios for the introduction of ICT into education – on a gateway website for teachers (up to 2005);
• provision of schools with comprehensive ICT facilities, and scope for them to formulate their own development plans (up to 2005);
• involvement of teachers in projects which encourage the use of ICT in teaching (educational software, virtual upper secondary education, international projects, etc.);
• evaluation of the effectiveness of using ICT in education (up to 2005).

Source: Eurydice (2001)

Knowledge in mathematics and science is as important as ICT education in the formation of ICT savvy employees. The role of mathematics for developing skills for analysing data and different situations, solving problems, developing arguments and proving hypothesis, logical thinking, etc is now broadly acknowledged. Scientific and mathematical literacy are also included as indicators of the quality of learning in schools[63]. EICTA suggests[64] strengthening secondary education in mathematics and scientific disciplines, as these are 'the basis of all technical and scientific education' and 'one of the key elements to future competitiveness' and particularly important for ICT professionals. Therefore, the existing

[63] European Commission, DG Education and Culture (2002).
[64] EICTA (2001).

high standards in mathematics, science and informatics in most CCs are promising for supply of good ICT professionals in the future.

Table 11: Mathematics and scientific scores

Country	PISA		TIMSS 1995 (8th grade)		TIMSS 1999 (8th grade)	
	mathematics	science	mathematics	science	mathematics	science
BG	:	:	527	545	511	518
CY	:	:	468	452	476	460
CZ	498	511	546	555	520	539
EE	:	:	:	:	:	:
HU	488	496	527	537	532	552
LV	463	460	488	476	506	503
LT	:	:	472	464	482	488
MT	:	:	:	:	:	:
PL	470	483	:	:	:	:
RO	:	:	474	471	472	472
SI	:	:	531	541	530	533
SK	:	:	534	532	534	535
TK	:	:	:	:	429	433
A	515	519	539	558	:	:
B	520	496	550	533	558	535
D	490	487	509	531	:	:
DK	514	481	502	478	:	:
E	476	491	487	517	:	:
EL	447	461	484	497	:	:
F	517	500	538	498	:	:
FIN	536	538	:	:	:	:
I	457	478	491	497	485	498
IRL	514	513	527	538	:	:
L	446	443	:	:	:	:
NL	:	:	529	541	540	545
P	454	459	454	480	:	:
S	510	512	519	535	:	:
UK	529	532	498	533	496	538
US	493	499	492	513	502	515

Though the transitional period has eroded many of the past achievements of the educational systems in most CEEC10, some positive aspects remain as the good performance of students in international tests shows. 7th and 8th grade achievements in mathematics and science in 1995 indicated[65] that the children in Bulgaria, the Czech Republic, Hungary, Slovakia and Slovenia score higher than the world average, even higher than children in the US, Denmark, Germany, Ireland, the UK and other OECD countries. The widely discussed PISA study[66] also shows that secondary students in the Czech Republic, Hungary and Poland achieve better results than students in some EU member states. It is worrying, that the revised TIMSS[67] in 1999 showed that

[65] TIMSS 1995 results in EU and CCs in European Commission, DG Education and Culture (2000)
[66] OECD (2001b), Mathematical literacy is measured in terms of students' capacity to recognise and interpret mathematical problems, translate them into mathematical context, use mathematical knowledge and procedures to solve problems, interpret the results, formulate and communicate the outcomes. Scientific literacy scores are measuring students' capacity to use scientific knowledge, recognise scientific questions, relate scientific data to claims and conclusions and communicate them. OECD average score for mathematical and scientific literacy is 500 points.
[67] Third International Mathematics and Science Study (TIMSS) is a collaborative research study conducted by the International Association for the Evaluation of Educational Achievement, http://timss.bc.edu.

achievements in the Czech Republic and Bulgaria had declined. Other countries (Latvia, Lithuania, Cyprus), however, improved their results in 1999 (see Table 11).

While these tests highlight the average educational achievements in a given country, the international scientific Olympiads show the excellent results of some individuals and highlight country traditions in particular fields. Secondary students from Romania and Bulgaria, for example, regularly win gold medals at International Olympiads in mathematics[68]. Their performance is among the best in the world, after China, the US and Russia. The results for Hungary and Turkey also show the presence of excellent traditions in mathematics.

Most of the CCs also have a very strong presence at International Olympiads in Informatics[69], often taking more than one third of the gold medals (Table 12). In the last 5 years informatics students from Poland, Slovakia, the Czech Republic and Romania, followed by students from Estonia, Bulgaria, Hungary, Latvia and Lithuania, were among the best in these world contests. Almost all participants in national teams from these countries won medals. In comparison, EU15 students achieved lower results. Out of the EU15, students from Germany, France and the UK performed well in mathematics, and students from Germany, the UK, Finland, Sweden, Denmark and the Netherlands won gold medals in informatics in the last 5 years .

Table 12: Gold medals won at International Olympiads in Informatics, 1995-2002

	2002	2001	2000	1999	1998	1997	1996	1995
BG	1	2	-	-	-	-	-	1
CZ	1	-	-	1	-	1	1	4
EE	1	1	1	-	-	1	-	1
HU	-	-	-	-	1	-	-	3
LV	2	-	-	1	-	1	-	-
LT	-	-	-	-	-	-	1	1
PL	1	1	2	1	3	2	1	1
RO	2	2	2	1	1	1	-	-
SK	1	2	-	2	4	1	2	-
CC9	**9**	**8**	**5**	**6**	**9**	**7**	**5**	**11**
EU15	**1**	**2**	**4**	**2**	**3**	**6**	**2**	**0**
Total medals	**23**	**23**	**23**	**22**	**22**	**19**	**20**	**20**

The excellent performance of students from some CCs at international competitions illustrates the existence of a pool of excellence in mathematics and informatics, which is a good basis for the formation of ICT professionals at a later stage.

The overall economic situation in most CCs provides a possible explanation for the high individual achievements there. As the reward for success is very high, many people and organisations aim at excellence. Domestic organisations providing support and scientific advice hope to obtain recognition from the international community and possible future support in order to keep and strengthen existing traditions. The country sending winners can also enjoy the benefits of this ‘advertisement’ for its highly-skilled human potential:

[68] http://olympiads.win.tue.nl/imo/.
[69] http://olympiads.win.tue.nl/ioi/.

by attracting leading companies to establish local industrial affiliates or subsidiaries (e.g. Hungary).

Competitions can be also seen as a way to develop higher problem solving and competitive abilities of students. The process of preparing for competitions creates opportunities for collaboration and exchange of knowledge and experience between teachers and researchers, thus strengthening the whole learning process. Most CCs have assessed the importance of mathematics and informatics competitions as tools to identify and develop the intellectual abilities of young people and have long traditions, revealed by the results of their students. Cyprus recently launched a country wide mathematics contest with a view to promoting excellence in mathematics.[70] The question remains, however, whether proper institutional settings and environments are in place in order to take full advantage of the available potential and traditions and to use them in an appropriate way for the future benefit of individuals and the country concerned.

ICT graduates from universities and vocational schools

The most difficult question now in the CCs is how to preserve the available ICT capabilities and develop them further. Generally, the answer can be found in the education systems, - in particular higher education and its capacity to prepare future ICT professionals, researchers and teaching staff.

In the last few years, higher education in the CCs has undergone radical reform, targeted at integration in the European Higher Education Area. At present, it is characterised by university autonomy, new governing principles and new academic curricula. In the CEEC10, in particular, the new framework for higher education has facilitated the establishment of private universities, many of them specialised in domains relevant to economic needs. Universities have also responded to the increased demand for ICT skilled employees and have provided various ICT-related courses in addition to the specialised computer, IT and microelectronics courses. In the Czech Republic, all universities offer courses in basic computing, while the technical universities have focused on teaching computer science and information engineering. Poland has more than 30 technical universities throughout the country, some of them with long traditions in science and technology. In Estonia, the Tallinn Technical University has many IT-related departments, where students can obtain wide competencies in ICTs (Box 5).

Box 5: ICT competencies provided at selected technical universities in Poland and Estonia

In *Estonia*, the Tallinn Technical University provides ICT-related higher education and research. In the 5 departments at the Faculty of Information Technology, the students can obtain knowledge and skills in many areas: digital systems design, computer control and diagnostics, software, radio engineering, information and knowledge-based systems, telecommunications, signal processing, electronics design, applied electronics, electronic measurement, etc.

In *Poland*, ‘the origins of the Warsaw University of Technology date back to 1826. It is the largest academic school of technology in Poland, employing 2,000 professors, with 17 faculties covering various fields of science and technology’. The Faculty of Electronics and Information Technology, the largest at the University, carry out educational, scientific and research activities, covering almost the whole spectrum of relevant specialities – from microelectronics and optoelectronics, biomedical engineering, through instrumentation, measurement, control and robotics, to computer engineering and networks, multimedia techniques and telecommunication. At the this Faculty, which has 6

[70] European Commission, DG Education and Culture (2000), p. 16.

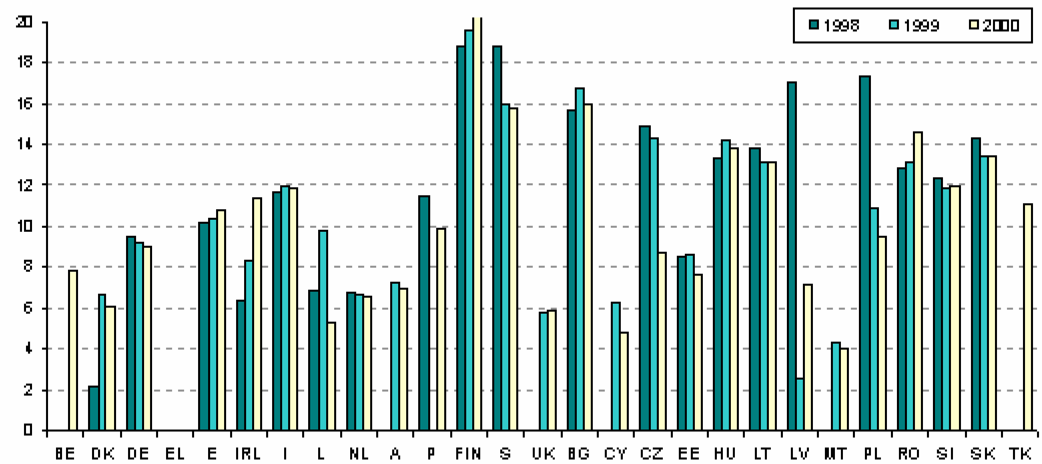
specialised institutes, more than 300 academic teachers provide education to around 3,400 full-time students.

Source: Tiits et al. (2002), http://www.elka.pw.edu.pl

At present, increasing numbers of young people are studying beyond secondary level. The percentage of the population leaving school without qualifications at this level has progressively decreased and as a consequence the educational level of the population has risen. So far, though, the student population in higher education in CCs (2% of population) is still relatively small compared to the EU average (3.2%).

In terms of patterns of specialisation in higher education, Eurostat[71] data show higher enrolment in social and humanitarian studies in most CCs (except Turkey), as well as relatively high numbers of students in more 'practical' disciplines such as business and engineering. The strong traditions in engineering of most CEEC10 are supported by high numbers of students in engineering subjects, significantly higher than in many EU members (Figure 3). Engineering staff redundancy, however, is one of the reasons behind the decreasing number of students in engineering subjects in most CEEC10. Romania is an exception as engineering enrolments are increasing, in Turkey[72] they almost doubled over the period 1991-1998.

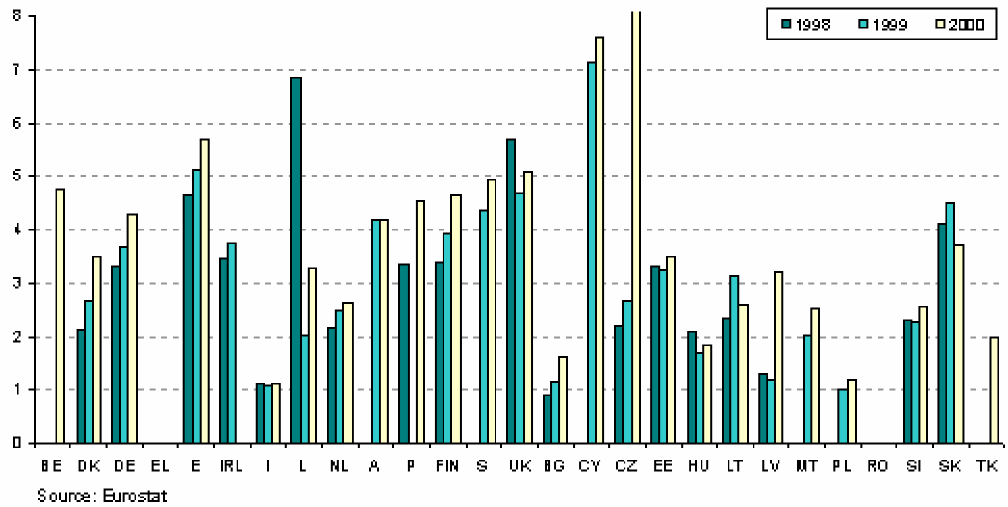
Figure 3: Students in 'engineering and engineering trade' as % of all fileds of study, 1998-2000



Source: Eurostat

[71] Eurostat(2000).
[72] Statistical yearbook of Turkey (1999).

Figure 4: Tertiary students in 'computing' as % of all fields of study, 1998-2000



ICT sector growth and higher salaries in most CCs have attracted many students to study communications or computers. As far as 'computing' is concerned, Eurostat data show a slight student decrease only in Slovakia and Lithuania in 2000 (Figure 4). In Latvia, for example, many secondary school graduates showed an interest in studying computer sciences, though only half the applicants were admitted to the universities. The situation looks very different from the trends in the EU15 where industrial actors and educational authorities are discussing measures to make the ICT profession more attractive and to fill the vacancies in the university programmes concerned.[73] Most CCs (except Cyprus, the Czech Republic and Slovakia) have fewer tertiary level graduates in computing as a percentage of all graduates than EU members (except Italy). Some experts[74] have questioned to what extent the data for CCs are comparable to those for EU members, particularly as far as the study field and the corresponding curricula are concerned. The ambiguity of data gathering might be behind the smaller percentage of 'computing' students in Bulgaria, Hungary and Poland, for example. On the other hand, there is a high probability that many existing ICT professionals have acquired their qualifications through self-training, non-formal learning or at work. The broad technical knowledge and skills of many engineers in these countries have also provided a good basis for their employment in ICT-related jobs.

At EU level, considerable attention is paid to the gender balance of ICT professionals and the need to encourage women to enrol in ICT-related study fields. As Eurostat data indicate, most CCs have higher percentage of female students in engineering subjects than most EU members. Only in Denmark, Spain, Portugal and Sweden the percentage of female students corresponds to that in most CCs. In computing, there is not a big difference between EU and CCs students – most have 20-25% female students. Bulgaria has the highest percentage of women in the CCs and EU members participating in both engineering (35%) and computing (50%). The Czech Republic, Slovenia, Malta and Slovakia have a lower percentage (around 10%) of women in computing studies.

[73] Career space (2001).
[74] Workshop "IS development strategies in candidate countries" (Seville, 23-25 February 2003).

A closer look at ICT-related subjects in Hungary shows that in the period 1993-2000 the students enrolled in ‘computer and mathematical programming’ and ‘computertechnics’ almost doubled, whereas the students in some traditional subjects like ‘telecommunications’, ‘microelectronics’, ‘control and system engineering’ seriously declined (Table 13). The highest number of students in ‘technological and economic informatics’ corresponds to business demands for interdisciplinary skills. Despite these trends, it is estimated that the number of ICT students in Hungary is not sufficient to meet growing demand. A possible solution being considered by public bodies is to promote IT education in polytechnics, where the courses take 3-4 years and provide more practical skills.[75]

Table 13: Students enrolled in full time tertiary education in Hungary, 1993-2000

Selected subjects	**1993/4**	**1995/6**	**1997/8**	**1999/0**
Mathematics	4053	3939	3255	2741
Applied Mathematics	0	0	64	158
Informatics	918	987	816	797
Computertechnics	312	494	524	621
Technological and Economic Informatics	1630	6281	8444	8443
Information-librarian	74	78	88	151
Integrated Engineering	0	134	0	27
Geo-informatics	0	0	185	186
Agricultural-informatics	0	0	1	0
Computer and Mathematical Programming	1147	1268	1482	2138
Intermedia	0	0	34	49
Telecommunication	512	297	406	0
Microelectronics	138	0	0	0
Control and System Engineering	251	107	0	0
Total in these subjects	**9035**	**13585**	**15299**	**15311**

Source: Hungarian Ministry of education, Budapest, 2001, quoted in STAR (2001)

In Estonia, in the period 1994-2000, the enrolment to IT bachelor and master studies at the universities rose significantly (Table 14). The growth of enrolments did not correspond, however, to an essential increase in graduates, though this is expected in the years to come. A worrying tendency in Estonia is that many IT students leave universities before graduation, responding to market demand for IT specialists. As national research shows[76] ‘The shortage of skilled labour has a twofold effect: firstly, a number of intellectually promising individuals disrupt their studies at university and leave for intellectually unchallenging work where they offer relatively low added value in small or medium sized IT companies, lured by attractive salaries. Secondly, a lack of competition between IT specialists does not facilitate personal development and skills enhancement, nor does it motivate them to generate new innovative solutions and distinguish themselves from other competitors.’

[75] STAR(2001).
[76] T.Pihl (2001).

Table 14: Higher education in mathematics and computer science in Estonia

		1994	1995	1996	1997	1998	1999	2000
Bachelor studies	Admittance	88	90	91	159	179	214	309
	Students	423	370	361	551	671	775	1044
	Graduates	33	64	54	35	36	56	76
Master studies	Admittance	22	16	26	39	28	57	73
	Students	49	49	58	79	80	115	150
	Graduates	15	15	10	11	14	14	20
Doctor studies	Admittance	7	7	10	12	13	14	11
	Students	10	16	23	31	43	47	49
	Graduates						6	4

Source: Statistical yearbook of Estonia, 2000, quoted in Tiits (2002)

In Bulgaria, 'computer systems and technologies' and 'communication techniques and technologies' are the engineering subjects most in demand. For example, in 2002 more than 50% of all applicants (more than 5,100) at the Technical University of Sofia put 'computer systems' first in their list of choices, and around 30% wanted to study 'communications'.[77] As the Arc Fund indicates[78], in 2001 29 universities offered ICT programmes and around 6,485 students (3% of all students) studied ICTs. The study programmes of many other subjects also include ICT training, thus almost 90% of all students gain ICT skills. It should be noted, however, that the share of students enrolled in 'informatics' is not very high, while 'engineering', although declining, still has a very high percentage of students (Table 15). As in Estonia, a low percentage of engineering students actually graduate, opting first for well paid jobs.

Table 15: Students in higher education in Bulgaria by fields of study (in % of all fields)

	1998		1999		2000	
Subject	enrolled	graduates	enrolled	graduates	enrolled	graduates
Pedagogic studies	10.7	18.9	12.2	15.6	11.7	10.7
Humanities	7.9	5.4	7.6	6.0	8.8	6.3
Social and behaviour sciences	11.1	9.5	12.8	10.5	12.2	13.7
Management and administration	20.9	24.1	21.0	27.0	20.4	31.3
Natural sciences	0.6	0.6	0.7	0.8	0.8	0.7
Mathematics	0.9	1.0	0.6	0.4	0.7	0.3
Informatics	1.5	0.5	1.7	1.1	2.4	1.6
Engineering	19.4	9.7	18.3	10.7	18.0	9.9

Source: Totomanova (2002)

According to Polish national sources, regular IT students (including those studying Computer Science, Electronics and Telecommunications, Robotics and Control Systems) account for around 1.5% of all students at technical and general universities and economics academies[79]. At the Technical University of Wroclaw in 2002, IT graduates made up 33% of all students at the university. More than half of all IT students from the Faculty of Electronics and the Faculty of Information and Management finished the 5 year regular course, while around 25% of students followed external or evening courses (Table 16).

[77] http://priem.tu-sofia.acad.bg
[78] ARC Fund (2002)
[79] In addition, 0.6% of all external and 0.1% of evening students.

Table 16: Students at the Technical University of Wroclaw, 2002 data

Number of graduates 2002	Total graduates	IT at Faculty of Electronics	IT at Faculty of Inform. and Management
regular, 5 years	2394	478	394
regular, 3 years	549	129	
external	570	164	78
evening	724	80	61
Total	4237	851	533

Source: Prof. Roman Galar (2003)

Vocational education and training has particular importance for the preparation of middle and lower-skilled ICT specialists. In Estonia, for example, communications, information technology, electronics-automation and telecommunications are among the vocational education and training programmes that have undergone rapid development over the last few years.[80] In 2000, students in the field of 'computing' represented around 11% of all students at post-secondary vocational level, whereas their percentage was rather low (less than 2%) at secondary level, and the number of 'computing' study programmes was also low (see Table 17). At secondary level, the highest number of students are found in 'engineering and engineering trades', and in 'business and administration' at post-secondary level.

Table 17: Specialisation opportunities in vocational education and training in Estonia in selected fields of study in 2000/1

Field of study	**After basic school**		**After Gümnaasium**	
	Programm	**Students**	**Programm**	**Students**
Teacher training and education science	1	1	1	25
Computing	8	289	35	1432
Business and administration	26	1107	82	4366
Engineering and engineering trades	134	5359	61	2056
Manufacturing and processing	89	2878	28	925
Environmental protection	1	58		
TOTAL (including other fields of staudy)	**501**	**17665**	**357**	**13207**

Source: ETF(2000a)

Table 18: Students and graduates of vocational and post-secondary education in Poland (2001/2)

Selected educational profiles	**Vocational secondary education**		**Post-secondary education**	
	students	graduates	students	graduates
educational science and teacher training	524	101	19080	5031
social and behavioural science	128328	37595	29885	16584
business and administration	156793	53624	33660	16032
natural science	1791	498	117	41
computing	2227	573	42745	11258
engineering	377055	130454	2925	1038
manufacturing and processing	125569	20211	821	307
TOTAL (incl. all available profiles)	**1136129**	**372850**	**131304**	**53545**

Source: Statistical institute of Poland (2002)

[80] ETF (2000a).

In Poland, similarly, many students enrolled in 'engineering' at vocational secondary education, and the share of students in 'computing' is very low at this level (Table 18). At post-secondary level, 33% of all students and 21% of all graduates are 'computing' students, reflecting a significantly higher level of interest. At this educational level, the subjects with highest number of graduates in 2001/2002 were 'business and administration' and 'social and behavioural science'.

From 1993 in Hungary the number of ICT students in vocational schools constantly increased, reaching 7% of all students enrolled in 2000. At the same time, apprentice training in ICTs decreased (see Table 19) following the general decline of apprentice schools.[81]

Table 19: Students enrolled in full time vocational schools in Hungary

Year	Apprentice school		Vocational secondary school	
	ICT	Total	ICT	Total
1993/1994	1018	174187	11344	192134
1995/1996	536	154294	11184	208415
1997/1998	367	132637	20240	227240
1999/2000	288	109534	17000	241369

Source: Hungarian Ministry of Education (2001), quoted in STAR(2001)

Formal statistics do not indicate whether the content of the study programmes is suited to labour market needs or the requirements of the Information Society. For example, the ARC fund[82] indicates in its study that 'IT education is not a decisive factor for recruitment. The reason lies in the fact that the skills sought are often not taught at university or school but are gained through individual learning or practical experience'. Therefore, many companies are trying to influence the education of young specialists in order to shorten the time they take to adapt as employees. In most CCs, university self-governance and flexible management have facilitated collaboration with companies. The interaction between industry and higher education establishments has been extended from initial sponsorship to collaboration in developing joint courses, programmes or training materials, carrying out research, participation of professors in business activities, engagement of students as trainees and workers, etc.

There is still a long way to go for most CCs before they achieve close integration of industry, education and research.[83] In the area of ICT higher education, in particular, CCs could take into consideration as an example of good practice the collaboration of ICT industry at EU level within the Career Space project for preparing 'Core Generic Skills Profiles' and 'Curriculum Development Guidelines'[84]. The basic requirements for the formation of future ICT professionals identified by the industry could be reflected in the curricula in order to:

[81] STAR (2001).
[82] ARC Fund (2002).
[83] systematically considered in TKL panel report (2001), European Commission, DG Enterprises (2000).
[84] see Career Space (2001).

- provide a foundation in technical skills and broad system perspectives;
- focus on team working within educational projects;
- introduce basic economic, market and business issues;
- develop personal skills for problem solving, lifelong learning and cultural tolerance.

In addition, links between universities and industry could be strengthened in order to improve ICT teaching and to provide students with practical experience on projects close to business needs and knowledge of recent technological developments.

Continuous learning focus

Higher education may be able to ensure ICT professional supply in the middle and longer term. However, companies need to find solutions for labour shortages now. Rapid technological change requires continuous learning from citizens and employees world-wide. Experts estimate that around 80% of big company spending on training is on IT training. According to the Gartner Group[85], IT users without formal education spend 6 times longer on tasks than the workers who have systematic knowledge of particular IT tools, and the losses in real terms for companies with self-educated workers are considered to be 73% higher. Therefore, many training courses in CCs are targeted at improving ICT knowledge and skills. For example, courses for obtaining the European Computer Driving Licence (ECDL) have been launched in many CCs, in most cases by domestic computer associations.[86] In Hungary, ECDL courses are integrated in the national upgrading programme for public officials. In Lithuania, ECDL is considered to be a tool for raising overall computer literacy, while in Malta evening courses are offered for improving adults' computer skills.

Recognising the deficiencies of the educational systems, the skills mismatch of the workers and the fact that competencies rapidly become out-of-date, companies and computer associations often elaborate their own programmes in order to retrain their employees or collaborate with e-Learning providers (Box 6). This is particularly important for enterprises involved in ICT development and maintenance, and major users and providers of knowledge-intensive services. Specialised training and re-training courses are offered for bank and telecommunications employees, computer specialists, etc. Companies place a high priority on employee certification according to internationally recognised standards.

[85] Quoted by IDG, http://www.idg.bg.
[86] European Computer Driving Licence Foundation, http://www.ecdl.org, country links.

Box 6: ICT training and certification in some CCs

In *Estonia* Baltic Computer Systems, with the support of the Swedish IT Fund and the Baltic Sea IT Fund, has opened a training centre providing training courses which integrate both IT-related and managerial aspects. A further goal is to educate and certify managers from Estonia's public and private sectors. Since 1993 more than 10,000 people have attended courses for IT managers, IT professionals and end users. As a recent survey indicates, 86% of the sample enterprises claimed they invest in personnel training in order to bridge the gap between higher education outlet and market needs, and weighted average investment in training at approximately 3% of their turnover.

In *Hungary* the certification of IT skills is very important. For individuals the COPIC (CEPIS) and CSDP (IEEE Computer Society) schemes are being considered for wider introduction and some results are expected from the "IT Professionalism" initiative supported by IFIP. Courses for end-users, system engineers, developers, help desk and technical staff are offered by many educational centers. For example, 'Training C' is a specialised company, which started in 1998 as a Compaq Authorised Training Center. It then became a Microsoft Certified Technical Education Center and within several years developed into a local partner of global e-learning providers (e.g. Prosoft, GTS Learning, Global Learning Systems).

In many CCs, *global e-learning providers* are active. Education centres in the Czech Republic, Estonia, Hungary, Slovenia, Romania, for example, are licensed by a UK-based company – Global Training Solutions (renamed GTS Learning) to provide IT education and certification to end-users and corporate clients. Another global IT training provider with local partners in some CCs (e.g. Hungary, Estonia, Latvia) is Prosoft, which provides education and certification programmes for developing Internet, Linux, A+, Cisco, Microsoft, Oracle and telecommunication skills.

Among the e-learning providers active in CCs (e.g. Bulgaria, the Czech Republic, Estonia, Hungary, Lithuania, Poland, Slovenia, Romania), Brainbench is considered to be the only company providing solely web-based services – *online certification* for more than 200 skills, mostly in the field of IT or office management. In addition to the opportunity for individuals to obtain certifications recognized in the US, Brainbench's partnership with CV-Online – a pan-European online recruitment service provider and career portal (an Estonian start-up), makes it especially attractive to IT jobseekers in the CEEC10.

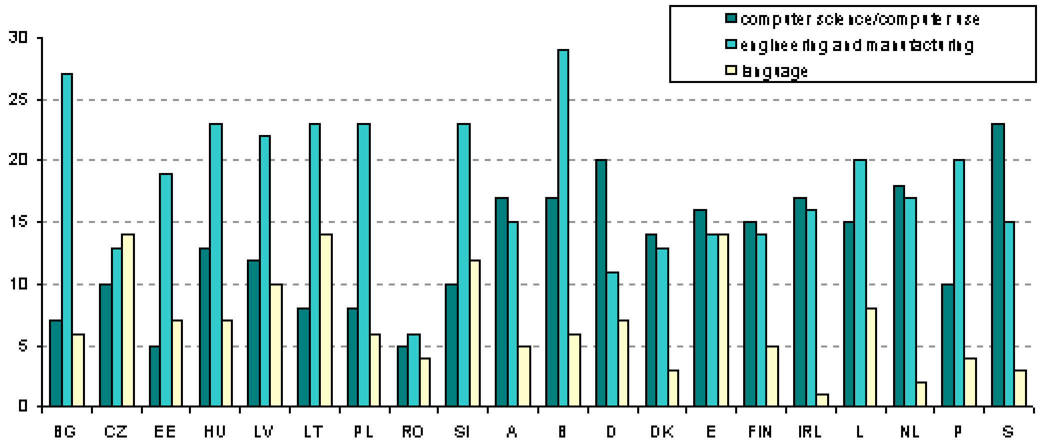
Sources: Saat(2000), Tiits(2002), Domolky(n.d.), Mroczkowski (2002)

A recent European survey[87] on continuous training indicates that the employees in big enterprises in CCs are offered better opportunities for training than those in smaller firms. In CCs (except Bulgaria and Romania) more than 40% of the enterprises with 50-249 employees provided continuous training to their workers. In economically more advanced countries like the Czech Republic and Estonia, more than 55% of enterprises with 10-49 employees provided training. The survey further suggests that financial intermediaries pay more attention to updating their employees skills. 'Computer science/computer use' and 'engineering and manufacturing' training seem to be very important for enterprises as they devoted more training hours to them. In this regard, there are some interesting differences between some CCs and the EU members (Figure 5). For example, most enterprises in EU member countries spent more time on computer-related courses than those in CCs, while the opposite was true for language courses and courses in 'engineering and manufacturing'. In both cases, courses in 'management and

[87] Eurostat (2002a).

administration' and 'accounting, finance' fields were provided less often to employees (a higher percentage of courses took place mainly in financial intermediaries).[88]

Figure 5: Share of training cources in total course hours (%), 1999



Sourse: Eurostat, Statistics in focus, 3, 2/2002

In the CCs, multinational companies such as Microsoft, Novell, Oracle, IBM, etc. have focused on training ICT professionals by launching special programmes and certification courses (as they do globally). For example, Cisco has established many 'Network Academies', which aim to provide ICT knowledge and skills, necessary for design, establishment and maintenance of small and middle networks in the CCs. The courses increase participant employability and provide a good basis for further learning in the area of computer networks and ITs. The world-wide 'Network Academies' collaborate with several local partners – ranging from universities and schools to NGOs and government organizations.

The e-training activities in the CCs are based on wide collaboration with educational authorities, universities, industrial or non-government organizations, etc. (Box 7).

[88] see Eurostat (2002b).

Box 7: Examples of public-private partnerships in selected CCs

In *Poland*, 'INTEL and Microsoft take part in the 'Teach to the Future' project which has a 555,000 Euro budget for training teachers to use ICT in various school subjects. The goal is to train 100 trainers and 4,000 teachers who will each be responsible for training 20 more teachers. Microsoft offers reduced rates for software purchased by the government. CISCO takes part in the 'CICSO Academies' project for training Internet and intranet specialists and technicians, in co-operation with the local authorities.'

In *Bulgaria*, many national initiatives have focused on computer education. Some of the already implemented projects worth a mention are: a joint initiative on the part of IBM Europe, the Bulgarian Ministry of Education and Science and the Open Society Foundation for ICT implementation in different subjects; the widely-used British Council programmes 'Train the trainer' and Cross-cultural studies; and the ViFax Programme for distance learning in French, using satellite connection and the Internet. A collaborative project involving the Ministry of Culture, UNDP, USAID and Cisco Systems Bulgaria was also launched in 2001 for the establishment of 3 regional centres and provision of ICT education and qualification courses in 25 'tchitalista' (old public cultural and educational places). Cisco has provided a training programme, which includes theoretical and practical education and many knowledge tests.

Source: Eurydice (2001), http://www.cisco.bg

There is still a long way to go in the retraining of the present workforce, as well as keeping the employees up to date with technological, economic and societal changes in all CCs. Many initiatives[89] are underway for building an open, flexible and transparent lifelong learning system, mainly related to encouragement of company-training activities, use of existing company-based training facilities or the building of regional training centres. The focus in most cases is primarily on areas where the demand and potential for economic gain are greatest (business, law, ICTs, foreign languages, etc.). In addition to traditional forms of training, CCs should use more actively the opportunities that distance education offers them to enhance the variety of training courses and facilitate accessibility of educational materials and training.

3.2. Ageing and mobility of the highly-skilled in the candidate countries

Decline and ageing of professors – still a bottleneck?

The expansion of participation in higher education in CCs can clearly contribute to overcoming the employment imbalance in the future. However, lack of indicators prevents us forming a clear picture of the quality of higher education provision. In most cases rising input has not seen a corresponding increase in the numbers of teachers. For example, the growth in private universities in some countries, whilst needed in order to meet quantitative demand, may not be able to call upon sufficient top-level experts to provide the teaching.[90] Moreover, the trends of decline and ageing of academic and research staff in the CEEC10 have raised many concerns about how to preserve past achievements in research and higher education.

[89] ETF (2000b).

[90] See the Czech Republic case: Filacek et al (1999) where six new universities have opened since 1990.

Unfortunately, the statistical data are usually too aggregate for estimating the stock of ICT researchers and university lecturers. It is well known that there was a substantial outflow of scientists and professors from technological activity in virtually all the CEEC10, and this did not appear to stabilise until the mid 1990s. Many researchers and professors, especially in the technical sciences, have been "brain drained". Foreign-owned companies and banks have attracted many highly-skilled engineers, programmers and system administrators by offering them better employment conditions, and have thus caused skilled personnel shortages in domestic companies and research units. In Estonia[91], for example, the Tallinn Technical University has lost dozens of highly educated employees to the banks. The STAR consortium indicates[92] a similar problem in Hungary, where foreign subsidiaries pay relatively high salaries to ICT professionals, and therefore higher education institutes have difficulties in recruiting professors to teach ICT, and in maintaining standards of teaching.

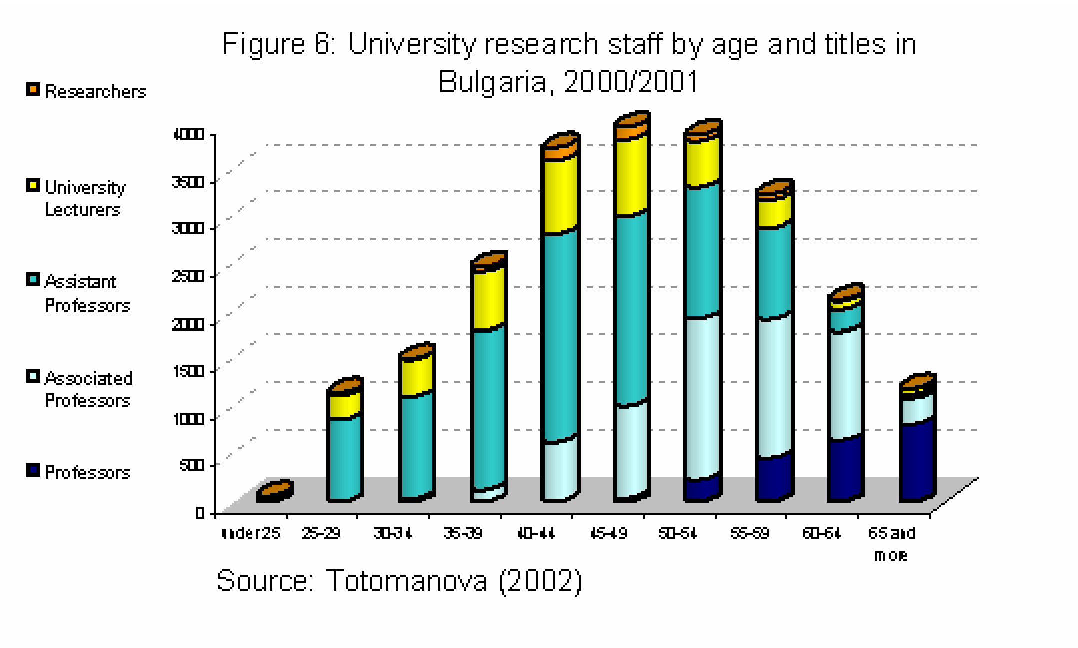
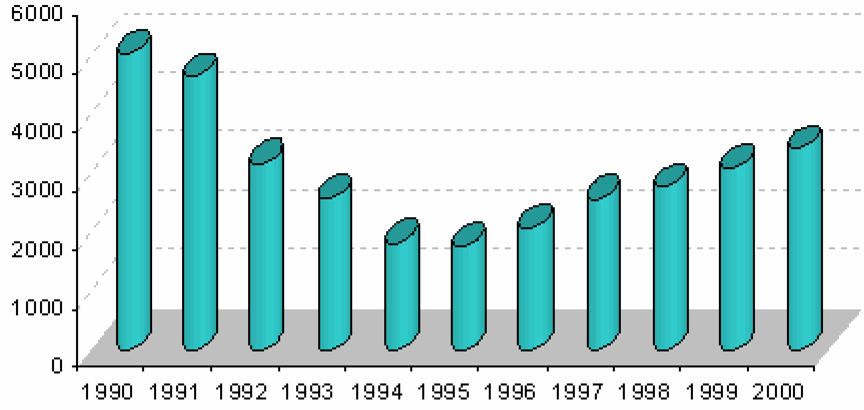


Figure 6: University research staff by age and titles in Bulgaria, 2000/2001

Source: Totomanova (2002)

[91] Kalja et al. (1999).
[92] STAR (2001), p. 23.

Figure 7: PhD students in Bulgaria, 1990-2000



Source: Totomanova (2002)

The other broadly discussed issue is the fact that academic staff in many CCs[93] is ageing rapidly. In Bulgaria, in 1997/98 alone, university staff numbers decreased by 15% due to ageing. The age structure of existing university staff does not paint a positive picture, either (Figure 6). For instance in 1997/98, 40% of professors were 60-65, and in 2000/01 29.8% of them were above 65 and 37.49% aged 60-65.[94] In Poland in 1995, only 0.1% of researchers under 40 years of age had the title of professor, whereas 5.9% of professors were 40-59. However, this changed in the period 1994-1998, when on average about 30% of professor's titles were obtained by persons aged up to 50.[95]

In the past decade, poor conditions for state-of-the-art research (due to outdated equipment) and low salaries in the research sector discouraged young people from choosing a career in R&D. Many young people did not enter a university career also because it takes so long to establish themselves in the independent position of full professor. After obtaining their Masters degrees young people have been no longer interested in post-graduate education or research careers in most CEEC10. Professors are worried[96], therefore, that present achievements in ICT higher education are based on the scientific potential of the past as young people are not choosing university careers, thus putting into question the longer-term prospects for education of ICT professionals.

In response, a number of countries are paying significant policy attention to attracting young researchers, through targeted seminars, training and exchange programmes. They have also focused on replacing and updating research equipment, connecting research and training institutions to emerging European and global 'e-Science' infrastructures. Talented people are expected to enter research careers in adequate numbers only if there are sufficient opportunities to train and an attractive environment in which to work (i.e. good teaching and research infrastructures, flexible and performance related career paths and good levels of remuneration).

[93] In Turkey, on the contrary, in the period 1994-1997 the number of researchers increased with about 39%. OECD(?).
[94] Totomanova, A. (2002).
[95] Kozlowski et al.(2000).
[96] Tukisa (1999).

More recent research indicates that these worrying trends have stopped and even reversed in many CCs (e.g. Estonia, Hungary, Poland, the Czech Republic). Efforts to overcome the problems in Estonia [97], for example, have achieved some results, and the average age of university staff has remained 46-47 since 1995. However, the increase in the number of doctoral degree holders is considered too slow. In order to ensure continuity of academic education and science, it is estimated that Estonia needs ca 80 new PhDs per year (the corresponding ratio in Finland and Sweden is as high as 200). In fact, 135 PhD students enrolled in engineering courses in 1999 (110 in 1998), but only 9 have graduated (4 in 1998).

Similarly in Hungary[98], the number of PhD students increased considerably: from 2,500 in 1993 to 3,800 in 1997. A sociological survey carried out by the Association of Hungarian PhD Students indicates that students are motivated by professional interest (4.46 points on a 1 - 5 scale), research (3.95) or career possibilities (3.59), opportunities for scholarships abroad (2.91). However, other factors like professor status, prolongation of student years or financial support are also relevant. It is promising for the future supply of teaching staff that many of the engineering PhD students have considered careers at a university or college (44%), though only 20% have chosen industrial research.

A positive trend can also be seen in Bulgaria.[99] After initial serious decline of PhD student enrolments, moderate growth was observed after 1995, though new enrolments in 2000 were still below 1990 levels (Figure 7).

Numbers of PhD students in Poland are also increasing. Their total number almost doubled in 2000, as compared with 1990 (Table 20). Fewer PhD degrees were awarded in technical sciences during the period 1990-2000 than in medical or agricultural sciences. Also, fewer technical scientists are interested in obtaining a second degree – 'habilitated doctor'. Only the numbers of degrees awarded in 'medical sciences' in two consecutive years – 1999 and 2000 – increased as compared with those awarded in 1990.

Table 20: Number of scientific degrees awarded in Poland, 1990-2000

	doctor				**habilitated doctor**			
	1990	**1995**	**1999**	**2000**	**1990**	**1995**	**1999**	**2000**
Total	2324	2300	4000	4400	973	628	915	829
Natural sciences	384	348	671	709	180	144	194	171
Technical sciences	420	391	611	679	201	102	142	135
Medical Sciences	517	661	1151	1157	148	104	165	181
Agricultural sciences	197	205	347	410	104	65	108	70
Social sciences	761	632	1155	1396	328	210	298	270

Source: Polish Official Statistics, http://www.stat.gov.pl/english/

Trends in international mobility of the highly-skilled

The view on the prospects for preserving and building ICT capabilities and skills in the CCs becomes more complicated when the migration of highly-skilled professionals (e.g. researchers, teaching staff, engineers, etc.) is taken into account.

[97] Tiits (2001), Hernesniemi, H. (2000).
[98] Association of Hungarian PhD Students, Doctoral education in Hungary, http://www.phd.hu/history.htm.
[99] Totomanova, A. (2002).

In terms of administrative barriers to mobility, researchers from CCs have advantages over other workers in that they will be given early free movement within the EU15, which will be supported by agreements on social security and bilateral tax, and the portability of supplementary pensions. This is specifically emphasised in recent EU action lines on skills and mobility, and on the mobility of researchers for building a European research area (ERA).[100]

When considering mobility of IT professionals, it is important to take into account the main factors that drive human beings to migrate[101]. General conditions for mobility are: unfavourable economic and social environment, political instability and poor quality of life. At a personal level, however, many other factors play an important role, e.g. remuneration, job satisfaction, career prospects, opportunity to learn and access information on the trends in the area, etc. Factors hampering mobility are family environment, lack of knowledge of languages, complicated administrative procedures and recognition of education and skills. In most CCs, typical factors behind labour force migration are unstable policy environments, economic restructuring or financial crises, poor quality of life, etc. However, the importance of these is decreasing with the implementation of overall reforms and approaching accession dates.

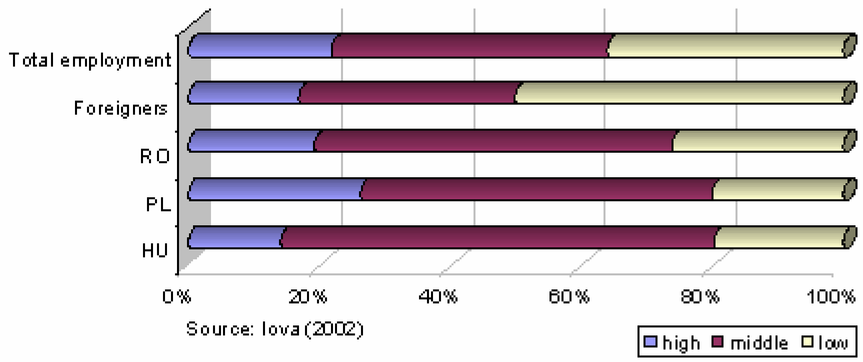
The problems that higher education has experienced in many CCs have influenced a number of young people to study abroad. For many students foreign universities are attractive because of the higher quality of education and tutor expertise they provide, the availability of more advanced technology environment and subjects not offered at home universities. The institutional factors – openness to foreign students and availability of grants – also affect their choice. According to the OECD[102], most students from Poland, Hungary and Turkey are also influenced by cultural and linguistic factors when choosing a German-speaking destination. The OECD observes a higher inflow of higher university students only in the Czech Republic (among CC members of the OECD), mainly from Slovakia. In Hungary, Poland and Turkey there are more students choosing to study abroad than there are coming into the country. Most foreign students in Turkey (91.1%), Poland (82.3%), Hungary (64.2%) or the Czech Republic (72.4%) are from non-OECD countries. A considerable number of students from Bulgaria (28.6 per 1,000), Estonia (26.5 per 1,000), Romania (21.5 per 1,000) and Slovenia (22.9 per 1,000) have chosen to study in an OECD country. For more than half of them this is an EU member state.

Unfortunately, it is almost impossible to find comprehensive data for the qualification level of migrant workers from CCs in the EU and this makes it very difficult to draw any conclusions. Many studies focus on migrant flows to Germany[103], where the skills ratio (share of the highly-skilled in the total number of immigrants) is 19% for Poland, for Hungary - 35%, Romania - 10%, Bulgaria - 39% and the Czech Republic and Slovakia together - 17%. Boeri[104] further indicates that ‘the formal education levels of immigrants from the CEEC10 are significantly higher than those of other foreigners. As Figure 8 also shows, the share of highly qualified migrants varies across countries. As compared with the average qualification of foreign workers in the EU, Polish and Romanian migrant

[100] COM(2002)72 and COM(2001)331.
[101] See also Casey et al. (2001), Bogdanowicz et al. (2001).
[102] OECD (2001a).
[103] Straunhaar, T. (2000).
[104] Boeri, T. (2000).

workers are better qualified. Even the proportion of low-skilled workers from these countries in the EU is lower than the percentage of low-skilled workers employed in EU15.

Figure 8: Employment in EU by qualification level, 1997



Source: Iova (2002)

There are expectations[105] that after enlargement takes place many skilled, relatively young and dynamic people may look for jobs in the present EU member states. This is supported by many developed countries' immigration policy, which facilitates the mobility of highly-skilled professionals. In order to fill local job shortages, national governments, for example in Germany, the UK, the Netherlands, have attracted highly-skilled workers from other countries. Measures like the H-1B visa in the US and the IT green card in Germany may aggravate the labour market situation in other less developed countries, by attracting their best-trained specialists. Therefore, many CCs (e.g. Bulgaria, Estonia, Poland) have concerns about the brain-drain of IT professionals.

Other sources support the opposite argument: that the attractive working conditions in the ICT sector in most CCs, as well as the stabilising policy environment and increasing quality of life will keep specialists in their countries. For example, a DG Research report of 1999[106] suggests that emigration of researchers to third countries will decrease (except for Bulgaria and Slovakia) with the growth of home economies. Further, a World Economic Forum survey [107] states that talented people would rather remain in Poland and the Czech Republic, whereas the probability of a brain-drain is much higher in Bulgaria and Slovakia. The Global Information Technology Report considers that Bulgaria and Romania are also more exposed to brain-drain problems (ranked under ICT opportunities in Table 3), while Latvia, Lithuania and Slovakia have an average risk of losing their skilled IT workforce, scientists and engineers.

In Estonia, non-competitive salaries are considered to be a factor supporting the tendency for highly-qualified ICT specialists to work abroad, while in Latvia salary increases are slowing down the brain-drain. In Hungary, most ICT graduates prefer to stay in the country rather than look for a job abroad.[108] In Poland many concerns about an IT

[105] Straubhaar, T. (2000).
[106] European Commission DG Research (1999), p. 248.
[107] quoted by Centre for economic development, p. 110.
[108] STAR (2001).

specialists brain-drain to the UK and Germany were expressed. However, the argument that good employment conditions and the expected EU enlargement will keep the specialists in the country prevail.[109] In Bulgaria, the situation seems to be improving, too. The Bulgarian Association of Information Technologies[110] claimed that more than 15,000 IT specialists have left the country over the last 10 years. However, recently it recognised that there are some signs that this process is reversing after the downturn of the new economy in many developed countries.[111]

Some insight into mobility of workers from the CCs is provided by the migration data of Germany and the US. The largest single group of foreign computer specialists in both countries is from India. The data indicate that no more than 25% of all green card holders in Germany are from CCs. [112] In the US, 'workers with special occupations' (H-1B visa) from CCs are more than three times fewer than the 'exchange visitors' from the group of non-emigrants with temporary visas (except Romania). In fact, most of the temporary workers in the US from CCs (especially from the Czech Republic, Slovakia and Lithuania) are 'exchange visitors'. Computer specialists are the largest group of workers with H-1B visa, but numbers from CCs are not very high[113].

A comparison with some EU member states shows that the number of highly-qualified immigrants in the US from Bulgaria, Poland and Romania is close to the number from the UK and Germany (Figure 9). This raises many concerns for Bulgaria especially, which has a much smaller population and the regular outflow of more than 900 highly-skilled professionals from the country (one fifth of all Bulgarian immigrants to the US) may endanger its future development.

[109] Actually, the requirement for equal treatment of all EU citizens irrespective of their nationality and the language difficulties might reduce the attractiveness of Polish specialists. The Warsaw Voice, The straight story on migration, Dec. 2000, http://www.thepolishvoice.pl.

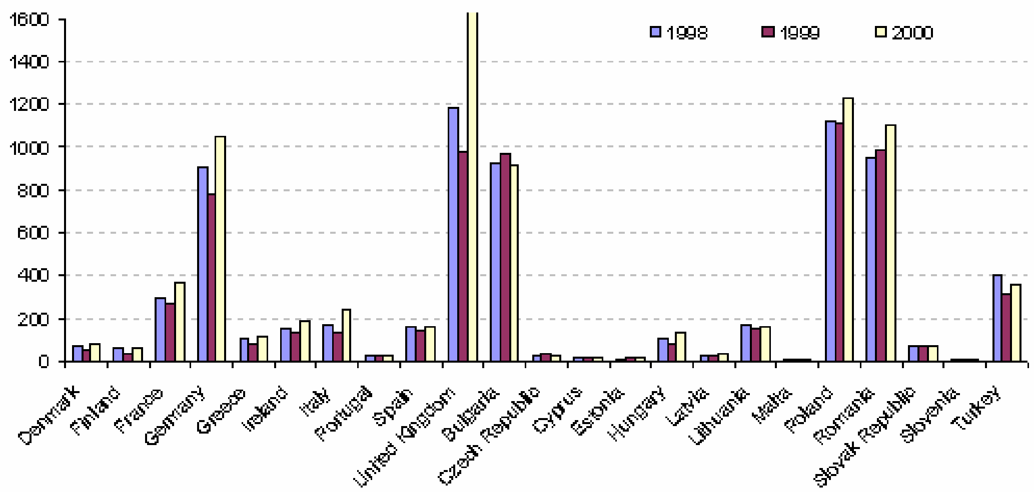
[110] referred to by Vitosha Research (2001).

[111] ISIS(2002).

[112] In 2002 in a press release of the German government was reported that 2,528 of the "Green Card" specialists were from India; 1,609 from Russia, Belarus, Ukraine and the Baltic States; 908 from Romania; 796 from the Czech Republic and Slovakia; 640 from the former Yugoslavia; 438 from Hungary; 362 from North Africa; 357 from Bulgaria; 296 from South America; 172 from Pakistan; and 3,398 from other countries. http://eng.bundesregierung.de/frameset/index.jsp.

[113] In 2000, the highest number of IT workers from CCs came from Romania (292), Turkey (233) and Bulgaria (178). Numbers of Romanian IT workers in the US almost doubled in one year, while in many other CCs (the Czech Republic, Hungary, Poland, Slovakia) they inflow decreased. The number of IT workers with H-1B visas from Poland (125) is not many as compared with the IT labour force as a whole in the country, while those from Estonia (13) correspond to the masters degrees obtained in 'mathematics and computer science' in the country in 2000. On the other hand, their number is very small compared to the estimated demand for computer specialists in Estonia. Databases of the US Immigration and Naturalization Service (INS).

Figure 9: US immigrants with professional specialty and technical occupation



Source: US immigration databases

A further issue is the inflow of foreign professionals into the CCs. Some migration flows are related to the needs of local offices of multinationals, NGOs or newly established foreign-owned companies. As indicated in Table 21, there are large differences in the number of foreigners with residents' permits in the CCs. Their share in the total population varies from 0.1% in Romania to 2.2% in the Czech Republic. In Romania[114], the objectives of most foreign workers in 1999 were business (28,740), technical assistance (6,105) or education and training (17,772). It is interesting to note that around 27% of them came from EU15 countries. In Poland[115], according the National Labour Office statistics, more than 10,000 work permits were granted in 2000 to foreigners to work as "managers", "specialists, experts, consultants" or "teachers, trainers, coaches", of which managers have highest share. Most of these come from EU members or the US.

Table 21: Foreigners residing in some CCs, 1999 (in 1000)

country	Bulgaria	Czech Rep.	Hungary	Poland	Romania	Slovakia
Total	102.3	228.9	127	42.8	61.9	24.8
% of population	1.2	2.2	1.3	0.1	0.3	0.5

Source: ILO(2002), Transformation and Migration in Central and Eastern Europe

It is promising that the universities in Hungary and the Czech Republic are able to attract many students from EU member states – more than 23% of all foreign students. The good educational and scientific traditions in Hungary, for example, made it possible to launch a new US-Hungarian initiative providing US students with the opportunity to study mathematics in Budapest.[116] Furthermore, many private universities have been established in CCs with external funding which aim to provide business or technical education corresponding to market demands. Most of them also attract foreign students from neighbouring countries (e.g. the Estonian Business School, the Central European University in Budapest) and thus foster cross-border co-operation.

[114] Iova (2002).
[115] quoted by Jan Kozlowski in a draft report on migration of highly-skilled workers in Poland.
[116] The Budapest Sun Online (15 August 2002), US students eager to learn from Hungarian maths professors, by Tamas S Kiss.

Though studying in the CEEC10 seems to be increasingly popular, the quality of education there and the future recognition of the degree obtained are considered to be important barriers for foreign students. CCs have worked to establish a quality assurance system in higher education during the last few years to overcome these obstacles. Furthermore, the efforts of most CCs to introduce a credit transfer system and degree structure changes in higher education have created conditions for international compatibility and acceptance of degrees and qualifications. These efforts have contributed to the international integration of higher education and are facilitating the mobility of foreign students.

Table 22: Possible economic effects of highly-skilled international migration

SENDING COUNTRIES: POSSIBLE POSITIVE EFFECTS	**RECEIVING COUNTRIES: POSSIBLE POSITIVE EFFECTS**
Science and technology • Knowledge flows and collaboration, return of natives with foreign education and human capital, increased ties to foreign research institutions • Export opportunities for technology • Remittances and venture capital from diaspora networks • Successful overseas entrepreneurs bring valuable management experience and access to global networks ***Human capital effects*** • Increased incentive for natives to seek higher skills • Possibility of exporting skills reduces risk/raises expected return from personal education investments • May increase domestic economic return to skills	***Science and technology*** • Increased R&D and economic activity due to availability of additional highly-skilled workers • Entrepreneurship in high growth areas • Knowledge flows and collaboration with sending countries • Immigrants can foster diversity and creativity • Export opportunities for technology ***Higher education systems*** • Increased enrolment in graduate programmes/ keeping smaller programmes alive • Offset ageing of university professors and researchers ***Labour market*** • Wage moderation in high growth sectors with labour shortages • Immigrant entrepreneurs foster firm and job creation • Immigrants can act as magnets for accessing other immigrant labour (network hiring effects)
SENDING COUNTRIES: POSSIBLE NEGATIVE EFFECTS *Human capital effects* • "Brain drain" and lost productive capacity due to (at least temporary) absence of higher skilled workers and students • Lower returns from public investment in tertiary education (waste of national public resources)	**RECEIVING COUNTRIES: POSSIBLE NEGATIVE EFFECTS** ***Higher education systems*** • Decreased incentive of natives to seek higher skills in certain fields, may crowd out native students from best schools ***Science and technology*** • Technology transfers to foreign competitors and possible hostile countries
POSSIBLE GLOBAL EFFECTS • Better international flows of knowledge, formation of international research/technology clusters (Silicon Valley, CERN). • Better job matches, including: greater employment options for workers, researcher's ability to seek work most interesting to them and greater ability of employers to find rare/unique skill sets. • International competition for scarce human capital may have net positive effect on incentives for individual human capital investments.	

Source: OECD (2001a)

It is difficult to measure the real inflow and outflow of highly-skilled individuals in the CCs. It is more important for the future of these countries to consider the impact of international mobility. The issues of 'brain-drain', 'brain-gain' or 'brain-circulation' are broadly discussed in research.[117] There are many arguments for the opportunities offered by human mobility. An OECD study summarises the possible impact of mobility of the highly-skilled for both the countries of origin and host countries. (Table 22).

CCs are already exploring some of the opportunities provided by the migration of highly-skilled individuals for the countries of origin. Most of them have obtained support from 'diaspora' networks in the difficult transition that their economies and societies have undergone and have taken advantage of the expertise of their 'brain-drained' professionals or former emigrants returning as entrepreneurs to the country. At the same time, the inflow of many managers and highly-qualified foreigners has contributed considerably to raising individual and organisational capabilities during the transitional period in the CEEC10. Remittances also have a positive effect on many countries, according to some estimates.[118] The National Bank of Bulgaria, for example, indicates that Bulgarian citizens from abroad made bank transfers totalling more than half a billion USD, more than total foreign direct investments (FDI) in the same year.[119] In Romania, remittances are considered to be an important means of poverty alleviation and of support to economic development[120]. As Table 23 indicates, in some CCs remittances are comparable with FDI inflow, and in Turkey they are significantly higher. As compared with the export/import statistics, remittances also show high numbers, especially in Turkey, Poland and Romania.

Table 23: International comparison of the remittances for sending countries, 1998

Country	Remittances, mil. USD	FDI, mil.Euro (1)	Remittances as % of exports	Remittances as % of imports
Bulgaria	230	479	3.8	3.8
Czech Republic	408	2416	1.2	1.1
Hungary	1018	1725	3.9	3.7
Poland	2897	5678	6.6	5.5
Romania	753	1812	7.9	5.8
Slovakia	366	504	2.8	2.3
Slovenia	112	148	1.0	0.9
Turkey	5727	838	10.5	10.3
Greece	7510	:	50.5	29.3
Portugal	4031	:	11.6	8.8
Spain	3249	:	2.0	2.0
India	10280	:	21.6	17.3
Korea	3352	:	2.1	2.9

Source: Iova (2002), based on World Bank data from the World Development report 2000/2001;
(1) Eurostat yearbook (2000)

These examples just sketch the possible positive effects of mobility for the CCs. Mobility of the highly-skilled in the CCs could be a subject of another study which would consider its impact on research and economy, possible actions for 'brain-gain' and efficient use of nationals abroad. It is the responsibility of national policy to turn the mobility of its

[117] Casey (2001), Straubhaar (1998), Boeri (2000), Mahroum(2001).
[118] Straubhaar (1998).
[119] Jordanov(2002).
[120] Iova (2002).

highly-skilled people into advantage. Ireland and India are both success stories in using the opportunities of international highly-skilled mobility for building their national ICT industry. However, many other factors are necessary such as a holistic policy approach, proactive institutional support, partnerships, etc., which could contribute to the development of a country into an 'ICT Tiger'.

3.3. Summary

This chapter has highlighted some major issues related to building and preserving ICT skills in the CCs.

The formation of ICT skills starts from early school age, where most CCs show good average results. In international comparisons of educational attainments in mathematics and science they perform very well, some of them better than many EU members. Some CCs even have a pool of excellence in mathematics and informatics – two subjects which are especially important for future working life.

ICT skills have attracted policy attention in all candidate countries, and subsequently many measures have been undertaken to ensure future skilled labour and to upgrade skills of existing workers. As rapid technological change requires continuous learning from employees, ICT training and certification gain particular importance in companies' agendas and public-private collaboration. The growing participation in ICT-related courses at universities in all CCs is related to the increased labour demand. However, the supply of ICT professionals may be insufficient to fill present and expected job vacancies, and there are also signs of a lack of correspondence between skills requirements of industry and university curricula.

The process of building future highly-skilled labour is affected by some dangerous trends, such as decline of university teaching staff due to ageing and mobility. The actions taken to attract young people into university or research careers have given some results, however, the number of PhD students is far from the estimated demand for professors and researchers.

International mobility of highly-skilled professionals has affected research, universities and the ICT industry in most CCs. However, the number of 'brain-drained' is not so high (with some exceptions) as to endanger their prosperity seriously. There are also some signs that CCs are able to gain from mobility, both by attracting foreigners and obtaining benefits from their citizens abroad. It would be of benefit to them to consider mobility of the highly-skilled not as a drawback, but as an opportunity, particularly in ICTs, and to undertake appropriate actions to support the available potential for industrial growth.

4. Outlook

This paper has focused on both the demand and supply of ICT professional skills in some CCs. Many issues related to ICT labour market trends and future prospects for the formation of experienced ICT professionals have been taken into consideration. The report has confirmed the common perception of availability of highly-skilled ICT professionals in most CCs. At the same time, it has indicated increasing demand for some categories of ICT workers, whose insufficient supply may effectively slow down the dissemination of ICTs and the development of a knowledge-based economy in the CCs.

The availability of ICT professionals and scientific traditions has allowed some CCs to attract foreign investors, and develop a high-tech industry, thus creating new jobs for skilled people. In addition, the provision of good educational opportunities has encouraged inward migration of students and teaching staff, contributing further to the success of the country.

Although the topic is not fully exhausted, some issues of interest for policy and research can be indicated, with regard to the common European future:

ICT skills monitoring

The integration of CCs into the EU calls for an early assessment of the problems these countries will face in the future on the ICT labour market. The lack of reliable and comprehensive data on ICT professionals supply, demand and mobility does not allow understanding of the labour dynamics, or consideration of future requirements and policy actions. There is a need to create an internal capacity in most CCs in order to better monitor and assess the ICT labour force in all sectors of the economy. Regular monitoring and an inventory of available and generated new skills could be a foundation for the proper functioning of the whole ICT labour market and for policy adjustment. Furthermore, up-to-date information on job shortages or vacancies needs to be made available to companies and individuals in order to support the recruitment process. On-going collaboration with EU bodies will facilitate the development in CCs of internationally compatible ICT monitoring systems and integrated jobs databases. An effect of these joint efforts could be better monitoring and support of employment and mobility in the enlarged EU, as well as earlier identification of possible skills shortages.

Technology-driven or broader curricula?

A second important issue is the qualitative assessment of the available skills and their relation to company demands and educational supply. At EU level, a lot has been done on defining 'Core Generic Skills Profiles' and 'Curriculum Development Guidelines'[121]. It remains for the CCs to consider their own situatuation, to avail themselves of the existing examples of good practice and to take part in a wide European dialogue on future ICT skills demands and respective curricula.

In this respect, it should be remembered that the boundaries between IT and other jobs are diminishing rapidly. Today, the professional competence of workers requires more

[121] see Career Space (2001), Determining the future demand for ICT skills in Europe, International Co-operation Europe Ltd.

than a specific job competence. There is a need for more than just technology training or management training. It is also necessary to provide engineers and software developers with much broader skills – for teamwork, for knowledge and project management, financial assessment of business or engineering solutions, development of complex projects and using available experience, etc – as well as profound professional knowledge. Analytical thinking, creativity, ability for learning and self-development, flexibility, self-confidence – all these skills are needed to improve employment prospects of individuals in the knowledge-based economy.

Recent technology developments require education institutions to broaden curricula and implement new teaching methodologies. At the same time, company interests are focused on skills in particular technologies, thus they often support education and training at universities and schools providing the necessary equipment, or setting-up technology labs. While this collaboration is useful in the short term, technology-dependent training may be counter-productive in the long run as technologies change. This poses questions for the future of education and training: How can educational systems respond to rapid technological change and labour-force demands? What role should industry play in this process – should it be simply a supplier of technology and donations, or should it be a partner for building a technology savvy labour force?

Partnerships for growth

The complicated problems following contemporary technological trends and the corresponding skills mismatches, raise the need for a broad partnership approach. Educational institutions, policy makers and industry are making efforts to overcome existing or expected ICT skills shortages. Generally, companies have focused on short-term solutions in order to find appropriate staff or to upgrade the qualifications of the available staff when technologies change. However, medium and longer term strategies to address skills gaps are directed towards work with educational institutions and labour market bodies.

More active involvement of industrial players in the educational process in CCs could take into consideration teachers and professors needs. Another action line could be to provide assistance for developing more general technology education, especially at higher-education level and to support industry-oriented individual tasks for students, projects and summer practice. At the same time, companies could take measures to reduce internal brain-drain and overcome the dominant short-term vision when recruiting their employees. Rather than attracting researchers with higher salaries, they could involve professors in company research and innovation on a contractual basis and offer part-time jobs to students. This seems to be a more sustainable scenario for the future. Another possible option is the involvement of industrialists in teaching courses on topics related to advanced technologies and present company practice. International collaboration could be considered, too, in particular the opportunities to attract prominent guest professors and researchers in the country.

There are many not utilised opportunities in the area of public/private collaboration in CCs and governments could play a more active role in the whole process. First, they could create an environment that promotes education and training, and encourage the collaboration of public and private actors in this process. One essential action line here is the supply of state-of-the-art technology to educational institutions. In addition, more attention needs to be paid to human resources and the development (and timely update) of educational content and programmes better suited to future labour market needs.

Encouraging talents and higher achievements in education

Europe is rich in cultures and histories. A wide diversity of traditions and methodologies also exist in teaching and learning. Policy co-operation in education and training is targeted at achieving certain common strategic objectives: improving quality and effectiveness of education and training, providing education for all, ensuring compatibility of education systems and mutual recognition of qualifications and training, etc. One possible result of implementing these objectives could be the standardisation of compulsory education and training. However, this scenario would not support excellence in mathematics and science, as any common standard for schools would focus rather on the average level.

It is important, therefore, to create conditions for preserving and facilitating the development of young talent and the traditions of excellence in the CCs. A special approach for the most talented children might help. Their educational needs should be carefully considered in order to provide adequate support and create opportunities to develop their talent, as well as to connect this significant national resource with potential future employers. In a pan-European perspective, joint initiatives for organising special courses or summer camps for gifted children could contribute to exchange of experience and early connection of talented future professionals and leaders.

Educational institutions and the research centres with traditions in preparing good mathematicians and engineers also deserve special attention. At EU level, the central role of mathematics and its application in science, technology, communications, economics and numerous other fields has been acknowledged, and some practical steps are underway to strengthen mathematics education. There is also room for wide European collaboration to encourage higher student achievement in mathematics and informatics at secondary level. The CCs could contribute their experience and practice. Some professional organisations like the European Mathematical Society[122] or EICTA could also be involved in actions to support excellence in mathematics and informatics.

Strengthening candidate countries' capacities and attractiveness

The only sustainable solution to the brain-drain of highly-skilled professionals is the creation of high quality opportunities. This is already recognised at EU level and many actions are underway. In the CCs, the answer is partly seen in the ERA and the Bologna process, and the subsequent actions for strengthening research collaboration, building attractive universities, and creating a favourable environment for study, work and life in the CCs.

International exchange through EU programmes or national exchange schemes are seen as an important precondition for increasing the qualifications of professors, researchers and students, for developing European research standards in the CCs and for wide

[122] Founded in 1990 after long efforts of the European Science Foundation (started in 1976) to find ways of improving European co-operation in mathematics. Its main goals are to promote research in mathematics and its applications and to assist and advise on problems of mathematical education, http://www.emis.de/ems-general.html.

European scientific integration. The development of joint courses and degrees with EU universities and colleges could draw CC universities into the mainstream teaching activities of the EU. Today, there are many examples of East/West collaboration in research, exchange of professors and students or the setting-up of research or training labs at universities. However, it is important to go beyond the collaboration at individual or department level and to foster long-term institutional co-operation.

Such initiatives will strengthen the integration of CC universities in the European Higher Education Area. Their participation on an equal footing, however, requires some efforts to build flexible and internationally consistent higher education and training, to make it more attractive for foreign students and to enhance its competitiveness. This clearly requires support to CC efforts to create conditions for international compatibility and acceptance of degrees and qualifications and to introduce greater flexibility in learning. Making CC universities more attractive also depends on the achievement of international recognition of the quality of teaching, development of new modes of delivery including open-distance learning and expanded use of ICTs throughout the higher education.

Higher industrial integration as a tool for growth and against brain-drain

Outsourcing and production integration are considered to be possible ways to keep ICT specialists in the country or to attract them back. Some CCs with more traditional industries may be less able to develop an ICT industry. However, when a potential for ICT-based growth is available, an active and holistic policy approach can facilitate ICT industry development. Some CC governments have already taken actions to support their national ICT sector. This seems to be not only a more sustainable solution to CC brain-drain, but also to regional development problems. Therefore, it could be further explored to what extent building new ICT clusters in new and old member states could contribute to strengthening the competitiveness of the ICT industry in the enlarged EU.

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LIST OF ACRONYMS AND ABBREVIATIONS

A	Austria
ATM	Asynchronous Transfer Mode
BAIT	Bulgarian Association of Information Technologies
BG	Bulgaria
CAD/CAM	Computer Aided Design/Computer Aided Manufacturing
CC	The 13 countries Candidate Countries in process of joining the European Union: Bulgaria, the Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia, Turkey
CEEC10	The 10 Central and Eastern European Countries in process of joining the European Union
CEPIS	Council of European Professional Informatics Societies (EUCIP - EUropean Certification of Informatics Professionals)
CIO	Chief Information Officer
CID	Centre for International Development
CMM	Capability Maturity Model
CRM	Customer Relationship Management
CSDP	Certified Software Development Professional
CY	Cyprus
CZ	Czech Republic
D	Germany
EBRD	European Bank for Reconstruction and Development
EE	Estonia
EL	Greece
EITO	European Information Technology Observatory
ERP	Enterprise Resource Planning
ESIS	European Survey of the Information Society
ERA	European Research Area
ETF	European Training Foundation
EU	European Union
EU15	The present 15 member states of the European Union
FDI	Foreign direct investment
FIN	Finland
GDP	Gross Domestic Product
HSCSD	High Speed Circuit Switched Data
HTML	HyperText Markup Language
HU	Hungary
I	Italy
IBS	Internet Business Strategy
ICT	Information and Communication Technology
IDG	International Data Corporation
IEEE	Institute for Electric and Electronic Engineering
IFIP	International Federation for Information Processing
ISCED	International Standard Classification of Education
ISIS	Information Society Initiative for South-Eastern Europe
ISCO	International Standard Classification of Occupations
IPTS	Institute for Prospective Technological Studies
IS	Information Society
ISO	International Organisation for Standardisation
ISP	Internet Service Provider
IT	Information Technology
KBN	State Committee for Scientific Research – Poland (Komitet Badan Naukowych)
LV	Latvia
LT	Lithuania
NGO	Non-Governmental Organisation

MT	Malta
OECD	Organisation for Economic Co-operation and Development
P	Portugal
PISA	Programme for International Student Assessment
PL	Poland
PSTN	Public Switched Telecommunications Network
RO	Romania
R&D	Research and development
SI	Slovenia
SK	Slovakia
STAR	Socio-economic Trends Assessment for the digital Revolution
SME	Small and Medium-sized Enterprise
TIMMS	Third International Mathematics and Science Study
TK	Turkey
UN	United Nations
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UK	United Kingdom
US	United States
WAN	Wide-Area Network
WIIW	Vienna Institute for International Economic Studies

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