Investing in the Future of Jobs and Skills

Scenarios, implications and options in anticipation of future skills and knowledge needs

Sector Report
Computer, Electronic and Optical Products

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Preface

This report presents the final results of the study *Comprehensive analysis of emerging competences and economic activities in the European Union in the Computer, Electronic and Optical Products Sector*. The report is part of a series of sixteen future-oriented sector studies on innovation, skills and jobs under the same heading, commissioned by the European Commission (DG Employment, Social Affairs and Equal Opportunities). Eleven of these studies were executed by a core consortium led by TNO (Netherlands Organization for Applied Scientific Research) and consisting of TNO Innovation Policy group (Leiden, the Netherlands), TNO Labour (Hoofddorp, the Netherlands), TNO Innovation and Environment (Delft, the Netherlands, SEOR Erasmus University (Rotterdam, the Netherlands) and ZSI (Centre for Social Innovation, Vienna, Austria). The core consortium was in charge of the overall management of the study, the further elaboration and application of the overall approach and methodology, as well as data collection and analysis. This study on future skills and jobs in the Computer, Electronic and Optical Products Sector has been executed by core team staff (see Annex 1 for team composition).

The study was carried out during the period January 2008-May 2009. Stakeholders in the sector, including the European sectoral partners and representatives of various other organisations, have been involved in various ways and forms throughout the study. This included a sectoral kick-off meeting at the start of the study and three multisectoral stakeholder meetings in Brussels during which intermediate results of the studies were presented and discussed. Valuable workshop discussions in the frame of the project were held and inputs received from a number of experts. Apart from multiple inspiring consortium ('internal') workshops, two main 'external' workshops were held. We would like to thank S. de Munck (TNO), P. de Jager (TNO), Professor P. Schelkens (Vrije Universiteit Brussels) and Th. Martens (Philips Corporate Technologies) for their participation in a first external workshop in Delft on scenarios and their implications in September 2008.

A draft final version of this report was validated and complemented during a second external, final workshop in Brussels on 20 and 21 November 2008. The final workshop brought together an apt mixture of different European and national sector experts representing the industry, European social partners, other various representative organizations, academia as well as the European Commission (see Annex 2 for a full list of participants). The workshop, which formed an explicit and integral part of the methodological approach, yielded a number of helpful comments and insights which have been used in further finalising the study. We express our sincere gratitude to all workshop participants and to all those that contributed to this study.

A special word of thanks holds for the European Commission, notably Jean-François Lebrun and Manuel Hubert, and Radek Owczarzak of the European Foundation for the Improvement of Living and Working Conditions, who proved to be excellent guides during the project.

Delft, 1 May 2009
Dr Frans A. van der Zee (overall project leader)

1 General introduction

This report presents the final results of the study *Comprehensive analysis of emerging competences and economic activities in the European Union in the Computer, Electronic and Optical Products Sector*. The report is part of a series of sixteen future-oriented sector studies on innovation, skills and jobs under the same heading, commissioned by the European Commission (DG Employment, Social Affairs and Equal Opportunities). The study was executed by a consortium led by TNO (Netherlands Organization for Applied Scientific Research) and consisting of TNO, SEOR – a consultancy of Erasmus University (Rotterdam, the Netherlands) and ZSI (Centre for Social Innovation, Vienna, Austria). The study was carried out during the period January 2008-May 2009.

While the main focus of the study is on the future of skills and jobs by 2020, the study is both backward- and forward-looking in nature. It analyses recent relevant sector developments and trends and, at the same time, depicts the current state of play in the sector with an emphasis on innovation, skills and jobs. Current trends and developments form the stepping stone and fundament for the second and third future-oriented part of the study which is scenario-based, forward-looking and exploratory in nature.

Background and context

The study should be placed against the background of the EU's renewed Lisbon strategy in which securing and improving EU competitiveness and redeploying the European economy to new activities with more value-added and new and better jobs are key. In the process of change and restructuring to adapt to new realities, there is a need for a more strategic management of human resources, encouraging a more dynamic and future-oriented interaction between labour supply and demand. Without there is the risk that bigger shortages, gaps and mismatches of skills will result not only in structural unemployment but also hamper longer-term competitiveness.

Skills and jobs are of vital importance for the future of the European economy and have recently gained increasing attention, both at national and EU level. As stressed by the European Council in March 2008, investing in people and modernising labour markets is one of the four priority areas of the Lisbon Strategy for Growth and Jobs. The New Skills for New Jobs initiative launched in December 2008 (European Commission, 2008) elaborates on how this could best be done. The initiative aims to enhance human capital and promote employability by upgrading skills, as well as to ensure a better match between the supply of skills and labour market demand. More transparent information on labour market trends and skills requirements, but also the removal of obstacles to the free movement of workers in the EU, including administrative barriers would help achieve this goal, and improve occupational, sector and geographical mobility. The initiative also stresses the need to improve the Union's capacity for skills assessment (by improved monitoring and forecasting), anticipation (by better orientating skills development) and matching with existing vacancies. The current financial and economic crisis makes these challenges even more pressing. Further strengthening the economic resilience and flexibility of the European economy and its Member States calls, along with other measures, for support of employment and further facilitation of labour market transitions (European Commission, 2008a:10).

Approach and methodology

The study takes a longer term future perspective, and looks ahead to 2020, but also back, and takes a highly aggregated European perspective. While it is fully acknowledged that more detailed Member State and regional analyses are important and vitally important for anticipating future skills and knowledge needs, the European perspective has been central in this analysis. Key to the study and a common point of departure was the use of a pre-defined methodological framework on innovation, skills and jobs (Rodrigues, 2007). During the course of this study this framework has been further developed, operationalised and applied to the sector. The approach combined desk research and expert knowledge available in a broad and dedicated research team with the knowledge and expertise of 'external' sector experts. The purpose of this *common uniform methodology* is to deliver results that enable comparisons across and between sectors and hence enable the preparation of possible future actions to investigate the topic of new future jobs and skills for Europe, by encouraging a more effective interaction between innovation, skills development and jobs creation. The methodology is structured along various steps, each step providing inputs and insights for next steps to come. Overall, the methodology covers the following steps:

Step 1. Identification of economic activities to be considered (i.e. sector selection)

Step 2. Main economic and employment trends and structures by sector

Step 3. Main drivers of change

Step 4. Main scenarios

Step 5. Main implications for employment – changes by job function

Step 6. Main implications for skills – emerging needs by job function

Step 7. Main strategic choices to meet future skills and knowledge needs

Step 8. Main implications for education and training

Step 9. Main recommendations

Step 10. Final Workshop.

Further and next steps

The results of this study – along with 15 other sector studies using the same approach and being released at the same time - will serve as a guide in launching further EU-led but also other actions, by industry, sectoral partners, education and training institutes and others. One important aim of the study is to promote the strategic management of human resources and to foster stronger synergies between innovation, skills and jobs in the sector in the medium and longer run, taking into account the global context and encouraging adaptations to national and regional specificities. A very important element in further enabling and facilitating these goals is sound and continuous monitoring together with a uniform and consistent way of analysing future skills and knowledge needs for the various decision-making levels involved. The approach taken in this study aims to provide a broader framework that does exactly this. Further dissemination and explanation of the methodology at the Member State, regional and local level are therefore vital in the follow-up of this EU level study, as is its actual take-up. The results of the study include implications, conclusions and recommendations to anticipate future skills and knowledge needs. It does not in any way, however, assess or evaluate current

or planned policies. Conclusions and recommendations may therefore coincide but may also oppose current policies and/or policy plans at the EU, national or regional level. The implications, conclusions and recommendations logically follow from scenarios – credible plausible sector futures – meant to better structure and anticipate possible future developments.

Looking ahead in times of crisis

Even though the year 2020 may currently seem far off for most of us, the future will announce itself earlier than we think. In times of financial and economic crisis there is a logical tendency to focus on the now and tomorrow; withstanding and surviving the crisis are prime. Nevertheless, at the same time the medium and longer term ask for adequate attention. In this current age of continuing and pervasive globalisation, strong technological change and innovation affecting production and consumption around the globe, timely preparations to be able meet future skills and job needs are called for more than ever before. This is even more true in the face of an ageing European society and ditto workforce.

Contents in three parts

The report consists of three main parts. Part I analyses recent relevant sector developments and trends and depicts the current state of play in the sector, with an emphasis on innovation, skills and jobs. The findings of Part I of the report combine original data analysis using Eurostat structural business statistics and labour force survey data with results from an extensive literature review of relevant already existing studies. While giving a clear and concise overview of the most important trends and developments, the prime function of Part I is to provide the fundaments and building blocks for Part II of the study. The findings of Part I are based on the present and the recent past. The second part of the report is future-oriented and looks at sectoral developments and more specifically developments in skills and jobs in and towards 2020. The core of part II consists of plausible future scenarios and their implications for jobs, skills and knowledge. These implications have been analysed for various job functions. In a final part III, a range of main strategic options ('choices') to meet the future skills and knowledge needs is reviewed, including implications for education and training. The study concludes with a number of recommendations for the sector (individual firms, sector organizations, sectoral partners), education and training institutes and intermediary organisations, and last but not least, policy-makers at various levels, ranging from the EU to the local level. Terminology used in this report is further explained and defined in a Glossary at the end of this report.

Part I

Trends, Developments and State-of-Play

Part I. Trends, Developments and State-of-Play

Guide to the reader

Part I presents the results of steps 1, 2 and 3 of the common methodology applied to the computer, electronics and optical products sector. Step 1 delineates and defines the sector. Step 2 presents the main economic and employment trends and developments in the sector (mapping) and reports the results of a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis. Step 3 analyses the main drivers of change of relevance for the sector based on a meta-driver approach and expert opinion. Part I of the report consists of 8 chapters. Chapter 2 identifies and statistically defines the sector. Chapter 3 provides an overview of the structural characteristics of the sector, including developments and trends in employment, production and value added. It contains information on work organisation (part-time/full-time, gender, age), and industrial relations, but also on emergent trends by function. It also addresses existing partnerships for innovation, skills and jobs, one of the possible policy instruments to better prepare for and adapt to the future, facilitate mutual learning and boost innovative capacity both at the sector and firm level. While not part of the methodology as such, partnerships form an interesting example of how the development of skills and jobs can be linked to innovation. Chapter 4 discusses the value chain (network) and its evolution over time, including issues of restructuring and relocation. Chapter 5 focuses on innovation, R&D and technological change, while chapter 6 analyses the impact of globalisation and trade on and for the sector. Chapter 7 highlights the importance of regulation especially in relation to employment. Chapter 8 provides the results of a SWOT analysis of the sector. Chapter 9 concludes with an overview of the most important drivers for the sector.

2 Defining the sector

The computer, electronic and optical products sectors are in the NACE Rev 1.1 classification defined as *D Manufacture of electrical and optical equipment*. This classification distinguishes four sub-sectors (see Table 2.1) One of these four sub-sectors, the manufacture of electrical machinery and apparatus n.e.c. (NACE 31), falls beyond the subject of this study and is therefore not included in this report. The NACE Rev 1.1 classification does not really reflect the current situation in the sector, with on the hand companies focusing on the design and production of components and on the other hand companies active in the design and the production of the end products. The electronic components manufacturers - producing Integrated Circuits and other components - can be regarded as the suppliers of the other. NACE Rev 2 – introduced in 2008 and gradually taking effect - concerns the most recent statistical reclassification, and reflects, apart from statistical revisions, also some of the structural developments in industry structure at aggregate level. NACE Rev 2 is more distinctive as to the different constituent elements of the industry than the former Rev 1.1 classification. It also includes, for instance, relatively new industries such as the electronic games hardware (i.e. game computers). Data collection under NACE Rev 2 has only started since January 2008; no data series are available as yet. Since the contents of this report relate to trends and the report is predominantly backward-looking in nature, based on time series, most of the statistical analyses take the previous classification Rev 1.1 as their point of departure. Hence, the quantitative part of the sector analysis will follow the NACE classification Rev 1.1. However, where relevant and possible, the qualitative analysis will follow as much as possible the distinction between (i) electronic components, (ii) computers, communication equipment and consumer electronics, and (iii) medical, optical and measurement products The following Table 2.1 shows the classification of the sector according to NACE Rev 1.1 and NACE Rev 2.

Table 2.1 Statistical classification computer, electronic and optical products sector

	NACE Rev 1.1	***NACE Rev 2***
Electronic components	32.1 Manufacture of electronic valves and tubes and other electronic components	26.1 Manufacture of electronic components and boards
Computers, communication equipment and consumer electronics	30.0 Manufacture of office machinery and computers 32.2 Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy 32.3 Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods	26.2 Manufacture of computers and peripheral equipment 26.3 Manufacture of communication equipment 26.4 Manufacture of consumer electronics
Medical, optical and measurement devices	33.1 Manufacture of medical and surgical equipment and orthopaedic appliances 33.2 Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment 33.3 Manufacture of industrial process control equipment 33.4 Manufacture of optical instruments and photographic equipment 33.5 Manufacture of watches and clocks	26.5 Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks 26.6 Manufacture of irradiation, electro medical and electrotherapeutic equipment 26.7 Manufacture of optical instruments and photographic equipment 26.8 Manufacture of magnetic and optical media

Source: Eurostat (2007b)

3 Structural characteristics of the sector: past and present

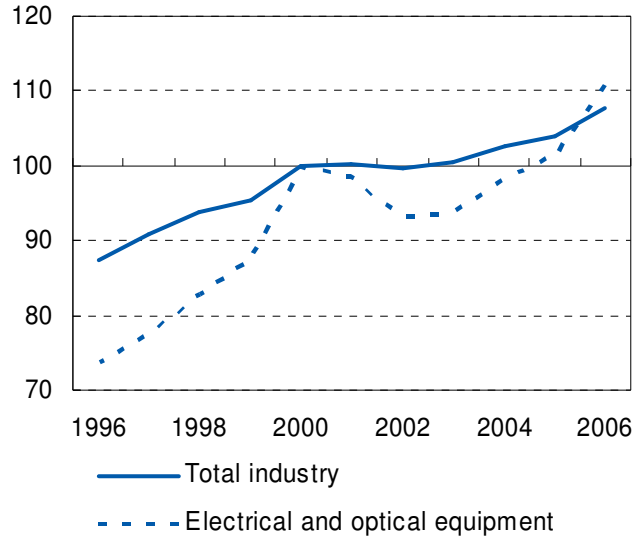
3.1 Production, value-added and employment trends in the EU

The computer, electronic and optical products sector accounted for 134,264 enterprises in the EU-27 in 2005, employing over two million persons. Total turnover in the computer, electronic and optical products sector amounted to EUR 405 billion in 2005, with the consumer electronics being the largest sector representing 51%, and electronic components and medical, optical and measurement devices accounting for 14% and 35%, respectively (Eurostat, 2008). The computer, electronic and optical products industries generated EUR 154 billion of value added, which is equivalent to 1.34 % of EU GDP in 2006 (see Table 3.1).

Trends in production

During the last ten years, EU-27 production of computers, electronic and optical products has risen steadily until 2006 and followed – at some distance - the economic cycle for industrial output as a whole (Figure 3.1). The average annual growth rate between 1996 and 2006 was 4.2% and surpasses the average growth of the total industry in 2005-2006. The main contributor to this growth rate was the radio, television and communication equipment manufacturing (NACE 32) (Eurostat, 2007a).

Figure 3.1 Index of production electrical and optical equipment compared to total industry EU-27, 1996-2006 (2000=100)



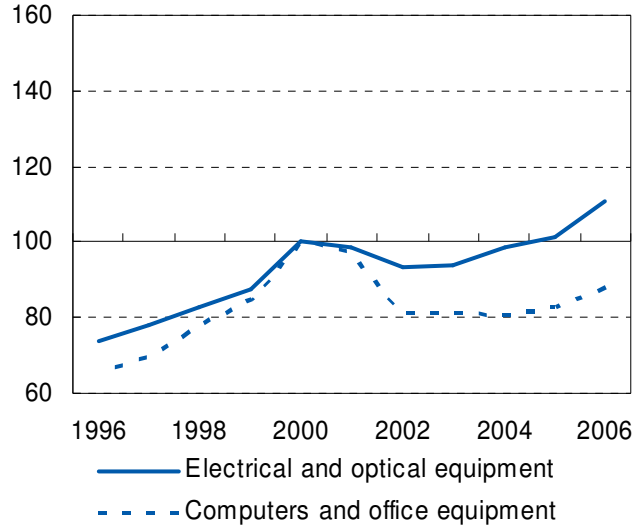
Source: Eurostat, 2007a

The largest producer of computer, electronic and optical products in the EU-27 is Germany, followed by France, the United Kingdom, and Italy. Together, these four countries represent 61% of the EU production in the sector in 2004. Germany is also the largest producer in the various sub-sectors. However, Ireland is the main producing country in the computers manufacturing. From the new Member States, Hungary is the biggest producer, followed at some distance by the Czech Republic and Poland (Eurostat, 2007a).

Over the years 1996-2006, production growth in the computer manufacturing sector (NACE 30) has followed the growth trend as observed for the sector as a whole, although in 2002

there was a stronger downturn in production than in average for the sector as a whole (see Figure 3.2). Since then, growth in production has been lagging behind (Eurostat, 2007a).

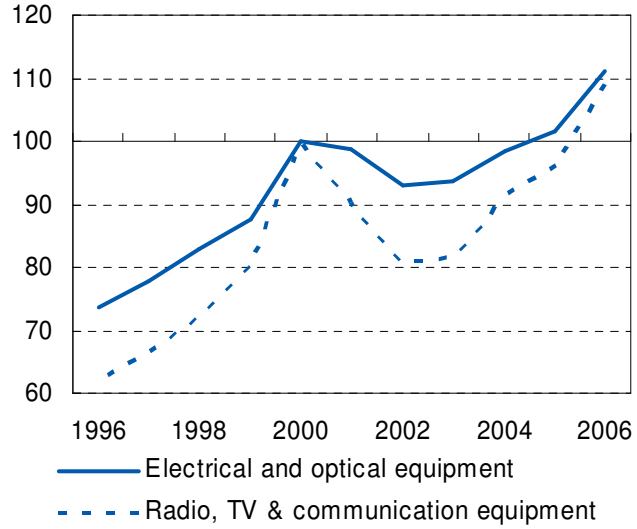
Figure 3.2 Index of production computers and office equipment compared to electrical and optical equipment manufacturing EU-27, 1996-2006 (2000=100)



Source: Eurostat, 2007a

Production growth in the radio, television and communication equipment sector (NACE 32) followed the same growth pattern as observed for the sector as a whole, yet more positive and more upward-bound (see Figure 3.3). Growth in the periods 1996-2000 and 2003-2006 was stronger than for the sector as a whole, but the downturn in the period 2000-2003 was much sharper than the overall sector average (Eurostat, 2007a).

Figure 3.3 Index of production radio, television and communication equipment compared to electrical and optical equipment manufacturing EU-27, 1996-2006 (2000=100)

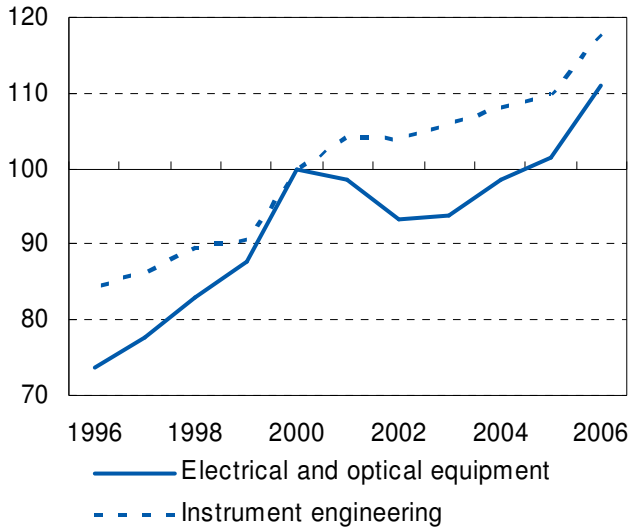


Source: Eurostat, 2007a

Production in the optical products sector (NACE 33) grew steadily over the period 1996-2006 and performed better than the industry as a whole (see Figure 3.4). The optical products

sector did not experience the downturn in production in the 'bubble-burst' period 2000-2003 that hit the rest of the sector. Main contributors to the growth in production were the medical and surgical equipment (NACE 33.1) and the measuring instruments sub-sectors (NACE 33.2) (Eurostat, 2007c).

Figure 3.4 Index of optical products manufacturing compared to electrical and optical equipment manufacturing EU-27, 1996-2006 (2000=100)



Source: Eurostat, 2007a

Trends in value added

In terms of value added performance, the computer, electronic and optical products sector in the EU has been outperforming the overall economy (i.e. all other sectors) by large. With growth levels in the 1995-2000 period of more than 9% annually and almost 13% in the new Member States, growth in the industry overall has been vigorous. Even after the bubble burst in the beginning of the century, growth has been stronger than for the economy as a whole, with 3.4% in the EU-15 and 7.8% in the new Member States[1].

[1] Note that due to missing data the EU is an approximation of the EU-27 only. GDP and trade data was not available for Bulgaria, Romania, Cyprus, Malta and Latvia. Cyprus and Malta lacked data on employment. This applies to tables 3.2 and following. The list of winning, losing momentum, upcoming, retreating (see subsequent tables in text) indicates for which countries data was available. Throughout this report, a change in volume or absolute number between two years - e.g. the number of jobs - is measured as the *average annual growth*. Similarly, a change of a share or an index is measured as *total change* over the entire period. That is, if the share in 2000 was 10% and in 2006 15%, we report a change of share of 5%.

Table 3.1 Value added computer, electronic and optical products industries, 1995-2006

	Computer, electronic and optical products industries				*Overall economy*			
	2006	**95-00**	**00-06**	**95-06**	**2006**	**95-00**	**00-06**	**95-06**
		%	%	%		%	%	%
EU	154 235	9.2	3.6	6.1	11 468 970	2.8	2.0	2.3
EU-15	147 240	9.1	3.4	6.0	10 883 245	2.8	1.9	2.3
NMS	6 995	12.8	7.8	10.0	585 725	2.7	3.7	3.2
Winning	69 814	12.3	8.6	10.3	3 260 306	2.2	1.6	1.9
Losing momentum	10 960	6.9	-3.0	1.4	435 178	4.9	3.4	4.1
Upcoming	27 261	18.9	8.2	12.9	1 992 038	2.5	1.8	2.1
Retreating	46 047	5.5	-2.1	1.3	5 747 595	3.0	2.1	2.5

	Value added Million euro	Annual average growth			GDP Million euro	Annual average growth		
	2006	1995-2000	2000-2006	1995-2006	2006	1995-2000	2000-2006	1995-2006

	Concentration index >100	**Concentration index <100**
Growth	***Winning:*** Germany, Denmark, Finland, Sweden, Czech Republic, Hungary, Slovenia	***Upcoming:*** France, Portugal, Slovakia
Decline	***Losing momentum:*** Austria, Ireland	***Retreating:*** Belgium, Italy, Netherlands, Greece, Spain, United Kingdom, Estonia, Lithuania, Poland

Source: Eurostat/TNO

Box 1. Concentration index: what it is and what it measures

The concentration index assesses the relative contribution of a specific sector to the national economy compared to a greater entity, such as the EU, thereby correcting for the size of the country. In more general terms, the concentration index is a measure of comparative advantage, with changes over time revealing changes in the production structure of a country. An increase of the concentration index for a sector signifies relatively fast growth of that particular sector in the country concerned compared to the same sector in the EU.

How does the concentration index work in practice? We'll give a few examples: if sector x represents a 5% share of the German economy and a 5% share of the EU economy, the concentration index of sector x equals a 100. If sector x represents 5% of the German economy, but 10% of the EU economy, the concentration index of sector x is 50. If the same sector x represents 10% of the German economy and 5% of the EU economy, the concentration index of sector x is 200.

The concentration index concept can be applied using different indicators (variables). In our study we measure the concentration index using employment, value added and trade, in order to make a distinction between the relative performance of countries EU-wide. We distinguish between four country groupings, each signifying a different sector performance over time. If a sector in a country has a strong position (hence showing a concentration index higher than 100) and has experienced a clear index growth over the last years, the sector is defined as *winning* in that country. If the sector has a strong position, but experienced a decline of the concentration index, we say the sector is *losing momentum*. If the sector has a weak position, but gained in the past, we say that the sector in that country is *upcoming*. If the sector has a weak position and experienced a decline of the index, we say that the sector is *retreating*.

If we take a look at which countries have been real winners in terms of sector value added growth, these include Germany, the Czech Republic and Hungary, Finland, Sweden and others. This group of winners scores relatively low on overall GDP growth, however. The group of retreaters is the largest group of countries and includes countries such as the UK, the Netherlands, Belgium, and a number of new Member States.

Table 3.3 shows that the group of winning countries makes up 44% of all value added in the EU (and showing high growth!), and the upcoming countries another 16%, together accounting for 60% of total sector value added in the EU. At the other extreme, the retreating countries make up for another 32% in share, and are heavily loosing (a 17% decline).

Table 3.2 Value added computer, electronic and optical products by sub-sector, 1995-2006

	NACE 30, 32, 33	*NACE 30*	*NACE 32*	*NACE 33*
	Levels 2006			
EU	154 235	13 976	71 796	68 463
EU-15	147 240	13 551	67 461	66 228
NMS	6 995	425	4 335	2 235
	Changes 2000-2006			
EU	3.6	-5.0	3.2	6.6
EU-15	3.4	-4.7	2.7	6.7
NMS	7.8	-10.8	14.8	4.4
	Changes 1995-2006			
EU	6.1	-1.1	7.1	7.6
EU-15	6.0	-1.0	6.7	7.6
NMS	10.0	-3.5	18.2	6.4

Source: Eurostat/TNO

Analysis of value added developments at the sub-sector level reveals sizeable differences. Striking is the deterioration in value added in the office equipment and computer manufacturing industry over the period 1995-2006. Both other sub-sectors performed comparatively well. The audio, video and telecoms manufacturing industry did particularly well in the new Member States, showing an average annual growth of 14.8% during 2000-2006 and 18.2% during1995-2006. The medical and optical equipment sub-sector also developed positively in both periods, especially so in the EU-15. France, Luxembourg, Sweden, Lithuania, the Czech Republic, Hungary and Finland did particularly well in the overall period 1995-2006, with annual growth rates of 12 to 21 per cent. In audio, video and telecoms manufacturing strong growers were Hungary (30.2%), Sweden (29.7%), and Finland (25.2%), followed by the Czech Republic (21.8%), France (15.9%) and Poland (14.4%). In the most recent period Sweden, the Czech Republic, Hungary, Denmark and Finland still showed strong growth, even though below 20%. Strong decreases were observed in the Netherlands (-14.8% annually during the period 2000-2006), Ireland (-10.4%), the UK (-9.8%) and Belgium (-8.1%).

Table 3.3 Value added computer, electronic and optical products industries, 1995-2006

	Share in country		*Share in EU*	
	Level	**Change**	**Level**	**Change**
EU	100	0	100	0
EU-15	95	-1	101	-1
NMS	5	1	90	18
Winning	44	15	156	57
Losing momentum	8	-4	207	-158
Upcoming	16	6	89	35
Retreating	32	-17	64	-36
	Share in national GDP	Total change in share	Share in value added sector EU	Total change in share
Definition	2006	1995-2006	2006	1995-2006

Source: Eurostat/TNO. Explanatory note: *defined as share in country divided by share in EU, times 100.

Trends in employment

The computer, electronic and optical products sector in the EU employs over two million persons, most of whom are based in the 'old' EU-15. Employment has been decreasing on average by 1.7% annually over the period 1995-2006. Yet in the new Member States employment has been steadily rising, with a growth of 1.6% annually.

Table 3.4 Employment computer, electronic and optical products industries, 2000-2006

	Level 2006	*Annual growth*	*Share in EU*	*Change in share*
EU	2 058 232	-1.7	100	0
EU-15	1 685 365	-2.3	82	-4
NMS	372 866	1.6	18	4
Winning	714 458	2.1	35	8
Losing momentum	197 344	-4.6	10	-2
Upcoming	71 253	1.7	3	1
Retreating	1 075 176	-4.0	52	-7

	Concentration index >100	**Concentration index <100**
Growth	***Winning:*** Germany, Czech Republic, Hungary	***Upcoming:*** Finland, Latvia, Lithuania
Decline	***Losing momentum:*** Netherlands, Ireland, Sweden, Bulgaria, Slovenia, Slovakia	***Retreating:*** Belgium, France, Italy, Luxembourg, Denmark Greece, Spain, Austria, Portugal, United Kingdom, Estonia, Poland, Romania

Source: Eurostat/TNO

When we take a closer look and try to group countries in accordance with their *employment performance* (taking together both employment growth and the concentration index, see glossary), we observe a group of winners consisting of Germany, the Czech Republic and Hungary, a group of upcoming countries including Finland, Latvia and Lithuania and groups of countries that show declining employment performance. Most of the EU Member States, both old and new, find themselves in one of the latter categories, with most being ranked in the least performing group of retreaters. Note that employment as a single indicator does not imply much about the economic performance of the sector as such. This changes when

combined with data on value added changes. For example, Lithuania now finds itself in the group of upcoming countries, whereas under value added Lithuania was ranked as retreating, clearly not a good sign when taken together, signifying a decreasing labour productivity over time.

Table 3.5 Employment computer, electronic and optical products by sub-sector, 2000-2006

	NACE 30, 32, 33	NACE 30	NACE 32	NACE 33
	Levels 2006			
EU	2 058 232	150 429	814 118	1 093 685
EU-15	1 685 365	117 277	634 077	934 012
NMS	372 866	33 152	180 041	159 673
	Changes 2000-2006			
EU	-1.7	-7.3	-3.6	1.0
EU-15	-2.3	-9.0	-4.8	1.0
NMS	1.6	1.7	1.6	1.6

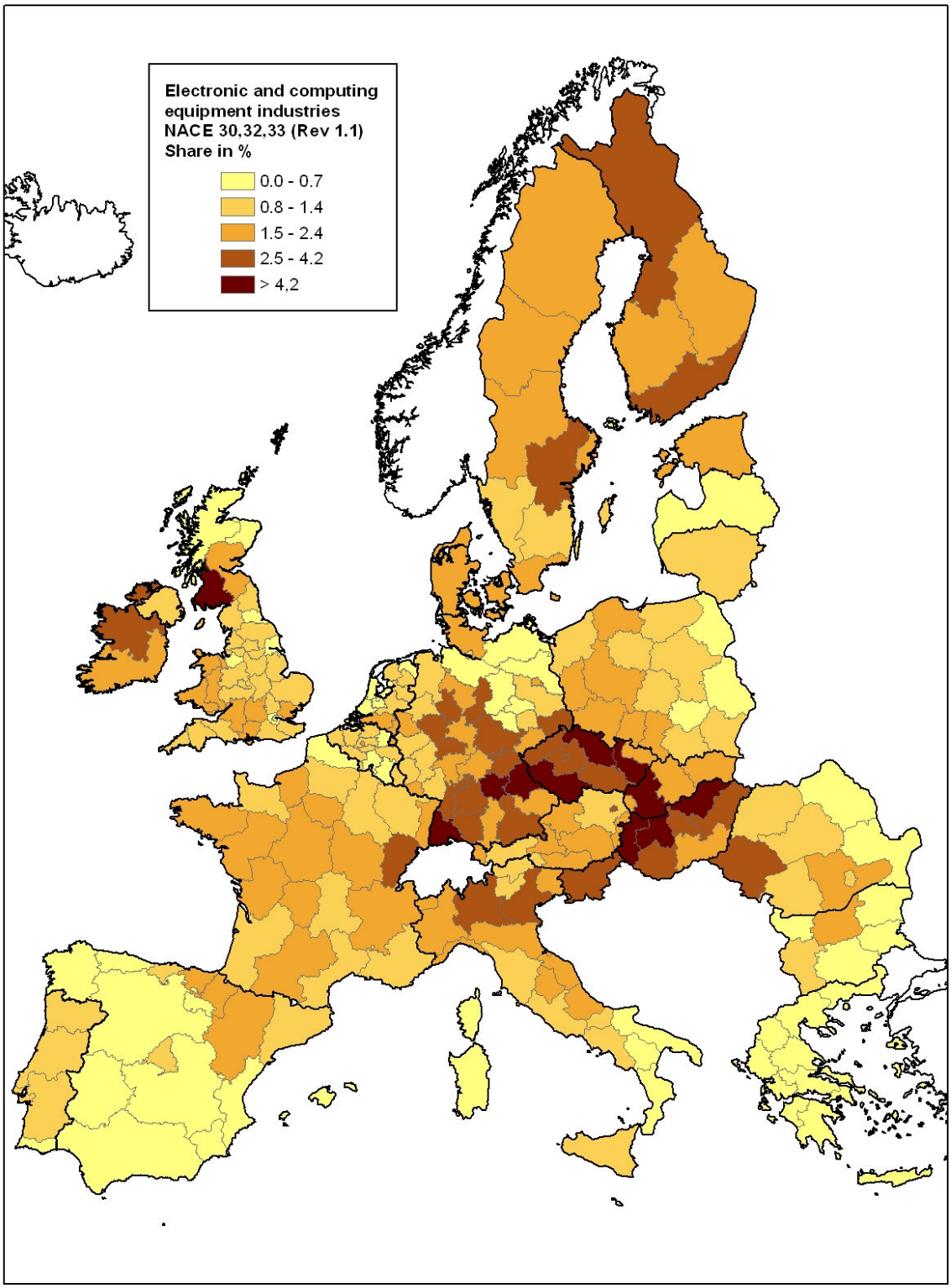
Source: Eurostat/TNO

Looking at employment in the different sub-sectors, i.e. office equipment and computer manufacturing (NACE 30), audio, video and telecoms manufacturing (NACE 32) and medical and precision instruments manufacturing (NACE 33), it is clear that more than half of employment is in the medical and precision instruments industry, which is also the only sector with a light increase in employment over time, both in the old and new Member States.

The audio, video and telecoms manufacturing industry and - especially - the office equipment and computer manufacturing industry show significant employment losses, of 3.6 and 7.3 per cent annually, respectively. This decline has predominantly taken place in the EU-15 (4.8 and 9 per cent, respectively). The declines are certainly not restricted to the EU-15 though, with for instance Hungary and Poland showing steep decreases in employment in office equipment and computer manufacturing (-15.8% and -13.5% annually, respectively). Steep increases at the other end do, however, also occur, such as in the Czech Republic (+26.6%) and Estonia (+16.2%). Also Austria (+22.8%), Portugal (+14.9%) and Greece (+10.6%) belong to the strong gainers. Whereas Austria is a retreater when looking at its *overall* employment performance, this does not hold for the office equipment and computer manufacturing sector.

In audio, video and telecoms manufacturing country differences in employment are almost as distinct, despite the less strong changes at overall EU level. The UK, Ireland, the Netherlands and Denmark faced a decrease of 12-13% annually, and Greece even of 21%. Increases in employment were far less spectacular, the front-runner being the Czech Republic, followed by Hungary (5.4%). Employment developments in medical and precision instruments manufacturing have been less pronounced, both overall and on an individual country basis, with notable exceptions being Ireland (+5.8%), the Czech Republic (+4.6%), Latvia (+6.3%) and Hungary (+6.9%), and in the negative Estonia (-24.4%) (all annual changes).

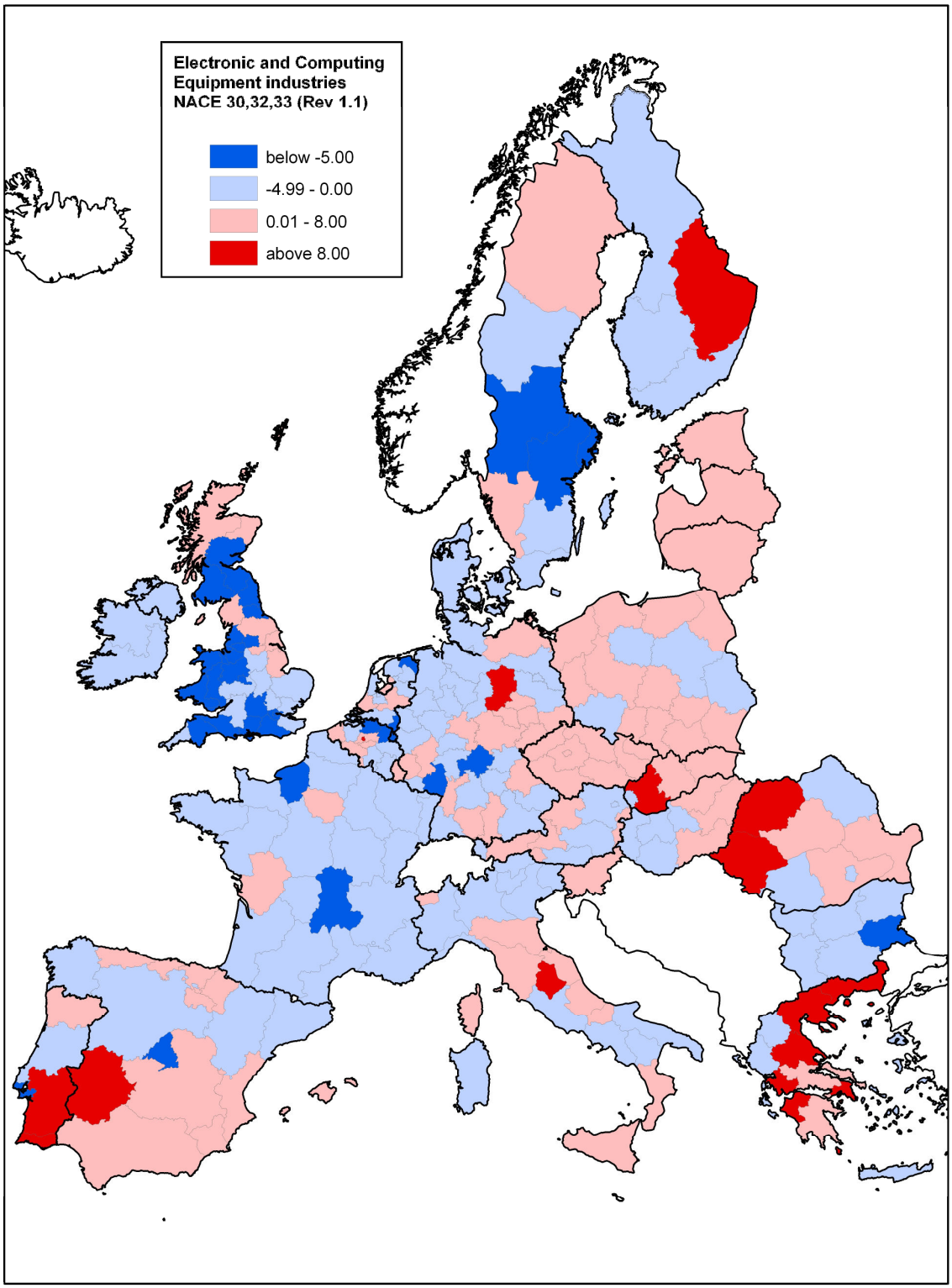
Figure 3.5 Vertical shares: employment in the computer, electronic and optical products sector in total employment by NUTS 2 region, 2006



Regional specialisation in employment in the computer, electronic and optical products sector is shown in Figure 3.5. What is clearly shown is that the sector is an important employer in many regions in Europe. The most specialised regions in 2007 can be found in Central Europe. Other regions that are highly specialised are located in Western Scotland, Finland, Ireland and Sweden.

In addition to regional specialisation patterns as revealed in 2006, Figure 3.6 shows the annual changes in regional employment in the computer, electronic and optical products sector over the period 1995-2006. Growth is observed in several regions in Spain, Italy, Greece, the UK, but also in many new Member States. Strong growth is shown in most of the eastern new Member States, the eastern part of Finland, certain regions in Germany, Italy and Slovakia, southern Portugal and its neighbouring region in Spain, western Romania, as well as several regions in Greece. Most countries that host growth regions also have regions in decline. A decline in employment can be observed in France, Finland, Ireland, Denmark, the western part of Germany, a large part of the UK, and in several parts of Italy, Spain, Austria, Hungary, Poland, Romania, Bulgaria and Sweden. The sharpest decline is shown in the UK, the Netherlands, Belgium, France and Germany, as well as Sweden and Bulgaria.

Figure 3.6 Employment changes in the computer, electronic and optical products sector by region, 1999-2006 (% per annum)



3.2 Value added and employment EU compared to US, Japan and BRICS

Europe's traditional competitors, the United States and Japan, faced strong declines in employment during the period 1995-2005 as is shown in Table 3.6. Declines were also observed in Europe, but only modestly so, except for the consumer electronics sector. But also here the decline was with 29% less pronounced than in the US (-51%) and Japan (-36%). Overall the EU-15[2] faced a decrease of 4.6% in employment for the sector as a whole, both the United States and Japan show a much stronger decline of over 30%. In the medical, optical and measurement devices sector Europe even showed an increase in employment of 8.5%, with the United States and Japan lost substantially (11% and 26%, respectively). In terms of the share of the sector in total manufacturing employment, Europe experienced a slight decrease of 0.4 percentage point to a share of 10.3%, against decreases of 2.2% and 1.7% in the US and Japan (share 12.6% and 16.5%, respectively).

Not only in employment, but also in growth of value added Europe outperformed the United States and Japan. Here Europe faced a growth of 62%, against a loss of 24% in Japan and 7.5% in the United States. The only sector in the US that showed a positive growth pattern over this period was the optical products sector (23%); yet growth in Europe in this sector was 9 times as high (208%). In the difficult consumer electronics sectors, the EU-15 showed a positive growth of 32% over this period, while the US and Japan showed substantial losses (-12.5% and -26%, respectively). In terms of value added growth per employee, Europe was outperformed by the US, except for the medical, optical and measurement devices segment. Also here strong increases were observed: 184% growth in Europe, against 39% in the US and 13% only in Japan. The strongest looser in all three regions in terms of employment as well as value added was consumer electronics.

However, when we compare the performance of Europe with the performance of the emerging BRIC economies (i.e. Brazil, Russia, India and China), the picture is much different (see Table 3.7). While Europe experienced an overall decrease in employment, Brazil, Russia and China showed strong increases in employment in the same period, the only exception being India. While Russia increased its employment especially in the electronic components sector, Brazil improved mainly in the optical products sector. The rise of China is especially remarkable with employment growing approximately from 3m to 8m between 1995 and 2005. Unfortunately no figures were available for China at the sub-sector level.

Value added grew substantially in China (+651%) and in Russia (+189%). Value added growth was comparatively modest in India (+24%), and negative in Brazil (-2.4%). This also held for the value added per employee (-10.6%), where both Russia and India faced substantial increases (+65% and 37%, respectively). Growth in value added per employee was stronger than the growth in employment, indicating productivity gains.

Most pronounced growth in Brazil occurred in the medical, optical and measurement devices sector, with employment and value added growing with 26% and 21%, respectively. In Russia the electronic components sector showed the most significant rise in employment (49%), with a sizeable increase in value added (169%), though even higher in the medical, optical and measurement devices sector (273%). The latter, however, showed only a modest

[2] Note that the figures in Table 3.6 have been taken from UNIDO and cannot be compared on a one-to-one basis with other figures in this report. No data were available for EU-25 and EU-27. For reasons of comparability, the UNIDO data have been unchanged.

rise of 4.5% in employment. India also witnessed a strong growth in value added in this sector (72%), yet with a loss of employment (-19%).

Table 3.6 Trends in employment and value added – EU-15, USA and Japan, 1995-2005 [1]

	Employment growth (in %)	*Change in share of employment manufacturing total (in %)*	*Value added growth (in %)*	*Change in value added share (in %)*	*Value added growth per employee (in %)*
Europe (EU-15)	-4.6	-0.4	62.1	2.8	69.9
Electronic components[2]	-1.1	0.0	31.9	0.1	33.4
Consumer Electronics[3]	-28.6	-0.7	-7.3	-0.9	29.9
Medical, Optical and Measurement devices[4]	8.5	0.3	207.8	3.6	183.7
United States[6]	-31.2	-2.18	-7.5	-3.2	34.3
Electronic components[2]	-35.7	-1.35	-12.5	-1.73	36.1
Consumer Electronics[3]	-51.3	-1.31	-31.1	-1.98	41.5
Medical, Optical and Measurement devices[4]	-11.3	0.48	23.2	0.51	38.9
Japan	-32.6	-1.71	-24.2	0.13	12.5
Electronic components[2]	-31.7	-0.68	-25.8	-0.1	8.7
Consumer Electronics[3]	-36.1	-1.01	-25.0	-0.02	17.3
Medical, Optical and Measurement devices[4]	-26.1	-0.02	-16.3	0.25	13.3

Source: TNO Research, based on data of UNIDO (ISIC Rev. 3)

[1] EU-15: 1995-2004 (Except France: 1996-200; Germany: 1998-2004; Greece: 1995-1998; Luxembourg: 1995-2003; Portugal: 1996-2004), Data for Europe (EU-15) is composed from data individual EU-15 countries ; USA: 1997-2004; Japan: 1995-2004

[2] Electronic Components comprises: 'Electric motors, generators and transformers' (ISIC 3110), 'Electricity distribution & control apparatus' (ISIC 3120), 'Insulated wire and cable' (ISIC 3130), 'Other electrical equipment n.e.c'. (ISIC 3190) and 'Electronic valves, tubes, etc.' (ISIC 3210)

[3] Consumer Electronics comprises: 'Office, accounting and computing machinery' (ISIC 3000), 'TV/radio transmitters; line communication apparatus' (ISIC 3220) and 'TV and radio receivers and associated goods' (ISIC 3230)

[4-] Medical, Optical and Measurement devices comprises: 'Medical, measuring, testing appliances, etc.' (ISIC 331), 'Optical instruments & photographic equipment' (ISIC 3320) and 'Watches and clocks' (ISIC 3330)

[6] USA:'Total' and 'Medical, Optical and Measurement devices' do not contain data on 'Watches and Clocks' (ISIC 3330)

Table 3.7 Trends in employment and value added - BRICs[5], 1995-2005

	Employment growth (in %)	*Change in share of employment manufacturing total (in %)*	*Value added growth (in %)*	*Change in value added share (in %)*	*Value added growth per employee (in %)*
Europe (EU-15)	-4.6	-0.4	62.1	2.8	69.9
Electronic components[2]	-1.1	0.0	31.9	0.1	33.4
Consumer Electronics[3]	-28.6	-0.7	-7.3	-0.9	29.9
Medical, Optical and Measurement devices[4]	8.5	0.3	207.8	3.6	183.7
Brazil	9.2	0.3	-2.4	-1.47	-10.6
Electronic components[2]	2.2	0.47	0.3	-0.46	-1.9
Consumer Electronics[3]	11.0	-0.18	-9.8	-0.97	-18.7
Medical, Optical and Measurement devices[4]	26.3	0.01	20.6	-0.04	-4.5
Russia	24.0	1.9	188.8	-0.46	64.5
Electronic components[2]	49.2	1.41	169.1	-0.42	32.2
Consumer Electronics[3]	5.8	0.04	39.8	-0.28	256.6
Medical, Optical and Measurement devices[4]	4.5	0.45	272.8	0.24	132.9
India	-10.5	-0.71	23.6	-2.02	38.2
Electronic components[2]	-2.7	-0.17	18.1	-1.34	21.3
Consumer Electronics[3]	-23.5	-0.34	15.3	-0.69	50.6
Medical, Optical and Measurement devices[4]	-18.8	-0.2	71.6	0.01	111.3
China[7]	125.4	8.25	650.8	6.51	N.A.
Electronic components[2]	N.A.	N.A.	N.A.	N.A.	N.A.
Consumer Electronics[3]	N.A.	N.A.	N.A.	N.A.	N.A.
Medical, Optical and Measurement devices[4]	N.A.	N.A.	N.A.	N.A.	N.A.

Source: <TNO Research>, based on data of UNIDO (ISIC Rev. 3)

[2] Electronic Components comprises: 'Electric motors, generators and transformers' (ISIC 3110), 'Electricity distribution & control apparatus' (ISIC 3120), 'Insulated wire and cable' (ISIC 3130), 'Other electrical equipment n.e.c'. (ISIC 3190) and 'Electronic valves, tubes, etc.' (ISIC 3210)

[3] Consumer Electronics comprises: 'Office, accounting and computing machinery' (ISIC 3000), 'TV/radio transmitters; line comm. Apparatus' (ISIC 3220) and 'TV and radio receivers and associated goods' (ISIC 3230)

[4-] Medical, Optical and Measurement devices comprises: 'Medical, measuring, testing appliances, etc.' (ISIC 331), 'Optical instruments & photographic equipment' (ISIC 3320) and 'Watches and clocks' (ISIC 3330)

[5] Brazil: 1996-2005, Russia: 2001-2005; India: 1998-2004

[6] Russia:'Total' and 'Medical, Optical and Measurement devices' do not contain data on 'Watches and Clocks' (ISIC 3330)

[7] Data for China based on ISIC Rev 2

3.3 Employment structure and work organisation

Industry structure developments by region

As Barrios et al. (2008) have argued, strong regional specialisation applies in ICT manufacturing. It appears that EU employment in ICT manufacturing is located in a limited number of regions in Northern and Eastern Europe, with Hungarian, Czech and Finnish regions being among the most specialised in manufacturing of office machinery and computers (NACE 30) and audio, video and telecoms (NACE 32). Irish and UK regions (both in Scotland and the Southern part of the UK) appear to highly specialise in office machinery and computers. An interesting question relates to whether employment variations in a given sector/region are likely to be influenced by the overall sector's variation in employment across the whole EU. In other words, whether employment changes observed at the regional level for a given sector may just be due to employment variations for the sector as a whole, such as a severe downturn due to increased global competition such as happened in the office machinery and computers sector. Another example applies to fast expansion driving employment growth as in the case of the medical and optical equipment sector (NACE 33), a sector that has shown to be particularly influenced by the overall macroeconomic cycle. Results of a shift-share analysis by Barrios et al. (2003: 30-32) indicate that the combined regional/sector dimension (the shift term in the analysis) is the most relevant in explaining recent employment changes in the EU medical and optical equipment sector (and also in the telecoms and the ICT services sectors), with more than a 50% of employment change explained by trends specific to the regions and industries considered (shift term) rather than sectoral performance (mix term), or general overall employment changes (share term) at national level.

Table 3.8 provides a summary of the employment changes for a number of selected regions, as analysed by Barrios et al. It shows that the overall decline in employment has especially taken place in UK regions.

Table 3.8 Regional changes in employment by sub-sector, 2000-2004

NACE 30	*NACE 32*	*NACE 33*
South Western Scotland (UK) -32.7%	Eastern Scotland (UK) -32.8%	Berkshire, Buckinghamshire and Oxford (UK) -13.9%
Shropshire and Staffordshire (UK) – 31.2%	Ile de France -5.9 (F) %	West Midlands (UK) -21.1%
East Wales (UK) -44.2%	Northumberland, Tyne and Wear (UK) -40.2%	Essex (UK) -15.8%
Hampshire and Isle of Whight (UK) -21.4%	Östra Mellansverige (Sw) -29.4%	Surrey, East and West Sussex (UK) -11.4%
Ile de France (F) -12.8%	Gloucestershire, Wiltshire and North Somerset (UK) -23.2%	East Anglia (UK) -15.8%

Source: Barrios et al. (2008). Figure indicating the % of change in employment in the sub-sector in the region.

Industry structure and employment by firm size

Most enterprises in the computer, electronic and optical products industry are SMEs. Of all employees working in the industry, slightly less than half work in large companies (over 250 employees) and slightly more than half in SMEs (defined as having less than 250 employees). Firms employ less than 50 persons account for around 30% of employment (see Table 3.9), a figure that is somewhat less in the new Member States. The majority of firms (96%) is found in this size category, however (see Table 3.10). Firms employing between 50 and 249 employees account for almost 22% of employment. The average firm size in the medical,

optical and measurement instruments industry is the smallest of the three, with one of the important explanatory factors being that the industry is far from homogeneous, with a collection of many small niche markets behind and therefore less attractive for large firms to enter.

Table 3.9 Employment by firm size. Computer, electronic and optical products, 2006

	Shares 2006			Total change of shares 1999-2006		
	<49	50-249	>249	<49	50-249	>249
	Number of employees			*Number of employees*		
EU	29.5	21.5	49.0	3.8	2.6	-6.4
EU-15	30.1	21.7	48.2	4.6	3.0	-7.5
NMS	26.3	20.3	53.3	-0.8	-0.2	1.0

Source: Eurostat/TNO. Note: Country groupings are based on employment (See Table 3.4).

Table 3.10 Number of firms by size. Computer, electronic and optical products, 2006

	Shares 2006			Total change of shares 1999-2006		
	<49	50-249	>249	<49	50-249	>249
	Number of employees			*Number of employees*		
EU	96.1	3.1	0.8	0.4	-0.1	-0.2
EU 15	95.7	3.5	0.9	0.2	0.0	-0.2
NMS	97.6	1.8	0.6	0.5	-0.3	-0.2

Employment, part-time work and self-employment

The relative number of entrepreneurs in the medical and optical equipment sector is considerably higher than in both other sub-sectors, and especially in the new Member States (14%). It is lowest in the audio, video and telecoms manufacturing sector, and only slightly higher in office equipment and computer manufacturing. There are large differences by Member State, however. Belgium, Greece, Italy, Spain and Poland stand out in terms of relative high numbers of entrepreneurs.

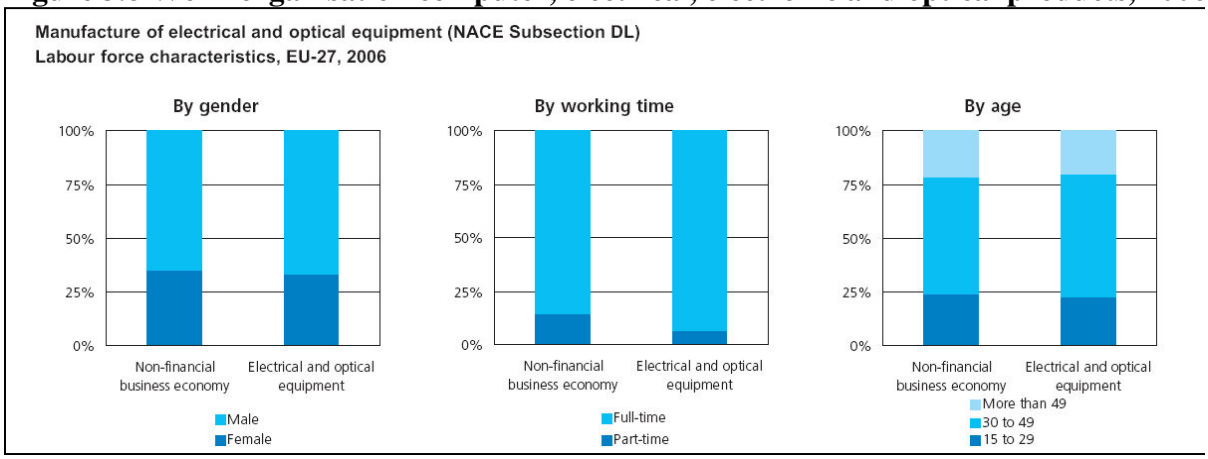
Table 3.11 Share of entrepreneurs and share of part-time workers in total employed, 2006

	Share of entrepreneurs in total employed			*Share of part-time in total employed*		
	NACE 30	NACE 32	NACE 33	NACE 30	NACE 32	NACE 33
EU	5	3	8	6	5	8
EU-15	5	3	7	7	6	9
NMS	5	5	14	1	1	3
Winners	5	4	7	4	1	10
Losing momentum	1	1	3	8	7	1
Upcoming	13		13	6		6
Retreating	8	6	5	5	4	7

Source: Eurostat/TNO. Note: Country groupings are based on employment (See Table 3.4).

As Figure 3.8 and Table 3.11 show, part-time work is not widespread in the computer, electronic and optical products sector and is particularly low in the new Member States. There are no signs that this trend will be reversed in the near future. Compared to the non-financial business economy the percentage of people working full-time in the computer, electronic and optical products industries in the EU-27 is high. Compared to the industrial average (7.6%, see figure), the proportion of workers engaged in part-time work is only slightly smaller. The distribution over age categories in the sector is not much different than the non-financial business economy in EU-27 in 2006 (Eurostat, 2007a).

Figure 3.8 Work organisation computer, electrical, electronic and optical products, 2006



Source: Eurostat (2007b). Note : figures apply to NACE sectors 30, 31, 32 and 33 and therefore include also electrical machinery and equipment.

Table 3.12 Employment by gender, age and education: Computer, electronic and optical products, 2000-2006

	EU		EU 15		NMS	
	Share	Change	Share	Change	Share	Change
Women	36	0	33	-1	50	2
Age < 40	53	-6	51	-7	58	-1
Age 40 – 50	27	2	28	3	23	-3
Age > 50	20	4	20	4	19	5
Low education	16	-6	17	-5	9	-5
Mid education	51	2	47	0	71	4
High education	33	4	36	5	20	1
Definition	Share % 2006	Total change % 2000-2006	Share % 2006	Total change % 2000-2006	Share % 2006	Total change % 2000-2006

Source: Alphametrics/TNO based on Eurostat Labour Force Survey

Gender distribution

Overall, 36 per cent of all employed are women, a figure that is considerably higher in the new Member States. In France, Germany, Italy, Switzerland and the United Kingdom, the share of women in overall employment tends to be in the 25-35% range, remaining stable over the period 1997 – 2007, and showing in some cases even a slight decline. Exceptions are Cyprus and Slovakia with 21.9 % and 52.7 % of all employed being women. Among the emerging economies of Asia, such as Malaysia, the Philippines, Thailand and Vietnam, the share of woman tends to be over 50 % (ILO, 2007; Eurostat, 2007a).

Working conditions
The working conditions in Europe and the USA in the electronic components industry are relatively good. The environments in which the production workers work are usually clean and relatively noise-free, with computer chips being manufactured in so-called "clean rooms". Still, the use of (hazardous) chemicals and machinery form a danger to the human health of the workers (CBI, 2005; US Department of Labor, 2008). There is a huge difference in the working conditions of European and US-based ICT manufacturing firms and manufacturing locations in other countries. The working conditions in production facilities that produce or assemble computer parts in developing countries are often below western standards: long working weeks, compulsory over-time, unsafe factories, the use of hazardous materials, wages below subsistence levels, etc. (SOMO 2005; CAFOD 2004).

Initiatives that aim to improve the working conditions further include, for example, the 2004 'Electronics Industry Code of Conduct' adopted by Hewlett-Packard, Dell, IBM, Cisco Systems, Microsoft and Intel and five Contract Manufacturers (Solectron, Sanmina-SCI, Jabil, Celestica and Flextronics). This code of conduct aims to ensure safe conditions, worker rights and environmental responsibility in the global electronics supply chain. (EICC, 2008) In the telecommunications sector, the Global e-Sustainability Initiative (GeSI) (including BT, Nokia, Deutsche Telekom and Vodafone) has identified labour issues as a priority for the industry to address.

3.4 Employment - main trends by job function

One of the most interesting indicators for analysing the future on jobs and skills is the trends and developments that can be identified at the (micro) level of job functions. More than aggregate employment and more than figures about gender and age distribution can changes in job functions tell us something about ongoing change and restructuring in the sector. Changes in (the need for) competences and changes in the distribution of job functions are closely linked to each other, both at the level of the sector and at the level of the firm. Competences are combined in occupation profiles, and can be distinguished in core competences, specialization competences or complementary competences (Rodrigues, 2007:34). Another distinction is between theoretical, technical and social competences (i.e. knowledge, skills and competences in ECVET) (ibidem). Identifying the changes in job functions by sector is a first step towards a better understanding of the changing competence needs in the sector. Competences for the purpose of this study are assumed to be located in a general grid defined by the main occupation functions: general management, marketing, financial and administrative management, R&D, logistics, production management, production, quality and maintenance (Rodrigues, 2007:35).

As a first step towards identifying trends in competences, the observed changes in the distribution of job functions over time will be analysed, using Labour Force Survey (LFS) data.[3] In the second part (the scenario-based future-oriented part), a further elaboration of these changes on the need for new and existing competences will be provided. The analysis starts with an analysis of the state-of-play, i.e. the situation as per 2006. Subsequently, changes in job functions over time are discussed, in general (overall) and for different categories of workers classified according to educational level.

[3] Data on occupational structure follow the availability of overall employment figures presented earlier.

Employment by occupation: state of play and main changes

This sub-section discusses the main trends in job function categories (occupations) in the computer, electronic and optical products sector. The analysis is based on a combination of labour force survey (LFS) data and general employment data collected by Eurostat. Due to the nature of survey data – being based on restricted samples of the total employment population – data reported at the most aggregate (EU) level is more reliable than the same information provided at Member State level if the focus is directed at sector or sub-sector level (see the separate data annex of this report). The same applies to the combination of occupation data and educational profiles. Figures therefore should be interpreted with caution, indicating primarily directions of change and less reliable where it comes to the magnitude of change.

As can be seen from Tables 3.13 and 3.14, engineers have the largest share (21%) in the computer, electronic and optical products industries in the EU, and especially so in the EU-15, with 19% and 21%, respectively. The new Member States employ remarkably less engineers (13%). A similar pattern can also be seen for computing professionals and other professionals, albeit less distinct. For the new Member States assemblers is the most common occupation (23%), with fitters (10%) being third after engineers. In the EU-15 assemblers and fitters account for 8% and 7% only. Service workers, other craft and related trades workers, and labourers have the lowest shares in employment in this sector (1%, 2% and 4%, respectively).

Table 3.13 Employment level by occupation computer, electronic and optical products industries, 2006

	EU-15	NMS	EU	Winning	Losing momentum	Upcoming	Retreating
TOTAL	1685 365	372 866	2 058 232	714 458	197 344	71 253	1 075 176
Managers	164 659	20 006	184 665	41 637	15 360	12 053	115 614
Computing professionals	134 768	22 875	157 643	47 312	16 611	8 183	85 537
Engineers	346 755	48 874	395 629	130471	33 359	15 777	216 022
Business professionals	76 649	12 879	89 528	27 719	13 300	2 763	45 746
other professionals	177 989	35 123	213 112	61 880	17 188	3 640	130404
Office clerks and secretaries	158 125	21 385	179 510	70 109	13 977	1 638	93 786
service workers	17 763	2 569	20 332	5 512	2 666	179	11 974
Metal machinery workers, blacksmiths	69 090	24 744	93 834	42 532	7 289	3 457	40 557
Electric equipment mechanics, fitters	115 237	37 756	152 993	59 790	10 087	5 121	77 995
Precision. handicraft. craft printing	103 591	14 504	118 095	70 999	9 320	2 936	34 840
Other craft. trades workers	38 350	6 217	44 567	26 934	3 170	1 798	12 665
Assemblers	137 041	85 005	222 046	65 783	30 819	8 379	117 065
Other plant and machine operators	77 487	29 444	106 930	35 577	11 135	3 798	56 421
Labourers	67 862	11 484	79 346	28 204	13 064	1 530	36 548

Note: The country grouping (winning, losing momentum, upcoming and retreating) is based on employment (table 3.4)

Table 3.14 Occupation shares computer, electronic and optical products industries, 2006

	EU-15	NMS	EU	Winning	Losing momentum	Upcoming	Retreating
TOTAL	100	100	100	100	100	100	100
Managers	10	5	9	6	8	17	11
Computing professionals	8	6	8	7	8	11	8
Engineers	21	13	19	18	17	22	20
Business professionals	5	3	4	4	7	4	4
Other professionals	11	9	10	9	9	5	12
Office clerks and secretaries	9	6	9	10	7	2	9
Service workers	1	1	1	1	1	0	1
Metal. machinery workers. Blacksmiths	4	7	5	6	4	5	4
Electric and -equipment mech. fitters	7	10	7	8	5	7	7
Precision, handicraft, craft printing	6	4	6	10	5	4	3
Other craft. trades workers	2	2	2	4	2	3	1
Assemblers	8	23	11	9	16	12	11
Other plant and machine operators	5	8	5	5	6	5	5
Labourers	4	3	4	4	7	2	3

Note: The country grouping (winning,, losing momentum, upcoming and retreating) is based on employment (table 3.4)

Table 3.15 Changes occupation shares computer, electronic and optical products, 2000-2006

	EU-15	NMS	EU	Winning	Losing momentum	Upcoming	Retreating
Managers	1	0	1	0	-1	4	2
Computing professionals	2	3	2	1	4	5	1
Engineers	3	4	2	1	-2	1	4
Business professionals	0	2	0	0	0	0	0
other professionals	3	-5	2	0	3	1	3
Office clerks and secretaries	-2	-2	-2	-1	-1	0	-4
service workers	0	0	0	0	0	-2	0
Metal, machinery workers. Blacksmiths	-1	0	0	0	0	-2	-1
Electric and electronic equipment mechanics and fitters	-1	-2	-1	-3	-2	-4	-1
Precision, handicraft, craft printing	0	-1	0	-1	0	1	-1
Other craft and trades workers	0	0	0	-1	0	2	0
Assemblers	-5	5	-2	2	-4	-2	-4
Other plant and machine operators	1	1	1	1	0	0	1
Labourers	0	-5	-1	-2	3	-3	-1

Note: The country grouping (winning,, losing momentum, upcoming and retreating) is based on employment (table 3.4)

There are some remarkable similarities and differences between the different groups of countries. The share of engineers in total employment is highest whether countries belong to the categories of winning, losing momentum, upcoming or retreating countries as earlier described. The upcoming countries have a very high share of managers (17%), while in the

winning countries their share is only 6%. In the group of winning countries the occupations precision, handicraft and craft printing form a fairly large share (10%), while in the other groups of countries, and the EU as a whole, their share is much smaller.

Overall, no major changes have occurred as to the shares of occupations in the computer, electronic and optical products sector between 2000 and 2006 (see Table 3.15). Some exceptions apply, however. The share of assemblers, for example, declined by 5 % in the EU-15, while at the same time their share rose by 5% in the new Member States. The share of office clerks and secretaries declined for all groups of countries. The share of engineers rose (by 2% for total EU), and as engineers form the largest share in total employment in the sector this shift is considerable in absolute terms.

Almost all occupations in the computer, electronic and optical products sector show a negative trend for low educated workers (see Table 3.16). The total share of low educated workers in the sector decreased with 5%. Especially the decline of low educated service workers is very significant (-20%). Strikingly, this decline took mostly place in retreating countries; in upcoming countries the share of low educated service workers remained stable. The computing professionals and precision handicraft craft printing are the only two occupations where the share of low educated workers is rising. While the picture looks more or less the same across the different country groups for computing professionals, for precision handicraft craft printing strong differences appear. In the winning countries the share of the low educated workforce engaged in precision handicraft craft printing ross with 5%, while in the upcoming countries it decreased with 23%.

Table 3.16 Changes occupation shares low educated employees, 2000-2006

	EU-15	NMS	EU	Winning	Losing momentum	Upcoming	Retreating
Managers	-2	-1	-2	-2	2	1	-4
Computing professionals	0	3	1	2	4	4	-2
Engineers	-2	1	-2	-1	-5	0	-3
Business professionals	-2	-7	-3	1	-4	0	-5
other professionals	-3	-5	-3	-3	-1	2	-2
Office clerks and secretaries	-1	-3	-2	2	1	-10	-4
service workers	-22	-7	-20	-8	-6	0	-29
Metal, machinery workers. Blacksmiths	-4	-8	-7	-7	6	-5	-7
Electric and electronic equipment mechanics and fitters	-4	-2	-4	3	-10	5	-10
Precision, handicraft, craft printing	3	2	2	5	-15	-24	3
Other craft and trades workers	-4	0	-5	-3	6	9	-17
Assemblers	-4	-11	-11	-9	-8	9	-12
Other plant and machine operators	-5	-1	-6	-12	-11	-24	-3
Labourers	-13	-18	-13	-11	-25	13	-12
Total	-5	-5	-6	-2	-6	-1	-8

Note: The country grouping (winning,, losing momentum, upcoming and retreating) is based on employment (table 3.4)

Table 3.17 Changes occupation shares medium educated employees, 2000-2006

	EU-15	NMS	EU	Winning	Losing momentum	Upcoming	Retreating
Managers	-4	7	-3	4	0	2	-7
Computing professionals	-6	-7	-3	-3	5	-23	-6
Engineers	3	-15	2	2	-2	4	2
Business professionals	4	3	5	-3	-2	-5	11
other professionals	3	14	4	-5	-8	-5	11
Office clerks and secretaries	-3	-17	-4	-1	-7	10	-8
service workers	12	7	12	21	1	0	10
Metal. machinery workers. Blacksmiths	5	9	9	6	-9	4	13
Electric and electronic equipment mechanics and fitters	4	5	6	-1	6	9	13
Precision, handicraft and craft printing	-3	-7	-3	-2	7	19	-5
Other craft. trades workers	5	-15	5	6	-24	-53	13
Assemblers	3	11	11	8	5	-6	11
Other plant and machine operators	4	4	6	11	9	18	5
Labourers	10	21	11	9	21	-8	10
Total	0	2	2	1	1	-6	2

Note: The country grouping (winning, losing momentum, upcoming and retreating) is based on employment (table 3.4)

The overall employment occupation share of the EU for middle educated workers in the computer, electronic and optical products industry increased by 2% between 2000 and 2006. Middle educated service workers and labourers showed the largest increases in shares, of 12% and 11 % respectively. The share of middle educated service workers rose especially much in the group of winning countries (21%). The increase in the share of labourers on the other hand, took place mainly in the group of countries that are loosing momentum (21%). The share of middle educated managers decreased by 3% for the EU as a whole, but rose with 7% in the new Member States, and to a lesser extent also in the winning and upcoming countries in the sector.

Throughout the EU highly educated workers experienced a considerable increase in number of occupations (4% growth). The increase was largest for the service workers, but this holds only for EU-15 countries (10%). New Member States showed no increase in the share of highly skilled service workers. Even more remarkable is that the increase in service workers took place in the group of retreating countries (19%); the group of winning countries showed a decline in the share of highly skilled service workers (-13%). And while the overall EU increase in the share of other craft trades workers is zero, there are some major shifts in their share in upcoming countries and countries that are losing momentum (a rise of 45% and 18% respectively).

Overall, a general trend of up-skilling can be observed in the EU computer, electronic and optical products sector, meaning a move to a higher –predominantly middle and high - educated workforce, with a consequent decrease of the low educated workforce.

Table 3.18 Changes occupation shares high educated employees, 2000-2006

	EU-15	NMS	EU	Winning	Losing momentum	Upcoming	Retreating
Managers	7	-6	5	-2	-1	-3	11
Computing professionals	5	4	2	1	-8	19	7
Engineers	0	14	0	-1	7	-4	2
Business professionals	-2	4	-1	2	6	5	-5
other professionals	0	-9	-1	8	9	3	-9
Office clerks and secretaries	4	20	6	0	6	-1	12
service workers	10	0	8	-13	5	0	19
Metal. machinery workers. blacksmiths	-2	-1	-2	1	3	1	-6
Electric and electronic equipment mechanics and fitters	0	-2	-2	-3	4	-13	-3
Precision, handicraft, and craft printing	0	5	0	-3	8	5	2
Other craft. trades workers	-1	15	0	-3	18	45	3
Assemblers	1	0	0	0	3	-4	0
Other plant and machine operators	1	-2	0	1	2	6	-2
Labourers	3	-3	2	2	4	-4	2
Total	5	3	4	1	5	7	6

Note: The country grouping (winning,, losing momentum, upcoming and retreating) is based on employment (table 3.4)

3.5 Productivity and labour costs

The average labour productivity[4] of the EU computer, electronic and optical equipment sector was EUR 52 000 in 2004 which is high compared to other manufacturing sectors. On the level of sub-sectors, the apparent labour productivity ranged from EUR 50 000 (instrument engineering) to EUR 70 000 (computers and office equipment).

Table 3.19 Labour productivity computer, electronic and optical products sector, 2004

	Apparent labour productivity (EUR thousand)	*Average personnel costs (EUR thousand)*	*Wage adjusted labour productivity (%)*
Electrical and optical equipment*	52.0	37.0	141.0
Instrument engineering	50.0	35.0	138.0
- Medical and surgical equipment and orthopaedic appliances	45.2	31.4	143.9
- Instruments and appl. for measuring, checking, testing, navigating and other purposes	58.0	43.0	137.0
- Industrial process control equipment	45.4	37.1	122.5
- Optical instruments and photographic equipment	50.0	35.0	140.0
- Watches and clocks	40.0	--	--
Computers and office equipment	70.0	40.0	179.0
- Office machinery	56.0	41.0	140.0
- Computers and other information processing equipment	74.9	39.3	191.0
Radio, TV & communication equipment	62.9	41.5	151.4

Source: Eurostat (2007a). Notes: * NACE 30,31,32,33, i.e. including also electrical machinery and equipment. The remainder of this table excludes NACE sector 31.

[4] Apparent labour productivity defined as value added divided by the number of persons employed.

The differences in average personnel costs between the sub-sectors are lower, ranging from EUR 35 000 (instrument engineering) to EUR 41 500 (radio, TV & communication equipment), resulting in an average of EUR 37 000 for the whole sector. The relatively large differences in apparent labour productivity among sub-sectors are reflected in the wage adjusted labour productivity, which overall amounted to 179.0 % for computers and office equipment and 138.0 % for instrument engineering (Eurostat, 2007b). The wage adjusted labour productivity is defined as the ratio of value added divided by personnel costs (the latter having been divided by the share of employees in the number of persons employed). Labour productivity in large companies is almost twice that in SMEs (Europe Innova 2006).

Marked differences exist though between the apparent labour productivity levels of the various Member States in all three sub-sectors, with a clear split between the 'old' and the new EU Member States (see Table 3.20). In office equipment and computer manufacturing, Ireland, the UK and Germany are clear front-runners in the EU-15; in the new EU-12 especially Hungary stands out with an absolute level that is higher than that of Finland and only somewhat below Sweden and France.

Table 3.20 Apparent and wage adjusted labour productivity by sub-sector, 2004

	Apparent labour productivity (in k€)			*Wage adjusted labour productivity (in %)*		
	NACE 30	NACE 32	NACE 33	NACE 30	NACE 32	NACE 33
EU-27	70.0	62.9	50.0	179.0	151.4	138.0
Belgium	59.9	102.8	53.4	136.8	147.7	119.2
Denmark	75.0	54.1	77.4	157.3	126.0	165.1
Germany	96.9	75.6	53.3	166.5	142.3	130.8
Ireland	107.2	203.0	104.1	251.3	486.7	290.3
Spain	28.2	40.6	38.0	85.9	126.4	132.9
France	56.6	61.2	58.9	131.8	115.3	124.2
Italy	43.8	49.9	44.8	120.3	126.8	129.3
Cyprus	..	23.4	20.4	..	199.5	123.5
Luxembourg	..	..	43.0	..		134.2
Netherlands	..	..	..	..	..	..
Austria	33.6	88.4	59.1	87.7	145.1	157.5
Portugal	31.1	50.4	23.3	129.4	202.0	137.9
Finland	44.7	146.9	62.8	123.0	277.1	147.0
Sweden	53.0	120.9	73.8	109.7	164.9	130.8
United Kingdom	107.4	60.4	70.0	250.0	146.0	168.9
Norway	80.9	78.3	73.2	118.3	128.3	117.9
Bulgaria	6.2	6.4	3.6	207.7	214.8	152.7
Czech Republic	14.0	18.4	13.1	162.2	190.5	143.8
Estonia	13.0	10.2	15.1	140.4	149.1	171.7
Latvia	12.0	14.5	6.6	237.7	314.0	156.9
Lithuania	7.6	10.3	9.3	194.4	172.7	162.3
Hungary	47.9	24.4	13.8	450.3	230.0	156.2
Romania	4.3	10.8	6.4	199.4	200.7	201.7
Poland	15.8	17.5	10.7	177.7	203.4	149.8
Slovakia	-9.1	9.4	10.8	-118.1	142.2	148.1
Slovenia	31.0	26.3	21.7	157.0	139.5	142.1

Source: Eurostat (2007a)

In terms of wage adjusted productivity, the top 3 countries in the EU-15 keep their front-runner position. However, most new Member States equal or do better than the EU-15, with Hungary outperforming all others. A similar pattern can be seen in the other sub-sectors. In

audio, video and telecoms manufacturing Ireland, Finland and Sweden do best in terms of apparent labour productivity, Ireland being the absolute front runner in terms of wage adjusted labour productivity. The same applies to the medical and optical equipment sector. Although in the new Member States apparent labour productivity is sometimes very low in absolute euro-terms (cf. Latvia, Bulgaria and Romania), their wage adjusted labour productivity is at similar high levels or higher than the high-performers in the old EU-15.

3.6 Industrial relations

The degree of unionisation in the computer, electronic and optical products sector is comparatively low compared to other sectors. Traditionally the ICT hardware industry has been located in regions with low levels of unionisation like Scotland and Wales or Silicon Valley and the South in the US. Nowadays much production manufacturing is located in so-called export processing zones in Asia with either limited access for unions to the work floor or even outright bans (ILO, 2007; CAFOD, 2004; SOMO, 2005). This trend also feeds back as a downward cost pressure to developed countries, lowering pay and working conditions. As a result production also within Europe shifts from West to the new Member States, making use of contract manufacturers that are less exposed to pressures from consumer markets. This outsourcing of production steps is an important trend especially in the EU-15.

Employees in European manufacturing firms are under the constant threat of outsourcing and off-shoring and have to compete with manufacturing firms all over the world. Although this is also true for other global manufacturing and services industries, in the computer, electronic and optical products industry outsourcing and off-shoring occur at a high frequency, the general trend being that OEMs (Original Equipment Manufacturers) try to outsource their production as much as possible. The impact of such divesture for employees depends per case and per employee and can be influenced by seniority rights, the availability of alternative jobs in the neighbourhood and the type of contract the employees has. Many employees on the work-floor are hired through temp agencies. The higher value added product manufacturing that still is located in Europe is not owned by OEMs, but is contracted to EMS (Electronic Manufacturing Services). Often these EMS are closed down after 3-5 years when preferred sourcing contracts end (SOMO, 2005; ILO, 2007).

3.7 Partnerships for innovation, skills and jobs

One of the central tenets of the renewed Lisbon Strategy is the partnership concept; by building a European partnership for growth and employment, the reforms needed to boost growth and employment will be facilitated and speeded up (European Commission, 2005). Partnership in this view “mobilises support” (mobilisation) and “gets the different players at work together” (collective effort), as well as “makes sure that the(se) objectives and reforms are taken on board by all the various players” thus spreading ownership (ibidem, page 14). In the implementation of the European Cohesion Policy, the partnership principle is fundamental as well. The EU recognises the importance of involving local and regional actors, in particular in areas where greater proximity is essential such as innovation, the knowledge economy and new information and communication technologies, employment, human capital, entrepreneurship, support for SMEs and access to capital financing. Beyond that public-private partnerships and further improvement of governance in the fields of entrepreneurial innovation, cluster management, innovation financing are promoted at all levels – from the local to the regional, the national and the EU level as well as across sectors. Partnerships for innovation, skills and jobs, in connection with technology platforms,

industrial high level groups, as well as lead market and cluster initiatives are being promoted at both European and national level.

Existing partnerships for innovation, skills and jobs generally show a number of characteristics, which include:

- *Involvement of all relevant actors,* ranging from companies, research organisations, education and training institutes to public administration and others.
- *Cross-sectoral approach:* even though partnerships may be assigned to a specific sector, they often work across different business sectors.
- *Cross-thematic approach, i.e.* linking innovation, skills and jobs.
- *Inclusion of general human needs into the partnership strategy:* human needs, such as housing, health or mobility can be part of the formulated partnership vision or strategy
- *Long term commitment of actors (members).*
- *Joint problem solving,* i.e. working on problems that cannot be met by one member alone
- *European dimension,* i.e. being established at the European level.

Partnerships for innovation, skills and jobs can create a leverage effect for innovation, especially if broader *general human needs* are taken into consideration.[5] For instance, partnerships in the tourism sector aiming at developing 'leisure' should combine knowledge in tourism with, e.g., culture, sports and environment. A partnership aiming at developing the quality of habitat consequently should combine knowledge on at least construction, furniture, electronics and urban management. Partnerships for innovation, skills and jobs integrating general human needs on European level are still very rare.[6] It is likely to find more inclusive partnerships on the national and regional level.

Whereas the potential benefits of partnerships are clear, finding strong examples that fit the above characteristics at EU level are still difficult to find. There are, however, good examples in various sectors at the national and the regional level. Some of these stand out in terms of partnership approach, innovation capacity, approach for skills development, or their job maintaining and job creating capacity. Examples include the City Fringe Partnership for developing regional job opportunities in the printing sector and the ERRAC and EURNEX network in the rail sector where a European approach is combined with a strong effort to integrate latest research results in an virtual European training curriculum.

Partnerships, networks and clusters on innovation, jobs and skills often face similar barriers and obstacles, whatever sector is at stake. These include:

- *Restricted scope:* Partnerships often are set up in order to solve problems which can not be met by one partner on its own. The problems, thereby, are either defined bottom-up or articulated by the politics in a top-down process. In the latter case, the scope of partnership is limited to their given geographical scope and/or their thematic focus (If partnerships are established top-down as instrument to address specific problems they are usually restricted to the policy represented by the awarding authority, e.g. a particular Ministry). Similarly, partnerships and networks established at the European level, such as

[5] An argument put forward by professor Rodrigues at the workshop "Innovation policies for a knowledge intensive economy – assessing the European experience" in 2005 in Brussels.

[6] Outside the scope of the current series of studies, there is at least there is one good example, the European Construction technology platform (see http://www.ectp.org/default.asp).

e.g. networks of excellence, technology platforms, etc. have a specific thematic focus (in this case innovation in research and development).

- *Short-term nature:* Partnerships which are built up by means of public funding are often project driven, feature a short term nature and, generally, are not sustainable due to their dependence of a single fund.
- *Weak direct links between skills, jobs and innovation processes:* Skills upgrading and job opportunities are a result of innovation processes. Therefore, partnerships which focus on innovation do seldom focus on skills and jobs with the same strong interest.
- *Sectoral restrictions:* In general partnerships working on international or European level seem to be more likely to occur in strongly internationalised economic sectors with a common universal challenge (e.g. pollution or sustainable development). Then they are mostly limited to the problems they want to address.

Partnerships in the electronic, optical and computing equipment industries

The Electronics Leadership Council (ELC) (www.electronicsleadershipcouncil.org/default.asp) was formed in October 2005 as a response to the first recommendation of the Electronics Innovation and Growth Team's (EIGT) report in 2004. The ELC aims to become a relatively small but influential, business led body, representing the entire industry and its key stakeholders. An appropriate senior involvement of government and research and development associations was envisaged. The council monitors the implementation of the recommendations of the EIGT report and also initiates work streams for tackling some of the strategic problems that has been identified by the EIGT. The ELC does not duplicate activities that are working well, instead may provide the glue to give critical mass to existing activities or enhance existing activities where amore strategic input is needed[7] (e.g. in the area of skills).

The main objectives of the ELC are:

- to evaluate the key factors that will impact the electronics sector globally and identify the associated opportunities and challenges for the UK;
- to formulate a vision for the future of the electronics industry in the UK; and
- to agree on a roadmap (i.e. recommendations) for the industry and government to deliver this vision.

In its mission statement the ELC declares its role: clear leadership in steering the UK electronics industry towards greater innovation and creativity, growth and profitability. To achieve the objectives the ELC develops action plans for the sector alongside the following four work streams:

- Within the work stream *"Technology and Innovation"* it was agreed that innovations should be introduced into the market, small and medium sized businesses supported in implementing innovation as well as information and knowledge transfer between all stakeholders improved. Joint activities are set in order to pursue these objectives.
- The *"Skills & Education"* work stream will establish a more strategic approach to skills and education in all areas and will work to ensure that government resources are better targeted. Additionally, the work stream aims at the establishment of new

[7] DTI (ed.) 2005: Electronics 2015 – Making a visible difference, Electronics Innovation and Growth Team report, p. 12

training facilities, auditing of trainings and a stronger co-operation with the education sector.
- The third work stream deals with *supply chain management* by focussing on raising awareness of the value of better supply chain management across the industry.
- The fourth work stream aims to realise significant opportunities in *public procurement* for electronics business.

The council itself can be seen as networking organisation for innovation and knowledge dissemination. However, it itself does not develop innovation.

OptecNet, Germany
OptecNet Germany registered association (OptecNet Deutschland e.V., www.optecnet.de) is a supra-regional network of nine regional competence networks for optical technologies, including Bayern Photonics, HansePhotonik, OpTecBB, OpTech-Net, Optence, OptoNet, PhotonAix, PhotonicNet and Photonics BW. The network comprises small and medium sized enterprises, large enterprises, research and development institutions, education organisations, financial bodies and the consulting sector.

The membership structure as well as the objectives differ in the regional competence networks according to their specific focus. Several thematic workgroups (those are project and research co-operations between the different partners), are established in each regional network aiming at developing new products and services. Activities include the organisation of international thematic workshops as well as international information transfer and dissemination of results. Some regional networks are also characterized by a strong focus on fostering apprenticeship, vocational training and advanced vocational training.

The regional competence networks are mainly focussing on technological innovation through co-operation. Lately gained knowledge is incorporated into training courses for employees and qualification for unemployed in some regional networks.

The OptecNet is partner of the Competence Networks Initiative Germany and co-financed by the German Federal Ministry for Education and Research.

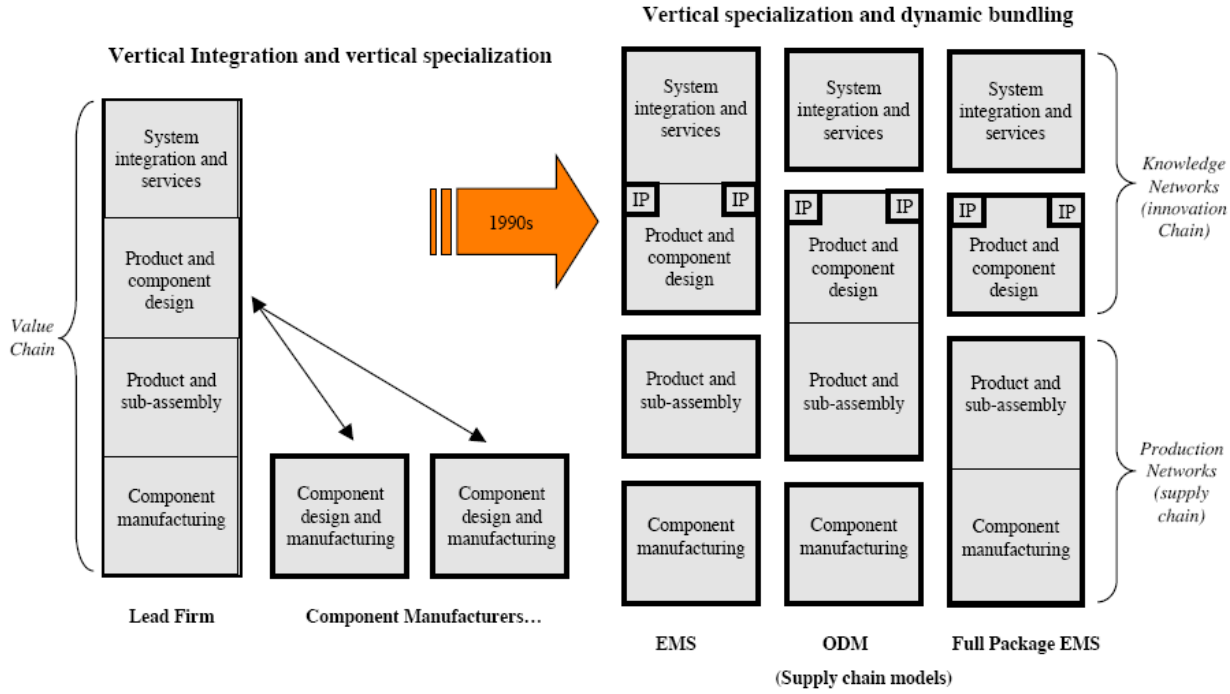
4 Value chains

4.1 Analysis of the value chain

The configuration of the value chain of the computer, electronic and optical products sector is nowadays characterized by at least three different ways of vertical integration and specialisation (see Figure 4.1). In the early 1990s, the prevailing form of organizing the value chain was through OEMs (Original Equipment Manufacturers). During the 1990s, some of the OEMs including IBM, Philips, Cisco, Sun Microsystems, HP, Alcatel and Ericsson, started to outsource some of the production manufacturing, but mainly kept 'in-house' the branding, marketing, R&D, design, and manufacturing of electronics products, including components. During the 1990s the OEMs gradually specialized further in core value added domains, including R&D and branding/marketing, and started to outsource the whole manufacturing and design part to new companies: the contract manufacturers. There are two

types of contract manufacturers: the ODMs (Original Design Manufacturing) and EMS (Electronic Manufacturing Services). The ODMs design and manufacture their own complete products and sell them to OEMs. Most of them are Asian - mainly Taiwanese – companies that integrated the design function with the manufacturing of electronic products and components. The ODMs usually have a limited range of (often computer) products and are mostly located in Taiwan or China. They can lower the investment costs for the launch of new products due to cost sharing. Some examples of ODM companies are Quanta, Asustek, Compal, BenQ and Lite-On, each with a turnover of over EUR 4 billion (2004 figures: SOMO, 2005). Some more recent developments are the ODMs that start selling their products with their own brand names and therefore directly compete with the products of their clients (OEMs), making them into own-brand name manufacturers (OBMs) (OECD 2006; SOMO, 2005; ILO, 2007).

Figure 4.1 The value chain over time



Electronic Manufacturing Services (EMS) are essentially service companies that take over the responsibility for design and system integration and outsource component manufacturing and assembly to other companies, either in Asia or Eastern Europe. The EMS provide this as a service to OEMs and are mostly North-American, though with global presence, seeking to locate their facilities near their customers and customers' end market. Their services range from manufacturing, product-assembly through logistics to after-sales services and support. Contrary to the ODMs, they apply a wide range of product and product categories, including PCs, telecoms products, medical electronics, industrial products etc. Their competence is to allow changes in production volumes and flexibility of production and production volume and to ensure vertical integration of the supply chain. The EMS face a risk, since they are dependent on a small amount of customers; therefore most EMS focus on marketing and product development to match the increasingly rapid changes on the demand side. Some examples of EMS companies are Flextronics, Hon Hai, Sanmina-SCI, Solectron and Celestica (all with turnovers of over 7 billion Euro, 2004 data (SOMO, 2005). Both the EMS and ODMs outsource the low value added product manufacturing to traditional

subcontractors based in South-East Asia, China, Mexico, Philippines and Costa Rica. Supply chain partnerships, joint ventures and alliances at global and regional level are formed to integrate the different parts of the value chain, consisting of research, production, design, setting standards, orchestrators, and assembly platforms. As OEMs require that their contract manufacturers act at a global level, these EMS and ODMs increasingly diversify geographically, not just in Asia and South America, but also by buying up facilities in Europe and North America (ILO, 2007; SUMO, 2005; OECD, 2006).

Although many contract manufacturers seem to become more vertically integrated, a reverse trend is also visible. There are also contract manufacturers that choose a virtual verticalisation model; they focus on their core activities, while at the same time offering their customers the best solution with related services (e.g. design, assembly, test and repair) without owning those services (ILO, 2007).

Firm interrelationships and industry structure
The interrelationships between firms in the electronics and computer equipment manufacturing industry are quite complex. The specialization and the competition between different type of firms (OEM, ODM, EMS) are complicated. At the same time the existence of complementarity between the different components is crucial in the computer industry. This complementarity can only be realized through standardization and interoperability of components (Economides, 1998). The industry strongly collaborates by annual revision of the roadmap for the semi-conductor industry, which sets the research agenda and the future development for the computer industry at large (interview De Jager 2008). Integration upstream in the value chain is occurring in the semi-conductor industry throughout both Europe and the world at large. Joint ventures and co-operation are the rule, also for traditional competitors (European Commission 2004). Electronic products contain many intermediate components, so that companies that are producing the intermediate components and assembling companies choose to locate near each other in order to lower their inventory and transport costs and decrease transportation time. In the electronic components industry, added value is created by proximity advantages of having semiconductor and end-user equipment manufacturers, like wired and wireless communications, automotive, consumer and industrial equipment close by (European Commission, 2006; US Department of Labor, 2008).

4.2 Restructuring

Outsourcing and off-shoring of manufacturing production
The OEMs (Original Equipment Manufacturers) have gradually shifted their focus from manufacturing (as their core competence in the past) towards outsourcing to contract manufacturers. Their prime competences now are in managing the supply chain and in contracting manufacturing partnerships. The labour-intensive manufacturing production processes are nowadays mostly located in Asia (Mason et al. 2002; SOMO, 2005). The buyer-supplier relationships are set to short-term manufacturing of products and components. Because of a high rate of R&D and innovation, leading to the creation of many new products and components, production and assembly manufacturing companies have to deal with high uncertainties regarding their orders (portfolio). Since new products can be either a failure (no more demand) or a success (much more demand), the contracts for product manufacturing and assembly are always very short term. Just-in-time supply, variable orders, tight ordering timescales and new demands in terms of higher product quality are influencing the buyer-supplier relationship. Factory practices allow for flexibility, such that in the morning it is decided how much will be produced that day and how long the working day will be, which

during the day depending on new orders can be adjusted. This has substantial implications for employees who are uncertain about the length of their working days and whether they have to work during weekends. Furthermore, employees often have little prospect of being long-term employed (ILO, 2007). This partially also holds for production in Europe, particularly in the new Member States.

Outsourcing and off-shoring trends by industry

Globalisation has become a major factor in the *computing equipment* manufacturing industry (see e.g. US Department of Labor, 2008). In the beginning of the 1990s only less than 5 per cent of all manufacturing of high-technologies was outsourced and vertical manufacturing strategies were the rule. Since then many companies have outsourced a substantial part of their activities towards Electronics Manufacturing Services (EMS). For the OEMs, only 25% of production in the sector concerns 'in house production', while 75% is outsourced to contract manufacturers (figures 2003; SOMO, 2005).

Not only has outsourcing become the rule, also the *type of outsourcing* has evolved during the last decade. First, outsourcing was based on the opportunities to reduce costs or meet specialized manufacturing for specific products on a contract-to-contract basis. Since products grew more complex and product life cycles decreased over time, companies had to increase their investments in capital equipment to keep up with the new manufacturing requirements. A new form of outsourcing emerged allowing to enter new markets quicker and more cost effectively by partnering with experienced companies,. This new form of outsourcing in the manufacturing of electronics is more collaborative with partners sharing strategic risks, characterized by a virtually synchronised supply chain (Accenture, 2003).

As regards the *electronic components and the consumer electronics* industry in Europe, already most of manufacturing production has been moved to China during the last 15 to 20 years. The main benefits for off-shoring and outsourcing in electronic manufacturing are: to reduce time-to-market and time-to-volume, to lower the operating costs, capital investment requirement and other fixed costs; to improve inventory management and to have access to world leading manufacturing technology, engineering and logistics capabilities (ILO, 2007). Frost & Sullivan expect in their analysis 'Trends in Electronic Manufacturing Services' that consumer electronics will be the main driver of outsourcing in the future, especially in design. According to Frost & Sullivan OEMs will increasingly focus on R&D activities and sales and marketing strategies and all other activities will be outsourced to EMS providers. EMS providers will have to face increasing competition with strong demands, among which effective value chain management, global presence as well as providing value added services (Evertiq.com, 2008).

While in the electronic components and consumer electronics industries most manufacturing production has been relocated to Asia, most of the higher value added and custom-made manufacturing in the *medical, optical and measurement devices industry* still takes place in Europe and is to a large extent conducted by SMEs.

5 Sector dynamics and the role of technological change, R&D and innovation

The computer, electronic and optical products sector is generally characterised by a short product life cycle, strong global competition and a comparatively strong emphasis on R&D. The semiconductor industry, for example, spends up to 20% of the annual revenues on R&D, making up for around 70 % of the R&D value performed in the entire IT components sector. Furthermore, other developments, like the increasing emphasis on consumer preferences and the increasing miniaturisation of electronic products and components have led to different dynamics in the R&D markets (European Commission, 2006; US Labor, 2008; ETEPS, 2007; IPTS, 2007b; Cleff et al. 2007). In general, there is a clear gap in R&D between North and South and between East and West of the EU. The Nordic countries spent huge resources on R&D especially related to the telecoms equipment industry. The new Member States show a lower R&D intensity, mainly because multinationals have located production but not their R&D facilities in these countries. Within the EU, approximately 80% of the funding for the private R&D expenditures comes from businesses (IPTS, 2007b).

While these general trends can be observed in the three sub-sectors alike, there are also important differences.

In the *office machinery and computers* (NACE 30), the EU-25 spent EUR 2.3 billion on private R&D activities in 2004, which equals 7.1% of the total EU-25 private investments in the ICT sector[8] (IPTS, 2007b). The research intensity of the sector (BERD/VA) increased in the period 2000-2004, which can be explained by a shift to higher value added and more technology intensive goods (IPTS, 2007b). Also the share of R&D staff in the total employment of the sub-sector increased between 2002 and 2004, but the amount of R&D investment per R&D employee increased only in Belgium. the Netherlands, Ireland, Sweden and Denmark (IPTS, 2007b). Approximately 90 % of the European R&D is performed in Netherlands, Germany, France, Sweden, Finland and United Kingdom (IPTS, 2007a) More than 50% of the R&D expenditures is concentrated in the Netherlands, which hosts R&D efforts of several large multinationals active in hardware and semiconductors (ETEPS, 2007).

In the *IT Components* (NACE 32.1) EU-25 spent EUR 6.8 billion on private R&D in 2004, equalling 20.6% of the total EU-25 private R&D expenditures in ICT (IPTS, 2007b). This sub-sector has the highest R&D intensity (35.6% BERD/VA) among the ICT sub-sectors, which has substantially increased from 2000 to 2004. Especially the semiconductors industry is very R&D intensive (15-20% of turnover is invested in R&D), which is mainly due to the permanent request for customisation and the medium- and long-term research on continuous improvement of materials (IPTS, 2007b). In addition, the semiconductors industry has a relatively high share of high educated employees. In the semiconductors industry many production and testing activities are off-shored and outsourced. This is of increasing importance for R&D activities as well. In the semiconductors industry R&D is extremely closely linked to production, which could imply that along with the off-shoring of production towards Asia, R&D activities might also be off-shored to that region. It is expected that mainly high-tech and research intensive activities like nanotechnology and photovoltaics will be important technological niches for the EU (IPTS, 2007b). The semiconductors industry is mainly concentrated in Germany, the United Kingdom, France and Italy (IPTS, 2007b).

[8] ICT sector is here defined as NACE 30, 32, 33, 64 and 72

In the *radio, TV and communication equipment* sector (NACE 32.2 and 32.3) EUR 6.5 billion is spent on private R&D in EU-25 in 2004. This equals 19.6% of the total EU-25 private expenditures in ICT. This sub-sector is R&D intensive (BERD/VA), although its research intensity declined from 32% in 2000 to 20.3% in 2004. Europe has a strong tradition in the telecoms equipment sector, with the presence of several major international players (Alcatel, Ericsson, Siemens, Nokia), who have seen a decrease in added value in the beginning of this century because of the dotcom bubble and the large expenditures for spectrum auctions for the 3G spectrum. As a result, also the R&D investments in this sub-sector have gone down since 2000 (IPTS, 2007b). The multimedia sector is quite different, with European players being strong in the premium segment, but weak in the mass market. This sub-sector is very R&D intensive and, despite many manufacturing activities have been off-shored because of cost reasons, EU-25 remains strong in R&D intensive niches. Nevertheless, a reverse trend is the increasing location of third country multimedia producers' R&D in the EU in order to customise their products to European markets (IPTS, 2007b). Approximately 90% of the European R&D is performed in Germany, France, Finland, Sweden, United Kingdom, Italy and Austria (IPTS, 2007a). Almost 50% of the European private investments in R&D are concentrated in Germany and France (ETEPS, 2007).

The *medical and optical equipment* sector (NACE 33) shows a high R&D intensity when compared to the manufacturing average, but it is slightly below the average of the ICT manufacturing. R&D expenditures are mostly concentrated in France, Germany and Italy, though with the highest R&D intensities occurring in Denmark, Finland and Norway. Over 90% of European private R&D in 2003 is performed in Germany, France, United Kingdom, Italy, Sweden, Denmark and the Netherlands (IPTS, 2007a). The electronic measurement instruments industry (NACE 33.2/3) in the EU-25 spent EUR 5.4 billion in 2004, equalling 17.4% of the total EU-25 private investments in ICT.

As a global trend, a growing difference is observed between investments in R&D in Asian countries like Taiwan and South-Korea with high R&D investments, and Europe where investment in R&D is lagging behind, with the EU accounting for only 8% of total world investments in the semi-conductor industry (European Commission, 2006b). This trend risks the very existence of the critical manufacturing infrastructures in Europe (European Commission, 2006b). Other R&D intensity[9] figures (IPTS, 2007b), however, show that the EU has a higher R&D intensity in semiconductors, in computers and office equipment, and in electrical components than other non-EU countries. Only for electronic equipment the R&D intensity lags behind compared to non-EU (IPTS, 2007b). European ICT companies claim – when asked in the Community Innovation Survey (CIS-3/4) - that lack of finance and high costs of innovation are barriers to innovation. However, customer wishes are a stronger incentive to innovate in the electronic, computing and optical industry compared to most other manufacturing sectors (Cleff et al., 2007).

Education and skills in relation to the sector's R&D and innovation profile

The computer, electronic and optical products sector is characterized by technological innovation that drives much of the industry's production, requiring a high proportion of engineers, engineering technicians, and other technical workers who carry out extensive research and development (e.g. US Department of Labor 2008). The volume of students in Computer Sciences and Electronic Engineering disciplines is generally judged insufficient to satisfy projected labour market demand. Eurostat figures indicate a shortfall of at least 100,000 graduates for the year 2004-5, whereas this figure is most probably even a significant

[9] R&D as a percentage of sales.

*under*estimation (EU ICT Taskforce, 2006). Some countries have specific education programmes targeted at increasing education related to the information industries, in order to increase the skills of future employees in the computer manufacturing (and also other related sectors). In Finland, for example, such a programme existed between 1998 and 2002.

A sizeable 33% of all employment in the computer, electronic and optical products sector is high-educated, yet with considerable differences bewteen Member States as well as between the EU-15 (36%) and the NMS (20%). More than half of the employed are medium-educated: 47% in the EU-15 and 71% in the NMS. Low-educated form a minority in the workforce, with 17% in the EU-15 and only 9% in NMS, which is also shrinking quite rapidly (minus 5% points over the peruiod 2000-2006). In the office machinery and computer industry (NACE 30) 17.6% of the employees are higher educated; in radio, television and communication manufacturing (NACE 32) over 25% of the employees are higher educated (Wintjes and Dunnewijk, 2008). The semiconductor industry has a very high share of researchers in their staff and employees in general have advanced engineering qualifications (IPTS, 2007b). Also the medical, precision and optical instruments sector (NACE 33) has a very high share of high educated employees. Nevertheless, a shortage of employees with high skills in the future is expected as there are not enough students in optics, also because there are not enough education programmes training students in optics (communicated by Prof. Schelkens, workshop 15 September 2008).

One of the recommendations at the end of 2006 of the ICT Task Force set up by the European Commission is that Europe needs to urgently increase employability e-skills.

6 Trade, globalization and international competition

6.1 Trade and international competition

International competition in the computer, electronic and optical products industries is strong, with global players setting the stage and with off-shoring (relocation) and outsourcing of especially manufacturing production being a pervasive phenomenon. At the same time, the degree of collaboration and cooperation in the sector is high, organized and orchestrated along global value chains. In recent years these value chains have gradually evolved into global value *networks*.

The international competitive playing field has changed strongly over the last decades. In the 1990s, OEM companies still predominantly competed against each other, with integrated value chains being the norm and with outsourcing being limited to certain parts of product manufacturing. In consumer electronics, for instance, the traditional strong role of the consumer electronic manufacturers has been diminishing, with service and content providers having increased their market power, and with new and highly specialised markets for electronic equipment emerging, e.g. in automotive. More generally, the emergence of EMS[10]

[10] EMS companies are mainly based in Northern-America, while OEM companies have been traditionally located in Northern-America and Europe, but nowadays also in Japan, South Korea, Taiwan and increasingly

and ODMs has led international competition in the computer, optical and electronic product manufacturing industries to become more fragmented, increasingly taking place in specialised sub-sectors. One of the more recent trends is the new competition between ODMs and their own clients (OEMs) as well as EMS companies starting to enter the ODM markets by designing their own products (SOMO, 2005; OECD, 2007).

Particularly China has been on the rise as a global production platform. More generally, Asian companies have been increasing their investments in R&D and trying to provide higher value added, hence directly and more competing with European firms. On the lower value added range, low-wage countries compete for attracting the product manufacturing, where Philippines, Costa-Rica, Mexico and China compete with the new EU Member States, the latter having higher labour costs, but also having closer proximity to the European markets. Seen from a global perspective, most competition for European firms in the computer, electronic and optical products industry stems from the US and East Asia. In medical and optical equipment, the EU faces strong competition from mainly the US, but increasingly so from China. In consumer electronics, the EU faces very strong competition from Asia, particularly from Japan, Taiwan and South Korea. In the electronic components industry, competition is particularly strong from the US (OEMs and EMS companies), Taiwan (ODMs) and China (assembly platforms).

Exports in the computer, electronic and optical products industries totalled almost EUR 500 billion in 2006. The vast majority of total exports is accounted for by the EU-15 countries. The new Member States, however, show export growth figures for the period 1995-2006 of 22.6%. With EUR 595 billion imports in the computer, electronic and optical products sector exceed exports by more than EUR 100 billion. Also here growth figures are strongest in the new Member States.

Table 6.1 Exports and imports computer, electronic and optical products industries, 1995-2006

	Exports		***Imports***	
	2006	1995-2006	2006	1995-2006
	Million Euro	*%*	*Million Euro*	*%*
EU	478 833	10.5	595 794	11.4
EU-15	436 330	9.9	551 948	11.1
NMS	42 503	22.6	43 846	16.2

Source: Eurostat/TNO

EU is thus a net importer of electronic components and products, with an increasingly negative trade balance. Global trade in ICT goods was increasing much last decade, and accounted in 2000 for almost 17 % of all merchandise trade (OECD, 2007). In the period 2000 and 2003 the manufacturing and trade of electronic goods showed a sharp decline; after 2003 trade in electronic components and products recovered. The last years there was a high increase in net trade, in particular with China (European Commission, 2006d).

Although overall the EU has a negative trade balance in computer, electronic and optical products with the rest of the world, some countries do have a positive trade balance as is described in Table 6.2. These winning countries are Luxemburg, Finland, Ireland, Sweden,

also in China. ODM companies are mainly located in Taiwan and China, while the low value added product manufacturing locations are in China, Philippines, Costa Rica, Mexico and Malaysia.

Estonia, and Hungary. The upcoming countries (Germany, Czech Republic, and Poland) have a negative trade balance with the rest of the world but a positive trend over the period 1995-2006. The rest of the EU countries are retreating, they face a negative trade balance and the trend is also negative.

Table 6.3 describes the relative comparative advantage in the EU. Relative comparative advantage compares the relative contribution of sector x to the comparative advantage of the national economy with other sectors. A comparative advantage of 0 means that the comparative advantage of the sector equals the average of the comparative advantage of the entire national economy. A negative comparative advantage indicates that the contribution to economic performance is less relative to other sectors. As we can see in table 6.3, this is the case for the computer, electronic and optical products sector. But for Luxembourg, Finland and Estonia it is the other way around. Revealed comparative advantage in these countries is relatively high, as in Ireland and Hungary, even though they are losing momentum.

Table 6.2 Trade balance computer, electronic and optical products industries, 1995-2006

	Trade balance 2006	***1995-2006***
	Million euro	*Total abs. change 1995-2006*
EU	-116 961	-69 469
EU-15	-115 618	-71 703
NMS	-1 343	2 234
Winning	19 230	9 736
Losing momentum	0	0
Upcoming	-2 312	7 168
Retreating	-133 879	-86 373

Source: Eurostat/TNO

Table 6.3 Revealed comparative advantage computer, electronic and optical products industries, 2006

	Revealed comparative advantage	***1995-2006***
	2006	*Total abs. change*
EU	-22	-5
EU-15	-24	-8
NMS	-2	48
Winning	21	37
Losing momentum	14	-17
Upcoming	-39	29
Retreating	-27	-10
	Concentration index >100	**Concentration index <100**
Growth	***Winning:*** Luxemburg, Finland, Estonia	***Upcoming:*** Greece, Portugal, Spain, Czech Republic, Poland, Slovakia
Decline	***Losing momentum:*** Ireland, Hungary	***Retreating:*** Belgium, France, Germany, Italy, Netherlands, Austria, Denmark, Sweden, United Kingdom, Lithuania, Slovenia

Source: Eurostat/TNO

6.2 Trade issues of relevance and importance to the sector

The computer, electronic and optical products sector is a strongly globalised and dynamic sector, characterised by high levels of trade and relatively low trade barriers. Existing trade barriers are mainly non-tariff barriers, particularly technical barriers such as technical regulations, standards and conformity assessment systems. Different laws and regulations and the lack of protection of IPR in some countries also remains an issue in international trade. Due to the relative low weight of components transport costs of electronic components and electronic consumer goods are relatively low. Even for experienced companies operating globally, the diversity of technical requirements, certification schemes and lack of transparency can be a significant burden in operating at a global scale. The fact that the EU is not a single market in all dimensions (cf services) adds to transaction costs both within the EU and internationally.

Developing country exporters fear that increasingly the high product and process-related requirements of industrialised countries, such as environmental and health requirements, although well-intentioned, are becoming technical barriers to export their products to the European markets. At the same time, the attention in Europe itself has moved from working conditions in manufacturing in Europe to working conditions in developing countries. Particularly NGOs have been able to draw attention to the existence of child-labour, poor health conditions at the work floor, and the importance of collective action and trade-unions (see CAFOD, 2004).

6.3 Outsourcing and offshoring

Since the 1990s the OEMs have outsourced important parts of their manufacturing production processes (production plants) to predominantly East and South-East Asia (for details also see section 4.2). In 2003 only 25% of production still concerned 'in house production', while 75% had been outsourced to Contract Manufacturers (EMS and ODMs). Cost advantages (lower wages, lower social costs, higher number of working hours), ample availability of labour, and future market potential have led European firms to relocate their production to elsewhere, predominantly Asia, usually supported by favourable location and tax incentive schemes provided by the receiving countries and/or regions. According to ESIA (2005), for instance, setting up a leading-edge model fab in China, South Korea or Malaysia would yield a net income flow of more than a factor 2 higher than the same fab in Germany or other Western European locations.

Offshore outsourcing to Asia has particularly been strong in consumer electronics. The increased off-shoring of production facilities appears to have already followed by a shift of R&D investments from Europe to Asia (IPTS, 2007a). In electronic components, Asian companies have been increasingly investing in R&D and in design, some of which has materialized in Europe. European companies still tend to spend most of their R&D in Europe. Contrary to the electronics and electronic components sectors, there is less outsourcing in the measurement, optical and medical electronic devices industry. The industry is typically characterised by many different niche markets, served by SMEs.

The advantages of Europe with its highly skilled workforce, strong research infrastructure and sizable internal market has in general not seemed to outweigh these favourable conditions in these Asian countries. There are some exceptions though. During recent years the new EU Member States have emerged as a location for electronics manufacturing, with a

growth of production networks in the region. Following the burst of the 2001 technology bubble, many establishments in countries like Hungary and Czech Republic where set up to cut costs. Central and Eastern Europe are particularly popular in lower added value product manufacturing, which are characterized by low levels of R&D investments and a low share of R&D personnel compared to the old Member States (IPTS, 2008; Reed Business Information, 2008). New recently emerging externalisation strategies include the trend towards collaborative strategic cooperation between experienced partners in a synchronised supply chain. Another trend is locating R&D close to production ("the fab is the lab").

Box 2. Defining and measuring relocation and outsourcing

One of the biggest challenges when analysing and discussing offshoring and outsourcing is the definitional issue of what precisely is meant and - closely related – how to measure the phenomenon. Outsourcing covers activities previously carried out in-house sourced to third parties whether abroad or in the home country. Offshoring in its strictest sense relates to activities being discontinued in the home country and transferred to a location abroad managed within the same entity or by an affiliated legal entity (OECD, 2007). Frequently, the political debate mixes the above three and also discusses job losses due to restructuring unrelated to offshoring under the same label. Furthermore, the political debate is fuelled by estimates which are the main source of evidence in the absence of hard statistics. Two broad sources on job relocation have as a result emerged: private consulting estimates and press monitoring estimates (Van der Zee *et al.*, 2007). While consulting estimates have severe limitations (ibidem), the estimates collected by press monitorings such as the ERM are more reliable. The most valid data, however, systematic official statistics on the employment impact of relocation, are not collected anywhere in the world today. As a result, academics who nevertheless want to use official statistical data resort to proxies of indicators of relocation activity, such as trade data, FDI flows and input–output tables (Van der Zee *et al.*, 2007). However, these indicators only measure the indirect effects of relocation and are affected by a number of other factors making hard conclusions difficult to draw.

7 Regulation

The sector operates within an established legislative framework that includes, amongst others, product safety, energy labelling, minimum efficiency requirements, eco-design and waste. In general, the computer, electronic and optical products sector seems to be less strongly affected by regulatory measures and tax laws than other sectors in the EU. Moreover, the overall importance of regulation on innovation in the sector appears less than in most other sectors (Cleff et al., 2007). This does not imply that regulation is not important. Strong labour, social, environmental and health regulations – while having a positive societal impact - also come at a cost affecting competitiveness. Strong regulation, for instance on environmental aspects, is however not always detrimental to competitiveness, but could also help in creating competitive edge (first mover advantages, strong home market). Most of the prevailing regulation in the labour, social, environmental and health domain is still formulated at national level, even though the EU gives some policy guidance, for instance by indicating the margins within which Member States are free to formulate their own policies. In some sub-sectors such as irradiation, electromedical and electrotherapeutic equipment products have to abide to more national and European legislation than other sectors, as many medical applications require high standards concerning reliability and health.

Where product regulation is concerned, EU regulation is generally more direct in its application, influence and impact European-wide. For the computer, electronic and optical equipment sector, four recent directives are of particular importance: the Waste Electrical and Electronic Equipment (WEEE), the Restriction of Certain Hazardous Substances (RoHS), the 2005 Energy-using Products (EuP) and the REACH directive. Other relevant directives include Directive 2004/108/EC relating to electromagnetic compatibility and the low voltage Directive 2006/95/EC.

The 2003 EU directives *Waste Electrical and Electronic Equipment* (WEEE) and *Restriction of Certain Hazardous Substances* (RoHS) together mandate the recycling and restriction of hazardous materials in electronic and electric equipment. Producers are held responsible for taking back and recycling electrical and electronic equipment. Certain heavy metals are required to be substituted (like lead, mercury, cadmium, and hexavalent chromium), as well as flame retardants (polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (European Commission, 2002a; 2002b). Medical devices, control and monitoring equipment are exempt from the RoHS.

The *Energy-using Products* (EuP) directive of 2005 aims at reducing the use of energy in products. The directive does not introduce directly binding requirements for specific products, but sets the requirements and criteria for environmentally relevant products, like computers and other electric and electronic containing products. Products that fulfil the EuP requirements will benefit both business and consumers, by facilitating free movement of goods across the EU and by an enhancement of product quality and environmental protection (European Commission, 2007). That the EuP directive is of relevance to the sector is shown, for instance, by the fact that the total energy and fossil fuel input in the production of a desktop computer or a memory chip are much higher than in other manufacturing sectors. The ratio of fossil fuel use to product weight is 11, which is much larger than the factor of around 1-2 for many other manufactured goods (Williams, 2004).

The 2007 *REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals)* directive has a direct consequence for the computer, electronic and optical equipment sector in the EU, as several - sometimes hazardous - chemicals are part of the manufacturing process. REACH which applies to new and existing chemical substances has been adopted in 2007 and requires firms to test around 30,000 existing substances over the coming years. While this will pose additional costs for industry, it will reduce current testing requirements for new substances to encourage innovation (DG ENTR, 2007). However, this view was not unanimously shared and intensive discussions and negations with industry preceded the adoption of the legislation. Fears that chemical activities would relocate to locations with laxer regulation were brought forward against the legislation. As a result the legislation was adapted to minimise the risks of an increase in non- productive costs, of cartel agreements and of disproportionate exposure of SMEs. Consequently the CCIC established in its 2007 report that the REACH implementation costs appear acceptable (EESC, 2007), although previously concerns over the levels of direct and indirect costs were raised (CCIC, 2005). The crucial factor to ensure a level playing field for the European industry is the implementation of the REACH regulation on imports. Due to concentration thresholds and volume limitations, not all imports fall under the REACH legislation, potentially putting the EU industry and mainly SMEs in a disadvantageous position (EESC, 2007). The impact on employment however is difficult to foresee.

In July 2007 the revised European Parliament and Council Directive 2004/108/EC relating to *electromagnetic compatibility* came into force, replacing an existing Council directive on this

subject. The recently re-codified *low voltage Directive* 2006/95/EC in December 2006 seeks to ensure that electrical equipment within certain voltage limits both provides a high level of protection for European citizens and enjoys a Single Market in the European Union. The *New Approach to technical harmonisation* {COM(2007)37}, which aims to iron out product-related legislative weaknesses that prevent consumers and enterprises from fully exploiting the benefits of the Internal Market.

8 SWOT

SWOT analysis is a tool in management and strategy formulation, used to evaluate the Strengths, Weaknesses, Opportunities, and Threats involved in a project, business venture or – as in this case – a sector, the latter being defined within a well-described geographical entity. The aim of a SWOT analysis is to identify the key internal and external factors that are important to achieving a particular objective or set of objectives. Strengths and weaknesses are internal factors that create or destroy value. For a company these can include assets, skills or resources that a company has at its disposal, compared to competitors. Opportunities and threats are external factors that create or destroy value. They emerge from either the company dynamics of the industry/market or from demographic, economic, political, technical, social, legal or cultural factors (STEEP or DESTEP, see also chapter 9). When applied to the sector level, SWOT has a similar meaning, albeit on a higher, more aggregated level. The SWOT analysis presented in Table 8.1 is the result of an intensive workshop discussion which was subsequently validated and amended in two external workshops, including the final workshop in Brussels (step 10 in the methodological framework).

In general, the strengths of the sector relate to a strong collaborative capacity in regard of future developments and innovations and a strong science base, which taken together result in Europe in a high capacity for R&D and design. Furthermore, several strong brand names exist in Europe, which warrant strong value added generative capacity. Threats related to these strong points are the increasing efforts of Asian companies in R&D and their move towards higher value added and doing the design themselves. This forces the EU to increase its investment in R&D in order to stay competitive. Weaknesses in EU manufacturing in computer, optical and electronic products are the high cost of low skilled labour, the lack of EU-job mobility, the lack of standardization between EU-countries and the lack of a single European market. Opportunities include the growing health and medical equipment sector in which Europe has a relative strong position, just as the high end market segments, in which companies provide high value added, providing custom-made products in low volume.

Table 8.1 Analysis of Strengths, Weaknesses, Opportunities and Threats - Computer, Electronic and Optical Products Sector

Strengths	**Weaknesses**
• Strong science base across sub-sectors • High performing groups (Eindhoven-Leuven; several groups in Germany, etc) • Strong 'surrounding 'ICT services • Strong base for open innovation • High purchasing power in home market → potential for lead market and market for high end products • Single EU market scale attractive for firms to locate • High management capacity to manage large orchestrator firms in sector • Strong brands creating value added	• Low skilled European labour uncompetitive (high wages and labour costs) • Development activities of R&D moving with production to Asia • Resources, particularly R&D, accumulated in few large firms • Weak IPR in third countries • Short development / product cycles increase competitive pressures • Lack of standardisation / competition between countries (regulation) • Fragmented research in national EU markets • Barriers to EU job mobility
Opportunities	**Threats**
• High value added products require strong design / creativity / product development competences at which European firms are good at • Megatrends of energy/environment and security as future growth markets – also driven by regulation • Digitalisation of production and consumption (digital media, e-health, e-democracy) • Health and medical equipment (e-health, robots, related also to ageing) and digital media as growth markets • High-end market segments as growth markets – white goods / audio / etc. • Short product life cycles expand markets	• Asia moving from production to R&D, design & manufacturing location • European R&D relocating with production to Asia • Decrease of high volume / low profit segments undermining industry – impact on high end segments • Concentration of large firms – globally mobile

9 Drivers

9.1 Identification of sectoral drivers: methodology and approach

The methodological framework as defined by Rodrigues (2007) serves as the starting point for the identification of drivers. Rodrigues identifies three main driver categories: economic, technological and organizational drivers, with the economic dimension representing the main trends in demand and supply, the technological dimension covering the main trends in process and product innovation (including services) and the organizational dimension representing main trends in job functions (conceptual, executive). The Rodrigues' approach in principle enables the identification of drivers, and especially so at the meso (sector) and micro (firm or company) level. The search and identification procedure of drivers itself is less

well defined, however. Implicitly it is assumed that expert opinion and desk study are sufficient tools to come up with a relevant and plausible set of drivers at the sector level.

During the first stage of the project, a methodological tool (approach) has been developed to facilitate and help the identification and further delimitation of drivers, to arrive at a set of key drivers. Apart from expert opinion mobilised and managed as discussion panel (in a similar manner as a SWOT analysis is usually organised), this approach strongly builds on the findings of existing foresight and other future studies. By consistently linking the search for drivers with the findings in existing foresight and other future studies, a more coherent and all-embracive methodology to finding sector-specific drivers can be deployed. This so-called 'meta-driver' approach of identifying main sectoral drivers starts from a more generic list of meta-drivers derived from a literature survey, and subsequently in a step-wise manner delimits the drivers to a set of most relevant and credible drivers. It does so by combining adequate expert (sector) knowledge in a panel setting. By subsequently asking the expert panel to score the different drivers on a range of characteristics, including relevance, uncertainty, and expected impact (similar to a SWOT procedure), a corroborated and conclusive list of sector-specific drivers can be derived. The meta-driver approach hence enables filtering out in a systematic and consistent way meso and possibly micro (sector-specific) as well as the macro (economy-wide) trends and developments judged relevant and important to the sector, directly and indirectly.

The meta-driver approach includes the following five steps:

Step 1. Drawing up of a list of relevant generic or meta-drivers based on literature review and expert knowledge (check-list: rows)

Step 2. Designing a list of key questions in order to identify the sector relevance and other properties of meta-drivers at sector level (check-list: columns)

Step 3. Filling in the check-list matrix: which meta-drivers do matter most for the sector?

Step 4. Which drivers do matter most for jobs and skills?

Step 5. Does the tailor-made list herewith cover all relevant sectoral drivers, i.e. are there any sector-specific drivers missing (check on completeness)

Arguments in favour of the use of the 'meta-driver' approach are:

- The ability and opportunity to use the rich potential of a multitude of already available studies on drivers, determinants of change and key trends
- Circumventing the risk of a too narrow focus on the sector per se while acknowledging sector-specificity, and avoiding the risk of analyzing sectors as if they were isolated (cf the difference between 'general equilibrium' and 'partial equilibrium' approaches)
- Guaranteeing overall consistency, coherence and completeness, as well as warranting a same point of departure important across lots/sectors – i.e. a way of integral assessment, making sure that all important factors are systematically taken on board.

An alternative and second way to arrive at a list of main sector-specific drivers of change is to start with a SWOT and subsequently translating the Opportunities and Threats part into sector-specific drivers. The SWOT is used as a tool to verify and check the resulting list of drivers. By combining the results of both the "from meta-drivers to sector-drivers" and the "from SWOT to sector-drivers" exercises a complete and consistent list of sector-specific drivers can be derived.

9.2 Sectoral drivers

In the following Table 9.1 the main drivers have been ranked. The main criteria for identifying these *main* drivers have been relevance (i.e. significance to the sector as such), uncertainty and expected impact on the sector (i.e. significance to the employment situation of the sector). Table 9.2 presents all drivers that have been considered in the scoring exercise.

Table 9.1 Main drivers in the computer, electronic and optical equipment sector

Driver	***Explanation***
Outsourcing and off-shoring	Substantial impact expected from this driver on levels and composition of employment as manufacturing moves to low(er) wage countries and to emerging markets; the skills need will shift towards managing outsourcing / offshoring; as well as towards abilities / skills to work in (national and international) value networks
Increased market segmentation	Move towards high value segments affects composition of employment with design and engineering becoming relatively more important functions
Global / regional production networks	Management of value networks important, but mostly already there and implemented → limited future impact on employment and skills expected
Higher income per capita	Increasing demand for high value added products; overall affect on employment limited but more skills in high end segments
Ageing	Adaption to changes in consumer demand – increasing demand for products designed for elderly people and medical equipment; but no impact on levels of employment / skills expected
Life style changes	Consumer demand key driver for sector, increasing individualisation leading to market segmentation
Internet	Driver for increased demand for hardware and integrated services in consumer segment
New business models	Large OEMs becoming orchestrator of supply chain with little manufacturing affecting levels, composition of employment and skills required
Emerging economies driving global growth	Increasing demand for computer, electronic and optical goods in developing countries as incomes will increase, esp. with the rise of middle income classes
Shortening of product life cycles	Leading to a higher production volume that will lead to either more employment, or a productivity increase of employees (working better, smarter, longer or harder)
Miniaturisation	Will ask different skills (e.g. in the field of nanotechnology) of employees and possible different assembly technologies that require different skills
Recycling	Increasing shift of the responsibility to the manufacturer to retake and recycle products, which will lead to increase of risks for employees that have to the deal with the hazardous materials in the products
Substitution of hazardous materials	Will reduce the risk for employees when working in manufacturing of electronic and optical equipment

Table 9.2 Assessment of main drivers based on the meta-driver approach

Category	Driver	Is this driver relevant for the sector? Y / N	How relevant is this driver for the sector? Scale 0-10	How uncertain is this driver for the sector? Scale 0-10	Are substantial impacts expected on the levels of employment? Y/N	Are substantial impact expected on employment composition? Y/N	Are substantial impacts expected on new skills? Y/N	Short, medium or long run impact?* S	M	L	Are substantial differences expected between (groups of) countries? Y / N	Are substantial differences expected between sub-sectors? Y / N
Ageing / demographics	Ageing - Adapt to the market demands of an ageing and more diversified society	Y	8	1	N	N	N		x	x	N	Y
	Ageing – declining labour force	Y	5									
	Population growth (birth and migration)	Y	2									
Economic	Income per capita and household	Y	9	2	N	Y	Y		x	x	Y	Y
	Income distribution	Y	3									
Globalisation	Outsourcing & offshoring	Y	9	1	Y	Y	Y	x	x	x	Y	N
	Increasing global competition	Y	9	1	-	-	-	x	x	x	N	N
	Emerging economies driving global growth (new market demand, especially BRICs)	Y	8	3	N	N	N	x	x	x	N	N
	Global / regional production networks (dispersed production locations, transport)	Y	8	2	N	N	N	x	x	x	N	N
	Counter-trend regionalism / protectionism	Y	6	6	Y	Y	N	x	x	x	Y	Y
Cultural values	Increasing market segmentation (tailor made production, mass customization)	Y	9	2	N	Y	Y	x	x	x	Y	Y
	Lifestyle changes	Y	8	2	N	Y	Y	X	X	X	Y	Y
	Increasing demand for environmentally friendly products	Y	5	4	N	N	N	x	x	x	N	N

Technology and innovation	Advances in IT impacting on organizational structures & new business models	Y	8	1	Y	-	-	x	x	x	N	N
	Internet changing production and consumption patterns (e-business; etc.)	Y	8	3	N	Y	Y		x	x	Y	Y
	New types of work organisation (teams-based, sociotechnique, etc.) **(see advances IT)**	N	-									
	New/additional value-added services (**see Internet driver)**	N	-									
	Other (sector specific)	N	-									
Natural resources	Availability (and price developments) of oil and energy	Y	3									
	Availability and price of other natural resources	Y	3									
Institutional / Political	Trade and market liberalisation (national level)	Y	3									
	EU integration – deepening (single European market etc.)	Y	3									
	EU integration – broadening (bigger domestic market)	Y	2									
	Quality of institutions (judiciary, transparency, lack of corruption, viable business climate, absence of structural rigidities, stability of legal framework)	Y	4									
	Labour market / health regulation	Y	4									
	Environmental regulation including energy efficiency	Y	6	4	N	N	N	x	x	x	N	N
	Security and safety regulation	Y	2									

Note: * Short = 0-3 years; medium = 3-7 years; long = > 7 years. All three categories may apply.

Part II.

Future Scenarios and Implications for Jobs, Skills and Knowledge

Part II. Future Scenarios and Implications for Jobs, Skills and Knowledge - Guide to the reader

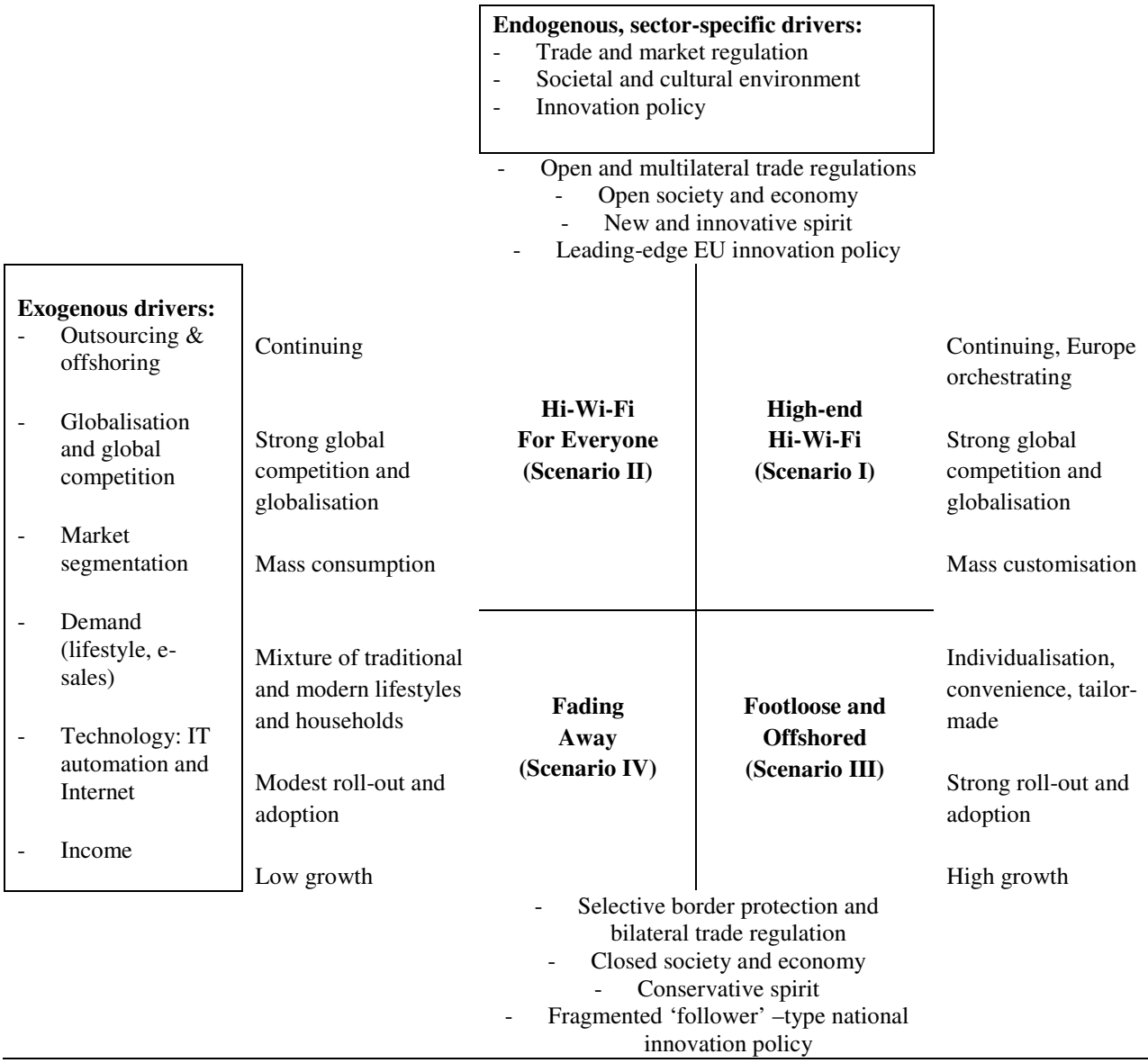
Part II presents the scenarios and their implications for jobs, skills and knowledge. It reflects steps 4, 5 and 6 of the common methodology. The contents of part II are as follows: Chapter 10 describes the structure and highlights the content of the four main scenarios (step 4). For each of these scenarios plausible yet different assumptions have been made as to how the main drivers of change will develop and add up to different states of the future. In subsequent steps the implications of the scenarios for jobs and skills are analysed. In order to facilitate a translation of these implications to the job function level, first a workable job function structure is proposed in Chapter 11. This structure is based on the functions as they appear in Eurostat's Labour Force Survey and further elaborated. Chapter 12 discusses the main implications of the scenarios in terms of future employment volumes by job function (step 5). Chapter 13 assesses the implications of scenarios for future skills and knowledge needs by job function. It translates the implications of the scenarios for skills and knowledge by function (step 6).

10 Scenarios

10.1 Overview of scenarios and main underlying drivers

Figure 10.1 presents four different scenarios and their underlying drivers for the computer, electronics and optical products sector (see further below). The scenarios which were specifically constructed for and used in this study are based on a clustering of relevant drivers identified in part I.

Figure 10.1 Drivers and scenarios computer, electronics and optical products sector



The scenarios are construed to 'scan' the future, and are for the purpose of this study used to assess the impact of future developments on jobs, skills and knowledge. It is important to understand what scenarios can deliver and what not. Scenarios depict plausible futures and might reveal possible paths of development towards these futures. They are neither

predictions or forecasts, nor wishful pictures ('dreams', 'crystal ball gazing') of the future. Grounded in existing data and trends, scenarios are derived in a logical and deductive way, with different and sometimes opposing presumptions about how key drivers might develop, resulting in inferences about plausible, i.e. credible and imaginable, futures.

In drafting the scenarios, a clear distinction has been made between exogenous and endogenous drivers; the horizontal axis in the figure represents the relevant exogenous drivers, whereas the vertical axis represents the relevant endogenous drivers. The main difference between the two categories of drivers is the scope and ability for direct influence. Exogenous drivers are drivers that form a "given" for the sector without much room for influence for/by individual actors drivers. Endogenous drivers are drivers that can be influenced at the sector level, for instance by national or European policy-making. Only those drivers that received the highest ranking - a score between 8 to 10 on a scale of 0 to10 (see Chapter 9) - have been taken into consideration.

The scenarios apply to the computer, electronic and optical products broadly defined. The distinction between the three sub-sectors - which is primarily data-driven as the categories conform to the available Eurostat NACE categories - has been used to describe and analyse past developments, trends and the current state-of-play. A more appropriate *analytical* way to look at distinctive future developments in the computer, electronic and optical products sector is to differentiate between electronic components and computers, communication equipment and consumer electronics on the one hand, and optical and medical products on the other. Where applicable, relevant and useful, reference will be made to this distinction in the next sections. Elsewhere, the computer, electronic and optical products sector will be treated as one aggregated sector. Note that the demographics – ageing of young and old – and its effects on labour supply have not been taken into consideration as distinguishing drivers between scenarios. Rather they are assumed to play similar roles in each of the scenarios.

One set of endogenous factors has been excluded from the scenarios; this concerns any of the strategies and/or policies taken to improve and further fine tune the educational and training system, as these are included in the next research step 8 'what can be the main strategic choices to meet these skill needs?' (see Chapter 13). In step 8, solutions are identified to meet the skill needs identified for each of the scenarios. Solutions include, amongst others, options to retrain workers, to offshore skills and to adapt the educational system. It should be mentioned that for the construction of the scenarios only those drivers with the highest ranking - a score between 8 to 10 (scale 0-10) as granted by a team of experts have been taken into consideration (see Chapter 9).

10.2 The drivers – building blocks for scenarios

The *exogenous drivers* that make up the four scenarios in Figure 10.1 reflect a world economy that is expanding further, with Europe finding its way but with the new emerging economies in Asia gradually but steadily growing in importance. In all scenarios, global competition and globalisation will increase, but at the right-hand side Europe is very much in control of orchestrating global innovation, sourcing and production networks. At the left-hand side Europe has to share this position with other leaders. A main difference between the left-hand and right-hand sides of the scenarios is defined through the development of income growth and in relation to that the extent of the need for customised and personalised products and the speed and reach of the adoption of ICT tools. The *endogenous drivers* on top of Figure 10.1 exemplify a situation of an open, creative and flexible society with effective and

streamlined European innovation policies as well as open and multilateral trade regulations. The bottom of the figure reflects a closed and conservative Europe with very fragmented innovation policies and selective and bilateral trade regulations. A further description of each of the individual drivers is given below, followed in section 10.3 by concise descriptions of the four scenarios.

Overview and description of exogenous drivers

- *Outsourcing and offshoring, especially of user industries*: Outsourcing and offshoring activities continue across sectors (e.g. automotive; ICTs) and time. Decreasing levels of offshoring may occur due to protectionist tendencies in response to globalisation as well as slower growth in world trade and third countries' economic growth; increasing levels of outsourcing may occur due to a positive conclusion of multilateral trade negotiations in WTO-context, as well as stronger growth of world trade and third countries' economic growth.
- *Globalisation and global competition:* globalisation will continue to play a major role in this sector, along fierce international competition. In all scenarios globalisation and global competition is supposed to be an important driver.
- *Income per capita*: Slower growth of income per capita due to less domestic growth and less global trade vs. faster growth of income per capita driven by an expanding global economy.
- *Technology*: Advances in ICT impact on organisational structure, with the Internet and automation changing production in ICT manufacturing, and in manufacturing in general. Technology also impacts the way consumers are able to buy their products (see further demand). Differences will apply to ICT, automation and broadband roll-out and uptake: strong on the right hand, moderate on the left hand.
- *Demand and market segmentation*: The demand for ICT products is very individualised for specific social groups with a strong demand for customisation and personalisation of products (right hand). At the other extreme, a mixture of traditional and modern lifestyles and households is observed together with a stronger demand for more standardised products (mass consumption), also because of income developments.

Overview and description of endogenous drivers

- *Trade and market regulation:* very important in all scenarios, with an emphasis on openness and trade, multilateralism and next WTO-Round successes on the upper end of the scheme, and an emphasis on selective border protection (operated via safety clauses) and trade, yet facilitated by bilateral trade agreements rather than by multilateralism at the bottom end of the scheme.
- *Societal and cultural environment*: at the top end the successes of the Lisbon strategy have brought about an open, creative society, which highly welcomes new technologies and opportunities. Appropriate regulation on issues of privacy and security ensure that trust in new technologies has been established. At the bottom end we observe a rather closed conservative society, without a lot of faith and trust in existing proven technologies, and with followers rather than early adopters and experimentalists.
- *Innovation policy:* on the one hand we observe a flexible and focused European innovation policy, with science and industry being even better supported, facilitated and stimulated to work on leading-edge high tech solutions (top of scheme); at the other hand we observe assume nationally-dominated fragmented (national) innovation policies without sufficient critical mass or focus (bottom of scheme).

10.3 The scenarios – detailed discussion

Based on the combination of endogenous and exogenous drivers we discriminate four sector scenarios for the computer, electronic and optical products sector:

- Scenario I: *High-end Customer Hi-Wi-Fi*
- Scenario II: *Hi-Wi-Fi for Everyone*
- Scenario III: *Footloose and offshored*
- Scenario IV: *Fading away.*

Scenario I: High-end Customer Hi-Wi-Fi
In the scenario High-end Customer Hi-Wi-Fi, the European computer, electronic and optical equipment industry creates sustainable high-end niches and is able to market its products both domestically and abroad. In High-end Customer Hi-Wi-Fi strong export goes hand in hand with continuing and strong international competition. European society is characterised by an open attitude, willing to experiment and looking for creative solutions for everyday problems (in the realm of work, leisure, quality of life). Together with a focussed European innovation policy and complementary streamlined national innovation policies, this creates a viable environment for regaining ground in both innovation leadership and market leadership for EU-based firms in the sector. The sector will first and foremost serve high-end niche markets. Due to life-style changes in society, consumers have a high demand for individualised products, which is met by the application of highly diversified mass customisation and mass individualisation. The specific needs of an ageing population will be addressed. Production of medical equipment is gaining importance and there is strong progress in recycling of materials, as well as developments in designing energy-efficient ICT equipment. European firms are the leading firms (e.g. Philips, Siemens) in organising and orchestrating the even more elaborate flexible international value networks. Most of the standardised production is being outsourced and offshored, but European companies increasingly move back to Europe their production facilities for high-end and niche segments of the European market. European companies are convinced that it is best to develop and produce high-end and niche products closer to the customers, that it enables better quality assurance and that it saves in logistics. The new Member States will gradually develop into a sizeable assembly platform for these high-end and niche products at the European market; it also gradually develops capacities in R&D and in the design of products.

Scenario II: Hi-Wi-Fi for Everyone
In the scenario Hi-Wi-Fi for Everyone it is predominantly the social and cultural climate that is conducive to change, with apt innovation policies stimulating further high tech innovations. However, European income growth is low, and with lagging growth (even falling behind) in the domestic market; consumer demand is also less individualized. Therefore, the most important opportunities for firms in the sector lie outside Europe: to export high tech niche products to the rest of the world. Product developments for specific groups, e.g. the elderly (health-related), halt in Europe because of fragmented markets and the dominance of national regulation; the single European market for services does not materialise. Europe specialises only in certain niche markets, like medical equipment for hospitals (but less for individual customers). Outsourcing and offshoring will continue and assembling presently located in the new Member States will move out of Europe as well. Only very specialised and tailor-made assembling of niche products for the export market will remain in Europe, probably in the new Member States. Although Europe will face multiple economic blocks to compete with, European firms will be able to compete fiercely on the basis of differentiation. Europe will belong to the leading coordinators of international value and production networks.

Scenario III: Footloose and Offshored
In the Footloose and Offshored scenario, income growth is strong and consumers are demanding more and more customised and personalised products and services. European society is, however, relatively inward looking. Innovation policies are fragmented across countries and do not generate sufficient mass to matter for innovation for this sector. European firms are outcompeted in meeting the demand for individualized products and services, including age-specific products. Highly customised high tech products and services are increasingly imported from outside Europe, especially from Asia. Indeed, consumers pick and choose from whatever is available, world-wide, and facilitated by the Internet. Assembling will move almost completely outside Europe, also the more specialised and tailor-made assembling. Several European firms will remain leading global value networks, but with hardly any production locations in Europe anymore. Transnational firms like Philips and Siemens - in that sense start to look more and more like clothing retailer Benetton: their headquarters, PR and marketing functions still being in Europe but most of the other vital company functions performed elsewhere and even outside the company. R&D – like production in the 1990s and the 2000s – has gradually moved out off Europe. For Asia or any other part of the world for that matter, Europe is no longer an important developing ground and source for high-tech products, services, knowledge and expertise.

Scenario IV: Fading away
In the Fading Away scenario income growth is low, and although Europe is still a sizeable market, the demand for renewing innovative products and services lags behind compared to other parts of the world. User industries tend to go where the(ir) markets are; Europe is losing ground in that respect. There is little demand for individualised products, including age-specific products and services. In general, European society is inward-looking with protectionist tendencies lurking. Innovation policy is mainly national policy and is fragmented. European firms show a striking lack of initiative and capability to develop new high tech products for the export market. European firms that still have some production in Europe will offshore and outsource the remainder outside Europe. Only the development and production of very specialised niche products will remain. Europe faces the risk of a brain drain of people working in the sector to other sectors, as well as the industry outside Europe.

Participants at the final workshop put the *High-end Customer Hi-Wi-Fi* as the most desirable scenario, but also the one most difficult to achieve. This scenario was regarded together with *Hi-Wi-Fi for Everyone* a *plausible* scenario for the medical, optical and precision devices sub-sectors. Most plausible overall, however, in the view of the workshop participants was *Hi-Wi-Fi for Everyone*. For the electronic components, computers and consumer electronics sub-sectors *Footloose and Offshored* also qualified as a very plausible scenario.

11 Job functions – towards a workable structure

In order to determine the quantitative and qualitative implications of the scenarios for jobs and skills, a workable job classification is needed. The occupational classification of the available sector data derived from the Eurostat Labour Force Survey (LFS) is used as a starting point (see Box 3). The advantage of using this classification is that developments in the past as observed in the LFS can help to foresee likely trends for the future. For example, it

might be expected that future developments in new Member States in some cases will follow similar paths as old Member States in the recent past. Moreover, where strong growth of certain job functions appeared in most recent years, one might have a reason to cautiously weigh and re-assess any further increases in future years, as the situation (markets and other factors) might have stabilised in the mean time. The share of job functions in total sector employment is not unimportant either; sizeable shares call for adequate attention. This does not imply that job functions with only very minor shares of the total should be ignored altogether. It might well be that occupations that have small shares now will face strong growth in the oncoming years, or are strategic and vital for growth of the sector as a whole, even if small in size.

However, the LFS job classification cannot be taken over one to one. First, the given LFS definitions of the job function groups are highly aggregated and cover therefore highly heterogeneous but not always comparable job functions. Reporting on this most aggregate level therefore would not be very illuminating. Second, some functions which may be strategic for the sector when looking at the future can be 'hidden' in a broader statistical category. This also includes 'new' emergent job functions. For both reasons some of the aggregated categories have been split up into separate job function categories, which have been given a more in-depth treatment. The opposite case, where certain job functions may be closely related, but do not fall within the same statistical LFS class, may also apply. Here it would be logical to combine them.

Box 3. The European Labour Force Survey

The European Union Labour Force Survey (LFS) is conducted in the 27 Member States of the European Union and two countries of the European Free Trade Association (EFTA) in accordance with Council Regulation (EEC) No. 577/98 of 9 March 1998. The data collection covers the years 1983 to 2006 and covers all industries and occupations. The national statistical institutes are responsible for selecting the sample, preparing the questionnaires, and conducting the direct interviews among households. The Labour Force Surveys are centrally processed by Eurostat, using the same concepts and definition, based on the International Labour Organisations guidelines and common classifications: (NACE (rev 1), ISCO-88 (COM), ISCED, NUTS).

Although the LFS can be used for comparative purposes, the relative small sample size (in 2002 the sample size was about 1.5 million of individuals, which represents 0.3% of the EU population) means that error margins can be high, especially when the industry itself is rather small.

Source: Eurostat (2008)

Third, in the trend analysis it was already observed that whereas in some countries employment shares of a particular (production) job function were extremely large, similar shares in other countries appeared extremely low, often with another closely related job function being much higher. A very likely explanation for this phenomenon is that in some countries workers are reported as job function x while in others they are reported as job function y, where basically similar tasks on the job are performed. By taking aggregates for these function types, this sort of reporting bias can be avoided. Fourth, the job functions that appear from statistical data analysis might not always be similar to what a person in or familiar with that sector would rank as the job functions that matter "in reality", i.e. from a work floor perspective. On the basis of discussions with experts and national sector skills studies, an attempt was made to provide a job classification that is both workable and recognisable by the sector in practice. This classification is shown as Table 11.1 below.

In order to establish a meaningful and appropriate classification, the existing LFS occupational classification for the computer, electronic and opticl products sector was adapted by either aggregating and/or selecting further differentiating some professions out of the original LFS statistical classification. This exercise was based on four criteria:

- employment shares (aggregating);
- closely related job functions (aggregating);
- strategic role in sector (disaggregating by further selecting among the occupational groups identified in the statistical classification);
- emergent job functions not yet covered and/or brought fully to light by current statistics.

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- employment shares (aggregating);
- closely related job functions (aggregating);
- strategic role in sector (disaggregating by further selecting among the occupational groups identified in the statistical classification);
- emergent job functions not yet covered and/or brought fully to light by current statistics.

Table 11.1 Job classifications

Classification in Labour Force Survey (LFS)	*Specific jobs of high relevance to sector falling in LFS classification*	*Job function categories as used in the next tables**
Managers	Corporate and specialist managers covering all firm functions. Especially managers that are capable of organising value chains, open innovation networks and global sourcing and production networks.	Managers
Computing professionals	Computer systems designers, analysts and programmers. Especially designers and system integrators	IT system developers IT system appliers and supporters
Engineers and related professionals	Electrical engineers and Electronics engineers. Especially designers and system integrators.	Production engineers R&D engineers
Business professionals Other professionals	Accountants, Personnel and careers professionals, Finance and sales professionals. Especially professionals that can translate market requirements into product specifications	Accounting & Finance Sales & Marketing Supply chain managers
Office clerks and secretaries Service workers	Office clerks and secretaries, customer services clerks, receptionists and information clerks, transport conductors	Support staff
Metal, machinery & related trades workers	Machinery mechanics and fitters, metal moulders, welders, tool makers	Metal & machinery workers
Electrical and electronic equipment mechanics and fitters	Electrical and electronics mechanics, fitters and services	Electrical and electronic equipment mechanics and fitters
Precision, handicraft, craft printing an related trades workers	Precision workers in metal and related materials, precision-instrument makers and repairers	Precision workers and repairers
Other craft and related trades workers	Other crafts	
Assemblers	Electrical and electronic equipment assemblers	Assemblers
Other plant and machine operators Labourers	Other machine operators Manufacturing labourers	Labourers

Table 11.1 shows the detailed job functions for the computer, electronic and optical products sector, based on the original LFS classification and the classification (third column) used in the remainder of this study. The following functions have been distinguished:

- *Managers*: top management and company owners/ entrepreneurs, but also including different specialist managers, such as HRM, finance, production, sales, and R&D management. Especially managers that are capable of organising value chains and innovation, sourcing and production networks are highly relevant for the sector.
- *IT system developers:* ICT professionals that develop and design systems and programmes such as system designers and programmers. Especially designers and IT systems integrators are important for the sector. In the optical products sector the focus will be on generating and processing images, which requires highly educated computing professionals.
- *IT system appliers and supporters*: ICT professionals that apply embedded software in the company as well as those supporting IT systems.
- *Production engineers*: electrical and electronics engineers, which apply and support the systems used in production.
- R&D engineers: electrical and electronics engineers that develop and design new products and processes and especially those that integrate systems, the 'architects'.
- *Accounting & Finance*: accountants and bookkeepers.
- *Sales and Marketing*: sales and marketing staff, capable of translating market requirements into product specifications, but also customer relation management.
- *Supply chain managers (SCM)*: a relatively new emergent category of high-educated workers who enable and facilitate complex regional and global SCM processes, including contracting.
- *Support staff*: on the one hand office clerks / secretaries & support staff covering administrative functions, including order management and stock keeping, and on the other hand legal professionals and HRM staff. Customer relation management and customer service activities are important especially in the consumer electronics sector.
- *Metal and Machinery workers*: metal moulders, welders, sheet-metal workers, blacksmiths, tool-makers, increasingly relevant for the optical products sector.
- *Electrical and electronic equipment mechanics and fitters*: electrical and electronics mechanics, fitters and services.
- *Precision workers and repairers*: precision workers in metal and related materials, precision-instrument makers and repairers, photographic workers. A distinction can be made between precision makers and repairers. Precision makers are usually highly qualified technicians, for example working in clean rooms, while precision repairers are especially active in after sales and maintenance, which often requires less high qualifications.
- *Assemblers*: electrical and electronic equipment assemblers, especially end-assemblers.
- *Labourers and operators*: manufacturing labourers, quality control workers.

An overall trend is that jobs become more standardised and more complex at the same time. Tacit knowledge becomes more explicit and codified and all tasks and responsibilities belonging to a certain job function are described. In addition, job functions are increasingly build up in a modular way, combining various tasks, responsibilities, skills requirements and competences needed: a 'pick and mix' system of job descriptions. However, this does not necessarily result in simpler jobs. On the contrary, the high level of quality requirements,

complicated products and production processes, increasing adoption of ICT and Internet, and increasing time pressures – just to name a few – make jobs more complex and demanding.[11]

12 Implications of scenarios by job function - volume effects

Different futures will have different implications for jobs, both in quantitative and in qualitative terms. In this chapter the implications of the four scenarios in terms of volume effects for each of the identified job functions are assessed. Trends and developments of the recent past provide an important starting point in forming an idea about these future developments. This quantitative trend information has been combined with expert opinions of a core expert team and supplemented with insights from invited sector experts in a dedicated workshop to assess which volume effects would be likely to occur for which job functions. It should be emphasized that the referred expected changes are qualitative in nature, reflecting the outcome of expert judgements and expert discussion as well as desk research taking into account the results of other studies. The results of the following chapter should therefore be used as a supplement and an independent expert assessment in addition to other more formal analyses, e.g. based on mathematical and/or econometric modelling and simulation.

Main volume trends based on the period 2000-2006 are as follows:

- *Managers:* managers represent 9% of the sector's workforce in the EU (equivalent to 185 thousand workers[12]), with a somewhat larger share (10%) in the EU-15, and a far lesser share in the new Member States (5%). Especially the number of high educated managers is increasing in the EU-15; the surge in managers in the new Member States is mainly based on the middle educated segment. It is expected that high educated managers will become increasingly important all over Europe. Especially managers capable of organising global value chains and innovation, production and sourcing networks will become important.
- *Computer professionals*: computer professionals represent 8% (158 thousand workers in 2006) of the sector's workforce in the EU. Over the period 2000-2006 their share increased with 2%. Especially high educated computer professionals have expanded their representation, but at the cost of middle educated IT professionals; this last group lost 6% in the EU-15 and 7% in the new Member States. On the other hand, the lower educated computer professionals increased with 3% in the new Member States. For the future it is expected that IT professionals will become more relevant, especially in relation to design, system integration and system architecture functions.
- *Engineers:* engineers represent by far the largest occupation function (19%, 396 thousand workers in 2006) and their share has increased with 2% in the period 2000-2006. This increase was somewhat stronger in the new Member States than in the EU-15. The share of low-educated engineers dropped with 2%, while the middle educated

[11] Comment by Prof. U. Huws at Final Workshop 20-21 November 2008; See also European Foundation for the Improvement of Living and Working Conditions (2007)

[12] Note that these figures (number of managers and all other job functions mentioned herein) are estimates, based on the latest Labour Force Survey (LFS) results.

engineers increased with 2 %. It is expected that especially the design functions, which require high education levels, will become highly relevant in the future.

- *Business and other professionals:* business and other professionals represent 303 thousand workers in 2006, which is a share of 14% of the sector's workforce in the EU. The number of business and other professionals remains relatively stable in the period 2000-2006, but there is a clear shift from lower educated professionals to middle educated professionals. Especially in the new Member States the middle educated professionals increased substantially. Nevertheless, the share of high educated business and other professionals decreased slightly. For the consumer electronics marketing and sales professionals will become increasingly important. Especially the translation from market requirements into product specifications as well as customer relation management will increasingly become important.
- *Support staff:* secretaries and office clerks represent about 10% of the sector's workforce (200 thousand employees), but is a declining job function in relative shares. Especially the lower and middle educated office clerks are diminishing and are increasingly replaced with high educated staff, mainly in the new Member States. Also the service workers are increasingly higher educated. The diminishing amount of support staff, in particular the lower educated job functions, is likely to be caused by productivity gains from ICT that allow organising work in a more efficient manner. This trend is expected to continue.
- *Metal and machinery workers:* metal and machinery workers represent 5% of the sector's workforce (94 thousand workers) in 2006 and their amount remained stable in the period 2000-2006. Also in this job function group, lower educated functions have been replaced with middle-educated jobs. It is expected that metal and machinery workers and in particular instrument makers will become more relevant because of the developments in the optical products sector.
- *Electrical and electronic equipment mechanics and fitters:* over-all Europe electrical and electronic equipment mechanics and fitters represent 7% of the sector's workforce (153 thousand workers in 2006). This share was somewhat higher in the new Member States (10%). In the period 2000-2006, the share of this job function group decreased slightly and again, lower educated jobs were replaced by middle educated jobs.
- *Precision workers and repairers:* in 2006 the precision, handicraft or craft related workers accounted for a share of 8% of the total worforce (163 thousand employees). This group of job functions remained stable in the period 2000-2006 and this is expected to continue in the future. Especially in the electronic components and optical products sector craft-related work will remain relevant.
- *Assemblers:* Assemblers is the largest group of employees in the new Member States (23%), but substantially less relevant in the EU-15 (8%). In total, 222 thousand employees are active in this function. The number of assemblers is diminishing in the EU-15, but still increasing in the new Member States. In addition, the job function assemblers is increasingly occupied by middle educated workers, at the cost of the lower educated workers. It is expected that end assembling will remain highly relevant in Europe, while sub-assembling will increasingly be done in Asian countries.
- *Labourers and operators:* labourers and operators of plants and machines represent 186 thousand workers in 2006 (9%). In the period 2000-2006 the amount of labourers decreased, especially in the new Member States, while the number of machine operators increased slightly. Like for other job functions, the share of lower educated jobs is diminishing and replaced with middle educated jobs.

The results in Tables 12.1 and 12.2 represent the relative expected changes in the volume of workers by job function in the computer, electronic and optical products sector by the scenario *end year* 2020. The tables show the different selected job functions and the changes expected for each of the scenarios. A distinction has been made between the electronic components and the computers, communication equipment and consumer electronics on the one hand and the optical and medical products on the other hand. In the last row an assessment of the overall expected job development is given. Table 12.1 represents the High-end Customer Hi-Wi-Fi and the Hi-Wi-Fi for Everyone scenarios. Table 12.2 highlights the Footloose and Offshored and Fading Away scenarios.

12.1 Volume effects scenarios *High-end Customer Hi-Wi-Fi* and *Hi-Wi-Fi for Everyone*

The High-end Customer Hi-Wi-Fi scenario gives the most positive results in terms of overall employment volume in 2020 (see Table 12.1). In this scenario, Europe will be leading and orchestrating the global innovation, production and sourcing networks and this will result in more managers, IT professionals and business professionals, especially those positions that require system integration capabilities. A sizeable assembly platform will gradually develop in Central and Eastern Europe with tailored production and assembly platforms, focusing on highly specialised niche markets. This will also increase the employment in assembling, especially in specialty assembling and end-assembling. The main difference between the electronic components and the computers, communication equipment and consumer electronics on the one hand and the optical and medical products on the other hand will be the fact that Europe will further extend its comparative advantage in the highly specialised and tailored medical and optical equipment segment, producing diagnostic equipment (X-ray, electro- and a range of other, mostly medical, equipment); radar, industrial process control equipment, but also instruments and appliances for aeronautical or space navigation. This development will result in an increase in specialised metal and machinery workers as well as precision workers and repairers.

The Hi-Wi-Fi for Everyone scenario will result in a relatively stable employment development. The opportunities will lie outside Europe and in very high-tech niche markets, for example in medical and precision equipment. Europe will remain an important orchestrator of global networks, hence requiring managers and business professionals capable of organising these networks, but it will not expand its leadership. Only very specialised and tailor-made assembling of niche products for the export market will remain in Europe, but the rest of the assembling will move outside Europe. Europe will continue developing specialised high-tech products, but it will be less extensive than in the first scenario. This implies that increases in employment are mainly to be expected in the optical and medical products sector.

Table 12.1 Scenario implications: relative volume changes by job function, 2009-2020

	High-end Customer Hi-Wi-Fi		*Hi-Wi-Fi For Everyone*	
	Electronic components, computers, communication equipment and consumer electronics	Medical, optical & measurement devices	Electronic components, computers, communication equipment and consumer electronics	Medical, optical & measurement devices
Managers	+	+	0	0/+
IT system developers	+	+	0/+	+
IT system appliers and supporters	0	0	0	0
Production engineers	0	+	0	0
R&D engineers	+	+	0/+	+
Accounting & Finance	0/+	0/+	0	0
Sales & marketing	+	+	0	0
Supply chain managers	+	+	0/+	0/+
Support staff	-	-	-	-
Metal and machinery workers	0	0/+	-	0/+
Electric and electronic equipment mechanics and fitters	-	-	-	-
Precision workers and repairers	0	+	0	+
Assemblers	0/+	+	-	0
Labourers and operators	-	-	-	-
Overall job change	**+**	**+**	***0***	***0/+***

Notes: - =decrease, +=increase, 0=maintain.

12.2 Volume effects scenarios Footloose and Offshored, and Fading Away

The net overall employment impact of the Footloose and Offshored scenario in 2020 imploy a stable development for the management and business professionals positions, but a real decline for the design and production functions. All production and also R&D has moved outside Europe and high-tech products and services are developed in other parts of the world, with jobs having moved with them. European firms are still important actors in organising the global value networks, but the only function they will keep in Europe are functions close to the market: marketing, PR and main headquarters functions. The impact of the Footloose and Offshored scenario will not differ between the electronic components and the computers, communication equipment and consumer electronics on the one hand and the optical and medical products on the other hand. The European consumer demand for these products is booming, but the products will be produced in and come from other parts of the world.

The Fading Away scenario has most negative employment implications. Due to negative market developments in Europe in combination with a conservative spirit, European firms will loose ground. European firms will move their activities completely outside Europe, although there will be some firms that will continue their function as organising and leading global value networks.

Table 12.2 Scenario implications: relative volume changes by job function, 2009-2020

	Footloose and Offshored		*Fading Away*	
	Electronic components, computers, communication equipment and consumer electronics	Medical, optical & measurement devices	Electronic components, computers, communication equipment and consumer electronics	Medical, optical & measurement devices
Managers	0/+	0/+	0/-	0/-
ITsystem developers	0	0	-	-
IT system appliers and supporters	0	0	-	-
Production engineers	-	-	-	-
R&D engineers	-	-	-	-
Accounting & Finance	0	0	-	-
Sales & marketing	0/+	0/+	-	-
Supply chain managers	0/+	0/+	0/-	0/-
Support staff	-	-	-	-
Metal and machinery workers	-	-	-	-
Electric and electronic equipment mechanics and fitters	-	-	-	-
Precision workers and repairers	-	-	-	-
Assemblers	-	-	-	-
Labourers and operators	-	-	-	-
Overall job change	***0/-***	***0/-***	**-**	**-**

Notes: - =decrease, +=increase, 0=maintain.

13 Implications of scenarios-main emergent competences

13.1 Introduction

Determining emergent competences is at the very heart of this study. In order to identify the main emergent competences by occupational function, the Rodrigues (2007) methodology refers to three main competences: theoretical, technical and social competences. This distinction builds on the distinction between knowledge, skills and competences in the European Qualifications Framework (EQF) and the European Credit system for Vocational Education and Training (ECVET) (see Box 4 below). The term human capital broadly defined by the OECD as 'the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being' (OECD, 2001:18) captures all three. The use of the term 'capital' leads one to think in terms of investments in education and training which are often necessary in order to acquire skills and knowledge. However, skills and knowledge can also be acquired through work experience, informal on-the-job learning and a variety of other means.

Box 4. Definition of competences, skills and knowledge in EQF and ECVET

Several definitions of knowledge, competences and skills are nationally as well as internationally under discussion. Moreover, Member States of the European Union still have different approaches in defining these terms. The European Union has set up a joint process to co-ordinate the different existing terminologies and to find a common basis. Aims of this process are for example to strengthen the mobility of the labour force within the European Union and to facilitate sectoral developments. In the following reference is made to the definition used by the European Qualification Framework (EQF) and the European Credit System on Vocational Education and Training (ECVET).

The EQF links national qualification systems and tries to make vocational training and lifelong learning more transparent and understandable. Therefore a common terminology was developed. The following descriptors are taken from the EQF (European Commission, 2008b; see also European Commission, 2008c):

- *Knowledge* refers to the outcome of the accumulation of information through learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of work or study. In the context of the European Qualifications Framework, knowledge is described as theoretical and/or factual;
- *Skills* refers to the ability to apply knowledge and use know-how to complete tasks and solve problems. In the context of the European Qualifications Framework, skills are described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments);
- *Competence* refers to the proven ability to use knowledge, skills and personal, social and/ or methodological abilities, in work or study situations and in professional and personal development. In the context of the European Qualifications Framework, competence is described in terms of responsibility and autonomy;
- *Qualification* refers to a formal outcome of an assessment and validation process which is obtained hen a competent body determines that an individual has achieved learning outcomes to given standards;
- *Learning outcomes* refer to statements of what a learner knows, understands and is able to do on completion of a learning process, which are defined in terms of knowledge, skills and competence.

Box 5. Skills needs, skills shortages and skills gaps defined

- *Emergent skills needs* are defined here as the change in skills that is needed to adequately fulfil a certain job function in the future. Addressing emergent skills is needed in order to avoid skills shortages and/or skills gaps in the future.
- *Skills shortages* exist where there is a genuine lack of adequately skilled individuals available in the accessible labour market. A skill shortage arises when an employer has a vacancy that is hard-to-fill because applicants lack the necessary skills, qualifications or experience.
- *Skills gaps* arise where an employee does not fully meet the skills requirements for a specific job function but is nevertheless hired. This skills gap needs to be closed through training. Skills gaps can arise where new entrants to the labour market are hired and although apparently trained and qualified for occupations still lack some of the skills required.

In the actual identification of future competences, the EQF/ECVET definitions are used as indicative. It is noted that the difference between competences and skills is not always clear-

cut, for instance where 'soft skills' come into play. A similar comment holds for what determines job or occupational qualifications.[13] Partly because of these identification issues, adequate measurement of competences, knowledge and skills is notoriously difficult. In some of the literature, the problem of skills measurement is sometimes avoided by using indicators (proxies) focusing on qualifications (high-level, intermediate-level, low-level) as well as occupations. For the purpose of identifying *future* skill needs such approach will not deliver useful results. Instead it is the knowledge and skills behind that need to be identified.

Rather than producing a full and exhaustive list of all competences for each job function, the key focus in this chapter is on identifying and describing key and critical competences for the future. The description will be focused but also general enough to be meaningful across countries. A slight extension of the original Rodrigues methodology is that together with the identification of critical skills and knowledge needs, a differentiation by scenario is made. Skills and knowledge needs are operationalised as expected key changes in specific skills and knowledge categories by occupation.

Throughout this report the term *competences* is defined as the "proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development." (see Box 4 for definitions). In the practical elaboration of competence needs hereafter the focus is predominantly on knowledge and skills needs, with a further distinction to what is usually described as 'soft skills' such as team working skills, and planning and organising. Note that the 'personal, social and/or methodological abilities' included in the definition of competences (see Box 4) come very close to what is generally understood as 'soft skills'.

A number of different skills categories have been taken into account, including social skills, problem solving skills, (self) management skills, skills related to entrepreneurship, as well as knowledge requirements (sometimes labelled as 'hard skills'). Table 13.1 provides an overview of the different skills and knowledge categories taken into consideration. Literacy and numeracy skills are not specifically mentioned in the tables. In practice these skills cannot be taken for granted. However, they are a prerequisite rather than an emerging skill to participate in the workforce especially in science-based sectors. For each job function key future skills and knowledge needs were identified. This was done in a workshop with a number of invited sector experts, and validated in two subsequent workshops, including the step 10 final workshop; the results therefore remain based on joint expert opinion. The analysis in Part I and the data tables formed a 'levelling' starting point for each of the discussants.

[13] 'Qualification' denotes the requirements for an individual to enter or progress within an occupation. It also denotes an official record (certificate, diploma) of achievement which recognises successful completion of education or training, or satisfactory performance in a test or examination. The concept of qualification varies from one country to another. It may express the ability – formally defined in work contracts or collective agreements – to perform a certain job or meet the requirements of the workplace. A qualification may give rise to a number of rights and prerogatives which determine the individual's position within the hierarchy of his/her occupational context. (Tessaring, 2004: 235).

Table 13.1 Overview of skills and knowledge clustered by category

Knowledge ('hard skills')
• Legislative / regulatory knowledge (environmental / safety / labour / contracting); Language*; e-skills; Marketing skills; Technical knowledge; Product knowledge; Product development
Social Skills
• Team working skills; Social perceptiveness (listening / understanding); Communication; Networking; Language*; Intercultural
Problem-solving Skills
• Analytical skills; Interdisciplinary; Initiative, Multi-skilling; Creativity
Self management
• Planning; Stress and time management; Flexibility; Multi-tasking
Management skills
• Strategic & visionary; Coaching and team building; Change management; Project management; Process optimizing; Quality management; people skills crucial for collegial management style
Entrepreneurial skills
• Supplier and customer relationship / understanding; Business understanding; Trend setting / trend spotting

Key 'new' competences were thus identified for various job functions taking High-end Customer Hi-Wi-Fi and Hi-Wi-Fi for Everyone as the most extreme focal scenarios. There will not be substantial different emerging competences between these scenarios as in both scenarios European companies will have opportunities for growth and will probably develop their business in the same direction. The main difference is in the market: the High-end Customer Hi-Wi-Fi scenario provides opportunities all over the world, while in the Hi-Wi-Fi for Everyone scenario provides mainly market opportunities outside Europe. The implications of the two other scenarios are not discussed in detail. Both Footloose and Offshored and Fading Away scenarios reflect 'gloomier' futures in which endogenous drivers are less well tuned to the interests of the computers, electronic and optical products sector in Europe, but with identical exogenous factors as scenarios High-end Customer Hi-Wi-Fi and Hi-Wi-Fi for Everyone. In other words, the global context in the top and bottom scenarios (see Figure 10.1) does not differ. What differs are the European factors.

The emergent future competences – defined as skills and knowledge needs - are identified and clustered together with similar ones in a concise overview table per job function (see next sections 13.2 to 13.11). Only *substantive key changes* in skills and knowledge needs are taken into account, which means that only part of the cells in the table is 'filled'. However, if a certain skill or knowledge type is highlighted in one scenario, but is not addressed in another,

this does not mean that it is irrelevant. Rather it means that relative demand for this skill in the latter case will not increase within the time frame 2009-2020.

13.2 Managers

Both the Hi-Wi-Fi scenarios are characterised by fast change and dynamic markets. While under the High-end Customer Hi-Wi-Fi scenario outsourcing and offshoring continues strongly and Europe will expand its network leadership, in the Hi-Wi-Fi for Everyone scenario Europe will stabilise this value network leadership. Diversification and segmentation of markets is key in the High-end Customer Hi-Wi-Fi scenario, requiring strong management skills to develop new markets and niches. In the Hi-Wi-Fi for Everyone scenario, the European market will offer fewer opportunities for customisation and tailoring, but the European firms will develop highly specialised and tailored products for the markets outside Europe. In the following the main future skills and knowledge needs are described. A summary of future skills and knowledge needs is provided in Table 13.2.

- Entrepreneurial skills of understanding consumer and supplier needs as well as spotting trends and market opportunities arising from structural changes are needed. Similarly the focus in these scenarios is on skills for developing new business in addition to managing and optimising of processes.
- Market segmentation implies organisational change management as old markets are restructured and new ones to be built up. This requires very well developed social skills to communicate change and inspire and manage people to grow and develop.
- Visionary and strategic skills are needed to identify market niches and successfully develop new business. With the focus on innovation and trend towards higher skilled employment management style becomes less hierarchical and more collegial.
- The changing organisational structures with increasing (out)sourcing, consumer and supplier relationships, project based team work leads to fluid organisational boundaries where management needs to be well networked and manage language and cultural differences.
- Due to a stronger differentiation of global supply chains and competition based on quality more than on price, total quality management skills will become more important.
- Globalisation and outsourcing requires more knowledge of global supply chain management, especially for SMES in order to strengthen their position in the sector.
- Global and virtual value networks bring new business models and types of collaboration, which will also require more knowledge of intellectual property.
- These skills and work requirements in a competitive global environment require managers to handle severe pressures for which time and stress management are crucial to function well over time.

Specific knowledge requirements:

- e-skills are crucial to operate in a modern business environment, also for managers; there is hence a need for continuously updating e-skills.

Table 13.2 Emerging skills and competences: Managers, 2009-2020

		High-end Customer Hi-Wi-Fi / Hi-Wi-Fi For Everyone
Knowledge / hard skills	Legislative & regulatory knowledge	
	e-skills	
	Technical knowledge	
	Supply chain management knowledge	
	Intellectual Property knowledge	
Social skills	Team working skills	
	Social perceptiveness	
	Communication	
	Networking	
	Language	
	Intercultural	
Problem solving skills	Analytical skills	
	Interdisciplinary	
	Initiative	
	Multi-skilling	
	Creativity	
Self management	Planning	
	Stress & time management	
	Flexibility	
	Multi-tasking	
Entrepreneurship	Understanding supplier & customers	
	Business development	
	Marketing skills	
	Trend setting / spotting	
Management skills	Strategic & visionary	
	Coaching & team building	
	Collegial management style	
	Change management	
	Project management	
	Process optimizing	
	Quality management	
Total emerging skilss and competences		Count: 18

Note: shaded areas highlight specific skills and knowledge that will become relatively more important in the future, and require up-skilling and knowledge upgrading. This does not mean that blank areas are irrelevant; rather here no change in terms of up-skilling and knowledge upgrading is needed. The darker the area shaded the more important it is in the scenario.

13.3 Computer professionals

Two different lines of IT work are distinguished:

- IT system developers: Developing and designing IT systems, products and processes for the sector itself
- IT system appliers and supporters: applying IT systems and infrastructure in the organisations active in the sector and providing support to these systems and infrastructure

IT professionals developing IT systems and products for the computers, electrical and optical products sector are already important for the sector, but the focus will be especially on skills related to system design and integration. The optical products sector requires extensive knowledge of optics, especially improved computing knowledge for generating and processing images. This will be extremely important for the development of completely new optical instruments for the medical sector.

IT support requires technical knowledge, also in relation to organisational change. Restructuring frequently results in IT systems integration. Furthermore, professionals need to keep up with technical knowledge of operating systems and programming languages. Although technical skills are very important, computer professionals working in the IT support need to develop their business and service-oriented skills in order to offer a full and proactive support service with regular (internal) client contact. Important soft skills are then customer interaction skills, the ability to work as a team, as well as understanding the business they work in.

Table 13.3 Emerging skills and competences: Computing professionals, 2009-2020

		High-end Customer Hi-Wi-Fi / Hi-Wi-Fi for Everyone IT system developers	***High-end Customer Hi-Wi-Fi / Hi-Wi-Fi for Everyone IT system appliers and supporters***
Knowledge / hard skills	Programming languages		
	Modelling & Simulation		
	B2B IT platforms		
	System integration		
	Imaging	In optical industry	In optical industry
Social skills	Team working skills		
	Social perceptiveness		
	Communication		
	Networking		
	Language	In NMS	
	Intercultural	In NMS	
Problem solving skills	Analytical skills		
	Interdisciplinary		
	Initiative		
	Multi-skilling		
	Creativity		
Self management	Planning		
	Project management		
	Stress & time management		
	Flexibility		
	Multi-tasking		
Entrepreneurship	Understanding supplier & customers		
	Business development		
	Marketing skills		
	Trend setting / spotting		
Management skills	Strategic & visionary		
	Coaching & team building		
	Collegial management style		
	Change management		
	Project management		
	Process optimizing		
	Quality management		
Total emerging skills and competences		Count: 15	Count: 13

Note: shaded areas highlight specific skills and knowledge that will become relatively more important in the future, and require up-skilling and knowledge upgrading. This does not mean that blank areas are irrelevant; rather here no change in terms of up-skilling and knowledge upgrading is needed. The darker the area shaded the more important it is in the scenario.

13.4 Engineers

Engineers represent by far the largest occupational function in the sector. With both scenarios characterised by fast change and dynamic markets, the move towards sustainable market niches and market segmentation are a key differentiator for the skills and knowledge requirements of engineers. Two main types of engineers are distinguished here:

- Production engineers
- R&D engineers.

R&D engineers belong to the most important job functions in both scenarios, as R&D forms the basis for growth in the sector in Europe and elsewhere. Production engineers are very relevant in the highly complicated production of high-tech products ('the Fab is the Lab'), especially in the optical, medical and precision products sector. Both require not only technical but also organisational and social skills. Social skills (esp. team working, communication and networking), problem solving skills (analytical, interdisciplinary, initiative, multiskilling, creativity) and self management (planning, flexibility, stress and time management) skills are important for both production and R&D engineers.

- In both scenarios, *R&D engineers* will need to focus on the design of new products and services, should be able to have a broad perspective on the needs of the markets (trend spotting, visionary skills), and should be able to integrate different solutions into one product or service. Although in Hi-Wi-Fi for Everyone the European market will ask for mass consumption, the European firms will develop their high-tech products for the export market. While technical knowledge in general, and product development and system architecture knowledge are key for R&D engineers, also business understanding / customer understanding is crucial.
- Innovation is organised around interdisciplinary expert teams on a project basis and in a collaborative working mode, even incorporating external experts either from universities or other firms. This requires increased project management skills from especially *R&D engineers*.
- As surveyors of the production process, process optimising and quality management skills will be important for *production engineers* as well, especially in high-tech products markets, including the medical, optical and precision equipment sector.

Training and educational needs:

- Interdisciplinary studies are needed to develop the skills and capabilities for designing products and services integrating several solutions addressing market needs
- At present, there are not so many students trained in optical sciences. This will imply a lack of trained people for the optical products sector in the near future. More students should be trained in the optical sciences.

Table 13.4 Emerging skills and competences: Engineers, 2009-2020

		High-end Customer Hi-Wi-Fi/ Hi-Wi-Fi for Everyone ***Production engineers***	***High-end Customer Hi-Wi-Fi/ Hi-Wi-Fi for Everyone*** ***R&D engineers***
Knowledge / hard skills	Legislative / regulatory knowledge		
	e-skills		
	Technical knowledge		
	Product knowledge		
	Product development		
	System architecture knowledge		
Social skills	Team working skills		
	Social perceptiveness		
	Communication		
	Networking		
	Language		
	Intercultural		
Problem solving skills	Analytical skills		
	Interdisciplinary		
	Initiative		
	Multi-skilling		
	Creativity		
Self management	Planning		
	Stress & time management		
	Flexibility		
	Multi-tasking		
Entrepreneurship	Understanding supplier & customers		
	Business development		
	Marketing skills		
	Trend setting / spotting		
Management skills	Strategic & visionary		
	Coaching & team building		
	Collegial m anagement style		
	Change management		
	Project management		
	Process optimizing		
	Quality management		
Total emerging skills and competences		Count: 14	Count: 20

Note: shaded areas highlight specific skills and knowledge that will become relatively more important in the future, and require up-skilling and knowledge upgrading. This does not mean that blank areas are irrelevant; rather here no change in terms of up-skilling and knowledge upgrading is needed. The darker the area shaded the more important it is in the scenario.

13.5 Supply Chain Managers

Supply chain management is a new function based on global reach of firms promising strategic advantages by sourcing globally, improving customer service and getting products to market faster. The function is a hybrid of previous job functions related to purchasing, sales and logistics. The skills required by SCM professionals are not scenario dependent.

While the demand for this type of job function manifests itself in the increasing numbers of university courses focused on supply chain management, the required competences can partially be acquired through codified knowledge but also rely in large parts on practical experience and learning on the job. Specific knowledge requirements relate to:

- University degrees in supply chain management / business management courses for people on the job
- Relevant IT skills of programmes related to supply chain management SCM / SRM / CRM etc.
- Trade regulation, taxes / tariffs
- Judicial / legal knowledge; contracts
- Financial knowledge: with volatile raw material prices increasingly financial instruments to hedge sourcing become relevant knowledge for professionals

Like most professional jobs a set of soft skills is required to function in a global environment. Global sourcing requires language / intercultural skills as well as standard social skills. Additionally, working with various partners around the globe also requires excellent project management skills and self management (stress & time management).

A pressing e-skill demand in both scenarios for SCM professionals are e-business skills for supply chain management to enhance effectiveness and efficiency in value chain management.

Table 13.5 Emerging skills and competences: Supply Chain Managers, 2009-2020

		High-end Customer Hi-Wi-Fi/ Hi-Wi-Fi for Everyone
Knowledge / hard skills	Legislative / regulatory knowledge	
	e-skills	
	Technical knowledge	
	Product knowledge	
	Product development	
	Financial knowledge	
Social skills	Team working skills	
	Social perceptiveness	
	Communication	
	Networking	
	Language	
	Intercultural	
Problem solving skills	Analytical skills	
	Interdisciplinary	
	Initiative	
	Multi-skilling	
	Creativity	
Self management	Planning	
	Stress & time management	
	Flexibility	
	Multi-tasking	
Entrepreneurship	Understanding supplier & customers	
	Business development	
	Marketing skills	
	Trend setting / spotting	
Management skills	Strategic & visionary	
	Coaching & team building	
	Collegial management style	
	Change management	
	Project management	
	Process optimizing	
	Quality management	
Total emerging skills and competences		Count: 10

Note: shaded areas highlight specific skills and knowledge that will become relatively more important in the future, and require up-skilling and knowledge upgrading. This does not mean that blank areas are irrelevant; rather here no change in terms of up-skilling and knowledge upgrading is needed. The darker the area shaded the more important it is in the scenario.

13.6 Accounting & Finance

Accounting and finance professionals are and will also in the future be required for the controlling, bookkeeping and financial activities of firms. In that context they play an important role to any organisation managing the complex flow of money. For that they require high analytical skills as well as a developed set of soft skills required for any professional job including relevant social skills.

Specific knowledge required relates to:

- Legislative / regulatory knowledge including accounting standards & regulation as well as financial regulations. In that context the computer, electronic and optical products sector is a global sector making it necessary for accounting and finance professionals to have an international orientation.
- E-skills are of crucial important, specifically programmes used for bookkeeping and accounting.

Table 13.6 Emerging skills and competences: Accounting & Finance, 2009-2020

		High-end Customer Hi-Wi-Fi/ Hi-Wi-Fi for Everyone
Knowledge / hard skills	Legislative regulatory knowledge (Accounting standards; financial regulations; contract law)	
	e-skills (accounting programmes)	
Social skills	Team working skills	
	Social perceptiveness	
	Communication	
	Networking	
	Language	
	Intercultural	
Problem solving skills	Analytical skills	
	Interdisciplinary	
	Initiative	
	Multi-skilling	
	Creativity	
Self management	Planning	
	Project management	
	Stress & time management	
	Flexibility	
	Multi-tasking	
Entrepreneurship	Understanding supplier & customers	
	Business development	
	Marketing skills	
	Trend setting / spotting	
Management skills	Strategic & visionary	
	Coaching & team building	
	Collegial management style	
	Change management	
	Project management	
	Process optimizing	
	Quality management	
Total emerging skills and competences		Count: 10

Note: shaded areas highlight specific skills and knowledge that will become relatively more important in the future, and require up-skilling and knowledge upgrading. This does not mean that blank areas are irrelevant; rather here no change in terms of up-skilling and knowledge upgrading is needed. The darker the area shaded the more important it is in the scenario.

13.7 Sales & Marketing

Sales & marketing staff is responsible for managing customer relations, marketing the products and managing sales activities. The global nature of the industry under the scenarios envisaged requires strong language and intercultural skills. In addition, sales and marketing work requires high level social skills to engage in extensive contacts with external parties such as customers or service providers. These social skills are part of the set of soft skills that are required in most professional jobs such as team working, communication, networking, language and intercultural skills in addition to flexibility, creativity, multi-tasking and project management skills.

With increasing market segmentation and niche markets emerging in the scenarios, entrepreneurial skills such as spotting of market trends and opportunities become increasingly important. Moreover, it will be very important to be able to translate market requirements into product specifications.

While sales and marketing is not a science but an art, it is mostly learned through learning on the job. Specific knowledge requirements relate to:

- Product knowledge, especially the technical understanding of products, in order to be able to serve clients.
- e-skills and particularly e-business skills as for most professional jobs are crucial and need to be up-to-date. Sales and marketing staff frequently works with specific IT programmes to manage client relationships / communication.
- With national differences in regulation of the sector, sales staff that sells products in international markets needs to be aware of differences in environmental and health and safety regulation to perform its tasks.

The relative share of sales and marketing is expected to be constant across both scenarios. Nevertheless, it is expected that in the Hi-Wi-Fi For Everyone, the amount of sales and marketing jobs will stabilise, while in the High-end Customer Hi-Wi-Fi sector employment in marketing and sales will increase.

Table 13.7 Emerging skills and competences: Sales & Marketing 2009-2020

		High-end Customer Hi-Wi-Fi/ Hi-Wi-Fi for Everyone
Knowledge / hard skills	Legislative / regulatory knowledge	
	e-skills	
	Product knowledge	
Social skills	Team working skills	
	Social perceptiveness	
	Communication	
	Networking	
	Language	
	Intercultural	
Problem solving skills	Analytical skills	
	Interdisciplinary	
	Initiative	
	Multi-skilling	
	Creativity	
Self management	Planning	
	Project management	
	Stress & time management	
	Flexibility	
	Multi-tasking	
Entrepreneurship	Understanding supplier & customers	
	Business development	
	Marketing skills	
	Trend setting / spotting	
Management skills	Client relationship management	
	Coaching & team building	
	Collegial management style	
	Change management	
	Project management	
	Process optimizing	
	Quality management	
Total emerging skills and competences		Count: 20

Note: shaded areas highlight specific skills and knowledge that will become relatively more important in the future, and require up-skilling and knowledge upgrading. This does not mean that blank areas are irrelevant; rather here no change in terms of up-skilling and knowledge upgrading is needed. The darker the area shaded the more important it is in the scenario.

13.8 Support staff

Support staff should be understood here as being in support of all other job functions and to improve work effectiveness. The category of support staff is defined here to include all other support job functions than the ones that have already been described and not requiring tertiary education. Most support staff functions are administrative related jobs. Key knowledge required for these activities are up-to-date e-skills to function effectively in an administrative environment (basic internet skills; spreadsheet and word processing skills; e-monitoring skills).

In addition, a number of social skills is crucial to perform support functions in an organisation well, especially team working skills and communication skills. Both will become increasingly important in project driven environments. Project driven environments require self-initiative to work independently, good planning, multi-tasking and stress & time management. In international organisations also for support functions language and intercultural skills become increasingly important.

While there is little difference in skill needs between the sub-sectors as support staff comprises tasks generic to the sector, nevertheless a basic technical understanding of the products is beneficial for people seeking employment in the sector.

Table 13.8 Emerging skills and competences: Support staff, 2009-2020

		High-end Customer Hi-Wi-Fi / Hi-Wi-Fi for Everyone
Knowledge	e-skills	
Social skills	Team working skills	
	Social perceptiveness	
	Communication	
	Networking	
	Language	
	Intercultural	
Problem solving skills	Analytical skills	
	Interdisciplinary	
	Initiative	
	Multi-skilling	
	Creativity	
Self management	Planning	
	Stress & time management	
	Flexibility	
	Multi-tasking	
Entrepreneurship	Understanding supplier & customers	
	Business development	
	Marketing skills	
	Trend setting / spotting	
Management skills	Strategic & visionary	
	Coaching & team building	
	Collegial management style	
	Change management	
	Project management	
	Process optimizing	
	Quality management	
Total emerging skills and competences		Count: 9

Note: shaded areas highlight specific skills and knowledge that will become relatively more important in the future, and require up-skilling and knowledge upgrading. This does not mean that blank areas are irrelevant; rather here no change in terms of up-skilling and knowledge upgrading is needed. The darker the area shaded the more important it is in the scenario.

13.9 Metal and machinery workers

Metal and machinery workers include metal moulders, welders, sheet-metal workers, blacksmiths, and tool-makers. In contrast to job functions described earlier, which require a large and diverse set of soft skills, the core competences of metal and machinery workers relate first and foremost to the technical knowledge required to perform the tasks of their work. The technical nature of this job function makes it crucial to keep the technical knowledge of workers up-to-date and to expand it towards promising market niches, such as the medical products sector. As metal and machinery workers are also responsible for overseeing the production process, knowledge about quality control skills is of increasing importance, especially in the production of high-tech products such as optical products. Knowledge of production relevant regulation such as WEEEm, RoHs, EuP and REACH is also getting more important. Nevertheless, also for metal and machinery workers the changes in work organisation require increasingly social skills related to team working and communication skills.

Table 13.9 Emerging skills and competences: Metal and machinery workers, 2009-2020

		High-end Customer Hi-Wi-Fi/ Hi-Wi-Fi for Everyone
Knowledge / hard skills	Legislative / regulatory knowledge (e.g. production relevant regulation such as WEEEm, RoHs EuP, REACH)	
	e-skills	
	Technical knowledge	
	Product knowledge	
	Product development	
	Quality control skills	
Social skills	Team working skills	
	Social perceptiveness	
	Communication	
	Networking	
	Language	
	Intercultural	
Problem solving skills	Analytical skills	
	Interdisciplinary	
	Initiative	
	Multi-skilling	
	Creativity	
Self management	Planning	
	Stress & time management	
	Flexibility	
	Multi-tasking	
Entrepreneurship	Understanding supplier & customers	
	Business development	
	Marketing skills	
	Trend setting / spotting	
Management skills	Strategic & visionary	
	Coaching & team building	
	Collegial management style	
	Change management	
	Project management	
	Process optimizing	
	Quality management	
Total emerging skills and competences		Count:10

Note: shaded areas highlight specific skills and knowledge that will become relatively more important in the future, and require up-skilling and knowledge upgrading. This does not mean that blank areas are irrelevant; rather here no change in terms of up-skilling and knowledge upgrading is needed. The darker the area shaded the more important it is in the scenario.

13.10 Electric and electronic equipment mechanics and fitters

The most important core competence of electric and electronic equipment mechanics and fitters is the technical knowledge required to perform the tasks of their work. The technical nature of this job function makes it crucial to keep the technical knowledge of workers up-to-date. This also includes knowledge of production relevant regulation and quality control skills. However, also for metal and machinery workers the changes in work organisation require increasingly social skills related to team working and communication skills.

Table 13.10 Emerging skills and competences: Electric and electronic equipment mechanics and fitters, 2009-2020

		High-end Customer Hi-Wi-Fi/ Hi-Wi-Fi for Everyone
Knowledge / hard skills	Legislative / regulatory knowledge	
	e-skills	
	Technical knowledge	
	Product knowledge	
	Product development	
	Quality control skills	
Social skills	Team working skills	
	Social perceptiveness	
	Communication	
	Networking	
	Language	
	Intercultural	
Problem solving skills	Analytical skills	
	Interdisciplinary	
	Initiative	
	Multi-skilling	
	Creativity	
Self management	Planning	
	Stress & time management	
	Flexibility	
	Multi-tasking	
Entrepreneurship	Understanding supplier & customers	
	Business development	
	Marketing skills	
	Trend setting / spotting	
Management skills	Strategic & visionary	
	Coaching & team building	
	Collegial management style	
	Change management	
	Project management	
	Process optimizing	
	Quality management	
Total emerging skills and competences		Count: 9

Note: shaded areas highlight specific skills and knowledge that will become relatively more important in the future, and require up-skilling and knowledge upgrading. This does not mean that blank areas are irrelevant; rather here no change in terms of up-skilling and knowledge upgrading is needed. The darker the area shaded the more important it is in the scenario.

13.11 Precision workers and repairers

Precision workers and repairers include precision workers in metal and other materials, precision-instrument makers and repairers. A distinction is made between *precision workers/makers*, highly qualified technicians specialised in precision production, sometimes working in protected clean rooms, and *precision repairers*, who are mainly active in maintenance and repair, an activity with a relatively high level of standardisation. For both the most import competence is technical knowledge of the work they do. It is very important to keep the technical knowledge up-to-date and to acquire new knowledge in new, but related, areas. Especially for the optical and precision products sector, expertise and knowledge of precision instruments and works is crucial. This also applies to quality control skills and product(ion) relevant regulation. Problem-solving skills including analytical and interdisciplinary skills, initiative and multiskilling, as well as self-management (flexibility) are key. However, also for precision workers and repairers the changes in work organisation require increasingly social skills related to team working and communication skills.

Table 13.11 Emerging skills and competences: Precision workers and repairers, 2009-2020

		High-end Customer Hi-Wi-Fi and Hi-Wi-Fi for Everyone ***Precision makers***	***High-end Customer Hi-Wi-Fi and Hi-Wi-Fi for Everyone*** ***Precision repairers***
Knowledge / hard skills	Legislative / regulatory knowledge		
	e-skills		
	Technical knowledge		
	Product knowledge		
	Product development		
	Quality control skills		
Social skills	Team working skills		
	Social perceptiveness		
	Communication		
	Networking		
	Language		If working internationally
	Intercultural		If working internationally
Problem solving skills	Analytical skills		
	Interdisciplinary		
	Initiative		
	Multi-skilling		
	Creativity		
Self management	Planning		
	Stress & time management		
	Flexibility		
	Multi-tasking		
Entrepreneurship	Understanding supplier & customers		
	Business development		
	Marketing skills		
	Trend setting / spotting		
Management skills	Strategic & visionary		
	Coaching & team building		
	Collegial management style		
	Change management		
	Project management		
	Process optimizing		
	Quality management		
Total emerging skills and competences		Count: 11	Count: 13

Note: shaded areas highlight specific skills and knowledge that will become relatively more important in the future, and require up-skilling and knowledge upgrading. This does not mean that blank areas are irrelevant; rather here no change in terms of up-skilling and knowledge upgrading is needed. The darker the area shaded the more important it is in the scenario.

13.12 Assemblers

Like in other production functions, the main competence of assemblers is the technical knowledge of the job to be done. Central and Eastern Europe will develop into a specialised assembling platform. Assembling in Europe will increasingly focus on the end-assembling of products as well the assembling of special high-tech products for niche markets. Quality control is one of the main skills needed. Changing work organisation will also require soft skills related to team working and communication (see Table 13.12). Language skills can be important especially for migrant workers, because they have to be well informed about the safety & health regulations and all kinds of instructions. As there is a constant need for increasing productivity and a strong time pressure, assemblers will need skills in stress & time management.

Table 13.12 Emerging skills and competences: Assemblers, 2009-2020

		High-end Customer Hi-Wi-Fi / Hi-Wi-Fi for Everyone
Knowledge / hard skills	Legislative / regulatory knowledge	
	e-skills	
	Technical knowledge	
	Product knowledge	
	Product development	
	Quality control skills	
Social skills	Team working skills	
	Social perceptiveness	
	Communication	
	Networking	
	Language	
	Intercultural	
Problem solving skills	Analytical skills	
	Interdisciplinary	
	Initiative	
	Multi-skilling	
	Creativity	
Self management	Planning	
	Stress & time management	
	Flexibility	
	Multi-tasking	
Entrepreneurship	Understanding supplier & customers	
	Business development	
	Marketing skills	
	Trend setting / spotting	
Management skills	Strategic & visionary	
	Coaching & team building	
	Collegial management style	
	Change management	
	Project management	
	Process optimizing	
	Quality management	
Total emerging skills and competences		Count: 11

Note: shaded areas highlight specific skills and knowledge that will become relatively more important in the future, and require up-skilling and knowledge upgrading. This does not mean that blank areas are irrelevant; rather here no change in terms of up-skilling and knowledge upgrading is needed. The darker the area shaded the more important it is in the scenario.

13.13 Labourers and operators

The number of production labourers in this sector is diminishing in Europe, as most of the simple production activities have moved outside Europe or have been replaced by machines. Future employment opportunities for this type of workers will be mostly in other positions within the organisation which requires up-skilling and retraining towards future skill requirements of, for instance, metal and machinery workers as well as precision workers and repairers. With the pool of labourers getting much smaller, those that stay in the sector face stronger skills requirements as well. A small replacement demand will continue to exist, with the character of this job function changing, requiring more – even if basic - IT-skills, stress management skills and a higher demand for flexibility. Quality control skills – product control but also process-related (labour safety) - will need gradual updating, to reflect increased product and safety demands.

Labourers outside production who are active in cleaning, catering (canteen) and (partly also) general maintenance – also part of the miscellaneous category labourers - will increasingly see their job outsourced to third party service providers; therefore, this type of job function will shift to the service sector. new technology.

Table 13.13 Emerging skills and competences: Labourers and operators, 2009-2020

		High-end Customer Hi-Wi-Fi / Hi-Wi-Fi for Everyone
Knowledge	Legislative / regulatory knowledge	
	e-skills	
	Technical knowledge	
	Product knowledge	
	Product development	
	Quality control skills	
Social	Team working skills	
	Social perceptiveness	
	Communication	
	Networking	
	Language	
	Intercultural	
Problem solving	Analytical skills	
	Interdisciplinary	
	Initiative	
	Multi-skilling	
	Creativity	
Self management	Planning	
	Stress and time management	
	Flexibility	
	Multi-tasking	
Entre-preneurship	Understanding suppliers customers	
	Business development	
	Marketing skills	
	Trend setting / spotting	
Management	Strategic and visionary	
	Coaching and team building	
	Collegial management style	
	Change management	
	Project management	
	Process optimizing	
	Quality management	
Total emerging skills and competences		5

Note: shaded areas highlight specific skills and knowledge that will become relatively more important in the future, and require up-skilling and knowledge upgrading. This does not mean that blank areas are irrelevant; rather here no change in terms of up-skilling and knowledge upgrading is needed. The darker the area shaded the more important it is in the scenario.

Part III.

Available Options to Address Future Skills and Knowledge Needs, Conclusions and Recommendations

Part III. Available Options to Address Future Skills and Knowledge Needs and Recommendations - Guide to the reader

In the final third part of this report, a range of main strategic options ('choices') is reviewed, including possible actions in education and training. The report concludes with a number of conclusions and recommendations for the sector (individual firms, sector organizations, others) and policy-makers at various levels, ranging from the EU to the local level. Part III reflects steps 7 (Main strategic choices), 8 (Main implications for education and training) and 9 (Main recommendations) of the common methodology. Its contents are as follows: Chapter 14 highlights the various strategic choices in response to future skills and knowledge needs. Chapter 15 focuses on specific implications for education and training. Chapter 16 concludes by providing a number of key recommendations and conclusions.

14 Strategic choices to meet emergent skills and knowledge needs

14.1 Introduction

This chapter identifies the main strategic choices to meet the skills and knowledge needs identified (step 7). It provides a framework to pick and select the most relevant strategic choices – i.e. solutions to meet future skills and knowledge needs - available. Strategic choices refer and relate to the medium- and longer term, even though emerging skills needs in practice may also apply to the now and tomorrow. Essential in seeking appropriate solutions is to keep this longer time perspective in mind. Rather than focusing on one single solution, a set of linked strategic choices will in most cases be the best strategy to follow. Prioritising both in time (what first, where to follow up) and in allocation of resources (budgetary focus) followed by further fine-tuning is a clear necessity to guarantee that skills needs are targeted and solved. Skill needs can be identified at various levels, ranging from assessments at the national or even European sector level - which are by nature rather general - to more precise assessments at the regional and company level. Especially for large enterprises not only the identification of skills needs but also the search for adequate solutions will be an integral part of an overall longer-term business strategy. Some solutions will be found within the company itself, for instance by reorganising functions within or between plants, by offering (re)training trajectories and by active global sourcing of personnel. For SMEs and especially for micro-enterprises[14] such longer-term, more strategic human resource management often will be more difficult to organise and operationalise. It should be emphasized that at all possible levels identified different actors need to act to address skills needs and offer solutions and preferably also in close concert. These can be individual firms, organised interests at the sector level (employers and employees), but also others. Local, regional and national governments have also a important role to play. This chapter offers first of all a better insight in the 'menu' of possible strategic choices (section 14.2). It also provides for a framework that can identify skills needs at the appropriate level and helps to decide which should be the actual choices to be made (see section 14.3). This framework is subsequently applied to the computer, electronics and optical products sector (section 14.4).

14.2 Possible strategic choices

The possible strategic choices contained in this chapter refer to the strategic choices originally proposed by Rodrigues (2007: 42) as well as a number of other, additional choices. Whereas *strategic* choices mostly refer to the medium and longer term, most of the choices mentioned can also be implemented in the short run, to 'mend' existing skills shortages and/or skills gaps. Each of the solutions at hand differs in whether or not it can resolve direct skills shortages and/or gaps. A longer term horizon, however, means that there is possibility of adapting, steering and fine-tuning the available solutions towards a more optimal allocation of skills supply and demand. In view of the time horizon, the period up to 2020, the strategic choices and instruments with a more long-term impact especially need to be addressed. Identification of possible solutions obviously is not enough. Concrete initiatives, policy and strategic decisions need to be taken at all appropriate levels with each actor having a different responsibility and a different role to play.

[14] Defined as firms with less than 10 employees.

Strategic choices to meet future skills needs need to be taken by a number of actors and at different levels (firm, local, regional, national, sectoral). For obvious reasons, firms are an important player in finding solutions for the skills needs – both in volume (skills shortages) and in matching any existing skills gaps. Companies avail of a number of options to meet their skills needs. These include:

A. Recruiting workers from other sectors
B. Recruiting workers from other Member States
C. Recruiting workers from non-Member States
D. Recruiting unemployed workers with or without re-training
E. Recruiting young people coming from the education system, with or without re-training (first job recruits)
F. Training employed workers
G. Changing the work organisation (including network collaboration and mergers)
H. Outsourcing and offshoring.

Sectoral organisations, educational institutions and governments also have a role to play. They will be the prime actors in addressing the following options:

I. Changing vocational education
J. Designing and offering new courses (continuing vocational education and training)
K. Providing information about jobs and (emerging) skills: career guidance; updating job profiles regularly.
L. Improve the image of the sector (joint action of companies together)
M. Stronger cooperation with the industry (internships, company visits for participants in education, image improvement).[15]

A more detailed description of these strategic options can be found in annex III. Whether these strategic options are feasible and viable depends on a number of factors. In order to discuss and select from the available list of strategic options, one should first - as described in the introduction - know whether and when skills needs are indeed likely to arise, both in quantitative (number of job functions) and in qualitative terms (what knowledge and skills). An important question that needs to be addressed first is at what level and to whom the skills needs question applies. Obviously for an individual firm different information is required for identifying these needs and taking the right action than for a national ministry or a training institute.

The identification of possible strategic choices would in principle require extensive and detailed future analysis at the Member State and preferably also the regional level of skills and knowledge demand and supply patterns by job function and sub-sector, in a similar way and along the steps provided by the methodology of this study so far. The methodology and step-wise approach followed are applicable at the national and regional level of analysis. Ideally, these results should be complemented by the results of labour market model forecasts to corroborate results. Such an analysis would also need to include an assessment of the numbers and skills composition of currently being educated, i.e. an assessment of all cohorts

[15] A more detailed description of these options can be found in annex I.

of primary, secondary and tertiary pupils and students (and their skills potential) currently in the educational system and arriving at the labour market in the oncoming years. It would need a thorough assessment of the current educational and training system itself, including the already decided changes herein for the oncoming years, to see whether the system as it is now in place is able to satisfy the prevailing and future new skills demands both in terms of numbers of new potential recruits and in terms of skills and knowledge.

14.3 Matching future skills and knowledge needs by making the right choises

In order to address the identified future skills and knowledge needs in an encompassing and timely manner, appropriate joint action is needed by all stakeholders, including the industry (firms, sector organisations and social partners), training and education institutes, intermediary organisations and, last but not least, government at all levels (EU, national, regional and local). Collaboration and co-operation between stakeholders will be needed, at all decision-making levels, in order to agree on and implement a package of feasible solutions. In order to prepare for this, timely, targeted and reliable information is essential.

This section presents a targeted short-cut strategic options decision tool to enable and support decision-makers in making the right (mix of) choices, supported by appropriate and reliable information on actual needs, possible choices and stakeholders to be involved. The strategic options decision tool is aimed to provide answers and solutions at the job function level and consists of a shortlist of a number of key questions - a concise menu of choice -, with answers providing decision-relevant information about the need and viability of available options. The questions need to be answered at the national, and where relevant at the regional level so as to map and identify the specific sector needs. The decision tool can also be used at the level of the firm. New job function information (e.g. new upcoming functions) can be added where thought relevant.

The key question list – consisting of six ‘framing’ questions, followed by option-specific questions - should be filled in for each job function. The ‘framing’ questions constitute a summary of main expected quantitative and qualitative skills needs developments. The filling in of the list should, however, only be done on the basis of an informed discussion between several stakeholders involved, representing together an informed body of knowledge on the various aspects at stake, including labour market developments and prospects at the sub-sector level, skill and knowledge requirements at job function level and developments in and make up/orientation of the educational and training system.

Key questions for identifying skills needs
Question 1. Is the demand for workers expected to decrease or increase between now and 2020? (both related to market prospects and replacement demand due to ageing)

If decreasing, there is probably less need for recruiting workers from other sectors and (non-) Member States and less need for recruiting unemployed.

If increasing, analyse whether less radical options are enough to meet demand or whether options should be chosen like recruiting workers from other sectors and (non-) Member States and recruiting unemployed. *[Note: see Table 12.1 and Table 12.2 for estimated volume effects per scenario.]*

Question 2. Are the required qualitative skills expected to be rather stable between now and 2020?

If there are not many changes in required competences, there is probably no need to apply many strategic options. Please focus on the options that are most effective.

If many competences are changing, there is probably a need to apply many strategic options. Create a package of strategic options to meet skills needs. *[Note: see Table 13.2 and following for the number of competences changing per job function per scenario.]*

Question 3. Do SME's and especially small companies (including micro enterprises) play a large role in the sector?

> If yes, several options (like recruiting) are less viable for companies themselves as it is often difficult for small companies to organize this. If this is the case, sector organisations or intermediary organisation might play an important role in helping to match supply and demand. Another solution could be found in changing the work organisation. Through cooperation or mergers, for instance, the relevant scale can be increased which makes it easier to use these options. The same holds, more or less, for the organisation of training and re-training. Larger (associations of) companies have less difficulties to organise this and the need for support from other actors is lower. [*Note: see Table 3.9 for number of firms per size class*]

Question 4. Are companies in general active on Member State level, EU level or global level?

> Companies who are active on a larger regional level will have, in general, more opportunities to use the option of recruiting workers from other Member States (for companies active at the EU level) and the option recruiting workers from non-Member States (for companies active at the global level). The same holds for the option offshoring. *[Note: see chapter 3]*

Question 5. Are workers in a job function in general low-educated?

> If yes, training is less easy to implement as a viable option as difficulties arise in organising this, while the need for training might be even higher. [*Note:see Table 3.14 to 3.16, for education shares*]

Question 6. Are workers in a job function in general old (i.e. older than the average age in the subsector and compared to other sectors)?

> If yes, training is less easy to implement as a viable option as difficulties arise in organising this and less new knowledge endogenously enters the companies, while the need for training might be even higher.

Key questions for identifying suitable options and relevant acting stakeholders

The six questions form the first part of the short-cut approach. The second part discusses the viability of strategic options to tackle and solve emergent skills and knowledge needs for each of the job functions identified. It confronts the list of available strategic options with the analysis of quantitative and qualitative developments on headlines based on the preceding six questions. For each job function identified an assessment is made on whether the available strategic options are relevant or not, and who should be prime actors to change the current situation into a more favourable direction. If the strategic option is considered relevant, a "yes" is filled in, else a "no" is included. If the strategic option is dependent on specific

characteristics of the sub-sector or components thereof, this is included in the table. For example, if recruiting workers from other Member States is only an option for large companies a "Yes, but only for large companies" will be included. Characteristics that are dealt with in the table are based on the six question analysis, representing:

- The change in volume (as a reference we include the most challenging scenario in terms of change required)
- The change in skills (as a reference we include the most challenging scenario, which is often the scenario with the largest change in skills and knowledge needs)
- Education level
- Age of the workforce
- Scale of the company and region the company is working in.

In principle, the following tables can be made scenario-dependent. In the descriptions below, the Hi-Wi-Fi for Everyone scenario and the High-end Customer Hi-Wi-Fi scenario have been taken as the point of reference as the most demanding and dynamic in terms of up-skilling, knowledge upgrading and change.

14.4 Managers

Table 14.1 presents viable strategic options for emergent competences of managers in both scenarios, the Hi-Wi-Fi for Everyone scenario as well as in the High-end Customer Hi-Wi-Fi scenario. The options are, first of all, recruitment of mangers from other sectors as well as, secondly, from other member and non-Member States. Via recruiting workers from other sectors the workforce of the sector increases in generic skills such as social skills, self management skills, E-skills and general management skills. However, workers with sector specific skills including legislative competences, business development skills, know-how on understanding clients and suppliers as well as knowledge about global supply chain management, quality management and intellectual property management are difficult to recruit from other sectors. Recruiting workers from other States (Member or non-Member) is a practice already implemented especially by large firms. In some countries the need for managers with outstanding strategic and visionary leadership skills is met by hiring managers from the United States (EIGT, 2004).

In formulating a recruitment strategy for managers from other sectors firms need to widen their recruitment horizon by incorporating younger groups as well as the female management potential. In general, the participation of women within the sector and, in particular, in management functions is still low (see Part I of this report). By making use of this potential within the industry, sector leadership and management styles could be changed due to gaining fresh ideas and vision. (Frenzel, 2001). The electronic, computer and optical sector is still dominated by men and up to now mangers are recruited mainly within the sector (EIGT 2008: 135). Thus, well developed traineeships and apprenticeships specifically targeted at younger groups and females are a viable option.

New recruits need to be trained in order to gain sector specific skills such as profound understanding of the needs of consumers and suppliers, business development skills as well as marketing, quality management, global supply chain management and intellectual property skills. The emergent demand for new and sector specific skills can better be met by designing and offering accurate up-to-date courses which are based on a solid co-operation between all

relevant stakeholders. Since trainings should be accurately fitting, a co-operation between stakeholders is recommended. This option is of great importance to SMEs, since they are not often linked to universities (EIGT, 2004: 145).

SMEs play a key role as employers in the sector: the total workforce of the sector is divided almost equally between SMEs and large firms. In the optical products sub-sector, for instance, SMEs are predominant (see Part I of this report).

Due to a general good reputation of managers and due to the availability of this occupational function at the labour market the demand for improving the image of this occupational function is not really required.

Table 14.1 Strategic options Managers

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SMEs play a large role?[16] 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Increase 18 Yes Global No No	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, mainly for general management skills	C
B. Recruiting workers from other Member States	Yes, mainly for large companies	C
C. Recruiting workers from Non-Member States	Yes, mainly for large companies	C, G
D. Recruiting unemployed with or without re-training	Yes, but only in rare cases	C, E
E. Recruiting young people from the education system	Yes, mainly through apprenticeships and placements for students	C, E
F. Training and re-training employed workers	Yes, in-house promotion and further training	C, E
G. Changing work organisation	No, limited in scope for skills shortages in this occupational function	-
H. Outsourcing and offshoring	No, because activities belong to the core of the companies. Only viable for few junior management functions	-
I. Changing vocational education	No	-
J. Designing and offering new courses	Yes, mainly aiming at "softer"[17] skills. Flexible forms of training are essential.	C, E
K. Providing information about emerging skills	Yes, mainly about emerging "softer" skills and sector specific qualifications	C, E, U
L. Improve the image of the sector	No, not necessary for this occupation functions	-
M. Stronger cooperation between stakeholders	Yes, in respect to a stronger diversification of workforce (women, youth)	C, S, E, G, I, U

Notes: 1. C (company), S (sector organisations and chambers of commerce), E (education & training), G (governments and regulators), I (intermediary organisation, public or private), U (trade unions).

[16] SMEs play a key role as employers in the sector: the total workforce in the sector is divided almost equally between SMEs and large firms. In the optical subsector, for instance, SMEs are predominant. (see part I).
[17] "Softer" skills refer to all skills with the exception of the technical skills (hard skills) in the sector.

14.5 Computer Professionals

Table 14.2 shows strategic options for emergent competences of computer professionals. Recruitment of workers from other sectors is a viable option since also generic IT skills are required for IT systems and IT support, maintenance and service. However, those tasks are often outsourced. Outsourcing is also a strategic option for computer professionals designing and integrating different electronic systems (ILO, 2007: 48). The demand for computer professionals designing IT systems is somewhat higher in the scenario High-end Customer Hi-Wi-Fi than in the other scenario. The demand for computer professionals applying and supporting IT systems is expected to stabilise in both scenarios. Due to expected skills shortages outsourcing is a more probable option in the High-end Customer Hi-Wi-Fi scenario.

In the High-end Customer Hi-Wi-Fi scenario the recruitment of workers from non-Member States, especially from Asia (Japan, Korea, Philippines) and from the United States as well as the recruitment of young people released by the education system is an important alternative to meet the knowledge demand and the needs for specific hard skills required in the sector.

Training of hard and soft skills is essential, especially for computer professionals. Training should include object oriented computer programming languages as well as updates on software development. In addition, the demand for knowledge in respect to the relationship between hardware and software seems to increase for computer professionals in the sector (EMTA, 2001: 17). Communication skills such as internal and external customer related communication, project and time management skills are of great importance in both scenarios.

Due to individualisation and mass customisation in the scenario High-end Customer Hi-Wi-Fi and due to the specialisation in niche markets in the scenario Hi-Wi-Fi For Everyone, software development and application is getting more specialised. Hence, training providers face difficulties to keep pace with software developments and the supply of adequate courses. The development and offering of such courses should build on a solid co-operation between all relevant stakeholders. Flexible (e.g. modular) forms of training are a strategic option to meet the rapid changing demand of technical skills in the scenarios. A strong co-operation between companies (especially SMEs) and training organisations is a necessity to guarantee that training is up-to-date and fits the demands.

Table 14.2 Strategic options Computer professionals

1. What is the maximum volume effect?	Increase for IT system developers, maintain for IT system appliers and supporters	
2. What is the maximum change in skills?	13 for IT system appliers and supporters and 15 for IT system developers	
3. Do SMEs play a large role?	Yes	
4. Is the sector national/EU/global?	Global	
5. Is the workforce old?	No	
6. Is the workforce low educated?	No	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, mainly for IT application and support and especially for young workers	C
B. Recruiting workers from other Member States	Yes, for IT application and support as well as for IT design functions	C
C. Recruiting workers from Non-Member States	Yes, more probable for IT design functions (e.g. Asia)	C, G
D. Recruiting unemployed with or without re-training	Yes, mainly for IT application and support but limited in scope. Less viable for IT design as training will be needed	C, E, I
E. Recruiting young people from the education system	Yes, for both functions	C, E
F. Training and re-training employed workers	Yes, for "softer" and hard skills	C, E
G. Changing work organisation	No	-
H. Outsourcing and offshoring	Yes, more viable for ITapplication and support and programming, not for designing and integrating complex systems	C
I. Changing vocational education	Yes	C, E, S, G, I, U
J. Designing and offering new courses	Yes, in respect hard and soft skills for computer professionals in the sector. Flexible forms of training are essential. Life-Long-Learning is essential	C, E, I
K. Providing information about emerging skills	Yes, mainly in respect to emerging "softer" skills and sector specific qualifications. Career guidance is needed	C, E, I, U
L. Improve the image of the sector	Yes, for women this is important	C, S, E, I, G, U
M. Stronger cooperation between stakeholders	Yes, in order to better match sector specific skills and general knowledge	C, S, E, G, I, U

Notes: 1. C (company), S (sector organisations and chambers of commerce), E (education & training), G (governments and regulators), I (intermediary organisation, public or private), U (trade unions).

14.6 Engineers

Table 14.3 presents strategic options for emergent competences of engineers. Engineers are the most important job category in the electronics, computer and optical sector. No major employment growth is expected for engineers active in production processes, but an increase in employment is expected for R&D engineers . They form the fundament for growth in both scenarios. For both types of engineers gaps in skills and competences will occur, but especially for R&D engineers. Consequently, all strategic options pointed out in the table are viable. The strategic options vary between the different engineering functions such as design engineers, electronic engineers and production engineers (control, equipment maintenance). Recruiting engineers from other sectors as well as recruiting unemployed engineers with training should be the main strategic option for electronic or production engineers. Thus, recruiting engineers from the chemical and biological sector, in particular in nano-optics and nano-electronics, is an alternative for the designing of electronic and optical components, even if specific skills are needed (Abicht et al., 2006). Another choice is to re-train electric and electronic equipment mechanics and up-skill parts of this occupational group (the volume in employment in this group is expected to decrease in both scenarios).

Recruiting workers from other Member States and, in particular, from non-Member States, recruiting young people released by the education system as well as training of employed workers are other possibilities. Due to limited resources, SMEs have difficulties to attract workers from other countries. Consequently, offering training for employed workers is of great importance for SMEs. Furthermore, changes in work organisation are an important strategic alternative. In the optical industry, in which SMEs are prevalent, job-rotation systems are already in place in order to train engineers and to obtain multi skills. However, the method is not very frequently used (VDI, 2004: 56). In a global supply chain international team work as well as project work assists in overcoming skills gaps and shortages in design, product development and production. For the same reason outsourcing and offshoring is an option.

Next to the strategic option of recruiting young people released by the education system another option exists: attracting young people of both sexes to conclude engineering / technical studies. The image of technical occupations is not as good as it should be. A co-operation between all relevant stakeholders can assist in improving the image and, therefore, is important in both scenarios.

The main driver of the sector is the rapid technological change. However, the VET systems do not adjust as quickly. Thus, the rapid technological progress in production is confronted with the slow absorption by the VET systems. Consequently, a modernisation of the VET system with modifications in respect to more flexible and modular training offers is essential. Tailor-made modular courses for engineers in the sector need to be adjusted and made accessible for the specific target groups such as younger groups, women, older workers, etc. Next to training offers on technical hard skills (especially for systems design) courses should also be provided on project management, team work and communication. According to the scenarios, self management training and courses to enhance skills on problem solving should be expanded in future. In addition, engineers should be stimulated in their entrepreneurship skills, especially in relation to understanding the customer and spotting trends. Team working and communication skills are of great importance and, therefore, should be an integral part of the trainings.

Table 14.3 Strategic options Engineers

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SMEs play a large role? 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Increase, especially for R&D engineers 14 (production), 20 (R&D) Yes in R&D, not really in production Global Yes for production, No for R&D No	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes for production. The option is not so viable for design engineers	C
B. Recruiting workers from other Member States	Yes, for all functions. Especially in NMS: higher education level, more women	C
C. Recruiting workers from Non-Member States	Yes, in respect to recruitments from Asia and the USA. The option is limited as Europe is not attractive (a.o. lower wages for researchers)	C, G
D. Recruiting unemployed with or without re-training	Yes mainly for production. The option is limited in scope as training is needed.	C, E, I
E. Recruiting young people from the education system	Yes, especially for R&D engineers Apprenticeships can be an important mean of training young engineers.	C, E, I, S
F. Training and re-training employed workers	Yes, for soft and hard skills in all functions	C, E, S, I (consultants)
G. Changing work organisation	Yes, an option for large companies and SMEs in order to match hard and soft skills	C, I (consultants)
H. Outsourcing and offshoring	Yes, for SMEs and large firms. However, the option fits mainly in both scenarios for production but not for product development.	C, I (consultants)
I. Changing vocational education	Yes, for a better matching of the demand of the industry and the supply of training.	C, S, E, G, I, U
J. Designing and offering new courses	Yes, hard and soft skills. Flexible forms of training are essential.	C, E, I, S
K. Providing information about emerging skills	Yes, mainly in respect to emerging soft skills and sector specific qualifications	C, E, I, U
L. Improve the image of the sector	Yes, in order to attract more personnel (especially women) to technical occupations in the sector and to overcome skills shortages	C, S, E, G, I, U
M. Stronger cooperation between stakeholders	Yes, in order to design coherent measures for attracting more personnel to engineering and to diversify the workforce (women, youth). In addition, yes, to improve the matching of supply and emerging demands.	C, S, E, G, I, U

Notes: 1. C (company), S (sector organisations and chambers of commerce), E (education & training), G (governments and regulators), I (intermediary organisation, public or private), U (trade unions).

14.7 Supply Chain Managers

Since Supply Chain Management (SCM) is a new occupational function, only few skilled people are available (EIGT, 2004: 117). As global supply chain management also appears in other sectors, e.g. the textile industry, recruiting SCM managers from other sectors is an option. In doing so workers with intercultural and language skills (Asia, in particular China, is one of the important production locations) as well as workers with other non-sector specific skills can be recruited. In order to fill the gaps of additional knowledge required such as know-how on legal, tax and financial issues companies can choose to recruit workers from other sectors and train them on sector-specific components.

The recruitment of workers from other member and non-Member States is a viable alternative. However, since university courses on SCM have been set up only recently, few people with fitting degrees are available. In order to meet the demand, sector specific business management courses for training on the job should be developed and existing sector-specific training possibilities of global SCM expanded in numbers. To precisely address the companies' needs a solid co-operation is required between all relevant stakeholders. In order to attract the few skilled SCM work force, the visibility of the sector should be improved, especially among students.

Changing the work organisation is also a viable possibility to meet skills requirements related to SCM. Job-rotation, job enlargement and job enrichment could help SCM managers to gain the different technical skills (e.g. logistics, accounting) and soft skills like project management skills. The interdisciplinary character of SCM makes this possible. Outsourcing and offshoring are other strategic options as some OEM and EMS companies already deliver this service (e.g. IBM). Nevertheless, this is not a suitable solution for all companies due to the inter-sectoral competition and the sensitivity in respect to strategic information.

Table 14.4 Strategic options Supply Chain Managers

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SMEs play a large role? 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Increase 10 Yes Global No No	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, but sector specific training is needed	C, E
B. Recruiting workers from other Member States	Yes, but limited in scope due to skill shortages	C
C. Recruiting workers from Non-Member States	Yes, but limited in scope due to skills shortages and relatively low wages in Europe	C, G
D. Recruiting unemployed with or without re-training	No, the option is not realistic due to less qualified personnel	-
E. Recruiting young people from the education system	Yes, but sector specific training is needed	C, E
F. Training and re-training employed workers	Yes, an option in order to meet the emergent hard and soft skills	C, E
G. Changing work organisation	Yes, for a better matching of the hard and soft skills. More viable for large firms due to the distinctive diversification of the division of labour in large firms.	C
H. Outsourcing and offshoring	Yes, the option is viable for all SCM as well as for parts of it.	C
I. Changing vocational education	Yes, in order to increase the supply of SCM as well as sector specific courses	C, E, I, S, G, U
J. Designing and offering new courses	Yes, mainly for enhancing sector specific and soft skills. Flexible forms of training are essential.	C, E, I
K. Providing information about emerging skills	Yes, in order to better match skills supply and demand..	C, E, I, U
L. Improve the image of the sector	No, not necessary for this occupational function	-
M. Stronger cooperation between stakeholders	Yes, in order to improve the matching of skills supply and emerging demand.	C, S, E, G, I, U

Notes: 1. C (company), S (sector organisations and chambers of commerce), E (education & training), G (governments and regulators), I (intermediary organisation, public or private), U (trade unions).

14.8 Accounting & Finance

Since emerging skills on accounting and finance, in particular legislative and regulatory knowledge of international nature as well as e-skills are universal skilled workers can be recruited from other sectors. Workers with e-skills can be recruited from other countries, amongst the group of young people and from the group of the unemployed. Given that the demand for accounting and finance professionals is expected to rise in the High-end Customer Hi-Wi-Fi scenario, training should be offered for the existing workforce. As regulatory and legislative knowledge often is country-specific relevant training should to be offered when recruiting workers with accounting and finance skills from other states within or outside the EU. Nevertheless, recruiting skilled workers from other Member States is a viable option for operations in the home state of recruits. In addition, outsourcing of accounting and finance for SMEs as well as offshoring of minor accounting duties is a possible strategic option to face the growing demand for skills.

Recruiting skilled workers from countries or markets other than the home market of the recruit is a less viable option due to expected deficits in national accounting regulation. If SMEs only operate on domestic markets this strategic option is even less probable for SMEs. Recruitment of workers from other states can be made more attractive via developing and offering training programs on international laws and rules. Modifications in vocational education (e.g. via tailor-made courses), up-to-date information about emerging skills, improvements of the image of the sector as well as solid co-operation between all stakeholders are not the most pressing strategic options (as attracting personnel in this occupation function is not difficult in the sector). Still, updating courses to the latest developments in accounting should be provided. In addition, the sector should improve its visibility for accounting and finance specialists. However, the need is not as high as for technical occupations (engineers and mechanics).

Table 14.5 Strategic options Accounting & Finance

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SMEs play a large role? 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Increase/maintain 10 Yes Global No No	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, a viable option due to sector independent skills.	C, E
B. Recruiting workers from other Member States	Yes, but limited due to national accounting regulation. More viable for large firms or Socieatas Europaea.	C
C. Recruiting workers from Non-Member States	Yes, but limited due to national accounting regulation. More viable for large firms and Socieatas Europaea.	C, G
D. Recruiting unemployed with or without re-training	Yes, but limited in scope (training is needed).	C, E, I
E. Recruiting young people from the education system	Yes	C, E
F. Training and re-training employed workers	Yes	C, E
G. Changing work organisation	No	-
H. Outsourcing and offshoring	Yes, an option for some functions	C
I. Changing vocational education	No	-
J. Designing and offering new courses	No, courses are not needed (if at all in order to increase soft skills)	-
K. Providing information about emerging skills	No, not necessarily needed	-
L. Improve the image of the sector	No, not needed for this occupational function	-
M. Stronger cooperation between stakeholders	No, not necessary.	-

Notes: 1. C (company), S (sector organisations and chambers of commerce), E (education & training), G (governments and regulators), I (intermediary organisation, public or private), U (trade unions).

14.9 Sales & Marketing

Table 14.6 presents viable options for sales & marketing. Nearly all options are more or less viable.

In the High-end Customer Hi-Wi-Fi scenario the occupational functions for sales and marketing are expected to increase in volume whilst in the Hi-Wi-Fi for Everyone scenario a stable volume of employment is likely. The scenarios do not differ in respect to emergent skills and competences. The majority of the emerging skills are genuine marketing and sales skills, only few are of sector-specific nature such as knowledge on legal regulatory and product knowledge. The emerging skills needs are expected to be met by offering training on and off the job internal and external.

Thus, all options are viable such as recruiting sales and marketing professionals from other sectors, Member States and non-Member States, young people released by the education system and unemployed if offering training. Outstanding knowledge on the product as such, the ability to apply the knowledge to different branches (automotive, aerospace, telecommunication, etc.), excellent communication skills and information on customer needs is of great importance in the scenario High-end Customer Hi-Wi-Fi for EMS. The same applies to marketing and sales professionals of ODM even if ODM focuses on the end-user. Because of the strong mass customisation of products, customer needs have to be spotted more carefully and latest consumer trends have to be identified regularly.

Experience is key to some sector-specific skills like sales conversation. Thus, practical aspects should be integrated into training and university courses. Further training can also be organized in-house and should integrate real case studies. Placement programmes are an adequate action taken by the industry to overcome practice deficits of students, in particular if the programmes are developed jointly by the industry and training providers. Furthermore, a need to increase e-business skills is observed in the sector which easily can be met by integrating e-business contents into existing vocational training courses (EIGT, 2004: 132).

Table 14.6 Strategic options Sales & Marketing

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SMEs play a large role? 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Increase 20 Yes Global No No	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, but sector specific knowledge and training is needed.	C, E
B. Recruiting workers from other Member States	Yes, a viable option for strategic and operative marketing.	C
C. Recruiting workers from Non-Member States	Yes, a viable option for strategic and operative marketing.	C, G
D. Recruiting unemployed with or without re-training	Yes, but limited in scope	C, E, I
E. Recruiting young people from the education system	Yes	C, E
F. Training and re-training employed workers	Yes, especially e-business skills need to be increased.	C, E
G. Changing work organisation	Yes, in order to strengthen soft and hard skills	C
H. Outsourcing and offshoring	Yes	C
I. Changing vocational education	No	-
J. Designing and offering new courses	Yes, courses need to be offered regarding sector specific knowledge and e-business skills. Flexible forms of training are essential.	C, E, I
K. Providing information about emerging skills	Yes	C, E, I, U
L. Improve the image of the sector	No, not necessary.	-
M. Stronger cooperation between stakeholders	Yes, to order to improve the matching of skills supply and emerging demands.	C, S, E, G, I, U

Notes: 1. C (company), S (sector organisations and chambers of commerce), E (education & training), G (governments and regulators), I (intermediary organisation, public or private), U (trade unions).

14.10 Support staff

In Table 14.7 strategic options for emergent competences related to support staff are presented. In both scenarios this occupational function is expected to decrease. Consequently, skills gaps will be more prevalent than skills shortages. However, basic skills required in this function, such as administrative skills as well as basic internet, spreadsheet and word processing competences are available in other sectors. Thus, recruiting workers from other sectors is a feasible option. Recruiting workers from other states (within or outside the EU) is another alternative. Disadvantages for recruiting workers from other states are the (often) high hiring costs as well as cultural barriers and missing language skills. Job agencies can play an important role here in recruiting support staff. Outsourcing and offshoring of some back office tasks (e.g. in accounting: customer documentation) is viable and, therefore, already practiced by enterprises. In both scenarios skills related to support international operating project teams will increase in importance. Support staff capable to perform such tasks can be recruited from other international operating sectors. Depending on the specific job profile basic technical skills will be required next to language and intercultural skills. Basic technical training for support staff should be developed jointly by training providers and sector organisations in order to meet the demand.

Finally, recruiting of unemployed is a viable option for this sector since some unemployed have the generic skills required. However, training should be offered in respect to the most pressing skills in the scenarios like e-skills, social skills, self management skills and initiative. Despite the fact that emergent skills for support staff, generally speaking, are not as pressing as emergent skills for engineers a general up-skilling of the workforce is required in both scenarios.

Table 14.7 Strategic options Support staff

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SMEs play a large role? 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Decrease 9 Yes Global No Mainly	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, in order to meet general skills demands (e.g. administrative skills)	C, E, I
B. Recruiting workers from other Member States	Yes, but limited in scope due to language barriers	C, I
C. Recruiting workers from Non-Member States	Yes, but limited in scope due to language barriers	C, I, G
D. Recruiting unemployed with or without re-training	Yes, together with training for certain skills	C, E, I
E. Recruiting young people from the education system	Yes	C, E
F. Training and re-training employed workers	Yes, especially regarding soft and e-skills	C, E
G. Changing work organisation	No	-
H. Outsourcing and offshoring	Yes, both are viable options if language barriers can be bridged.	C
I. Changing vocational education	No	-
J. Designing and offering new courses	Yes, regarding sector specific e-skills and soft skills training. Flexible forms of training are essential.	C, E, I
K. Providing information about emerging skills	No, not necessary	-
L. Improve the image of the sector	No, not necessary	-
M. Stronger cooperation between stakeholders	No, not necessary	-

Notes: 1. C (company), S (sector organisations and chambers of commerce), E (education & training), G (governments and regulators), I (intermediary organisation, public or private), U (trade unions).

14.11 Metal and machinery workers

Table 14.8 presents the strategic options of this occupational function. The demand for metal and machinery workers is expected to rise only in the optical products sub-sector. In all other sub-sectors (electronic components and computers, communication equipment, and consumer electronics) a decrease is likely. Hence, the strategic options should meet shortages and gaps in skills, particularly in the optical products sub-sector.

For production workers technical knowledge is essential, next to social skills that become increasingly important in all sectors for this occupational function. Due to a common set of general technical skills, recruiting workers from other sectors with technical knowledge in metal and machinery works is not a big challenge. Metal moulders or welders from other sub-sectors and from other sectors can, for example, easily be recruited. In case of low hiring costs and possibilities to bridge the language gap recruiting workers from other Member States and non-Member States is another alternative. Job agencies can play an important role here; human resource management tasks are increasingly been outsourced to these intermediary organisations.

Technical knowledge is of key importance in this occupational function. Hence, training courses enabling workers to use new machinery and new technology are required to keep technical skills up-to-date. In addition, workers with excellent soft skills are increasing in importance especially since product cycles are shortened in time. Thus, team work skills, communication skills and the ability to react flexible should be integrated in new courses for metal and machinery workers. Furthermore, knowledge about production related regulation of hazardous or dangerous materials combined with know-how on the proper treatment (with regular up-skilling of the workers) increases in importance. Another important emerging competence is knowledge of quality control measures.

Due to differences in learning between target groups such as younger and older workers, trainings need to be adapted to the specific demands of the target group. Recruiting young people from the vocational training systems is an important strategic option to meet the expanding skills needs in both scenarios of the optical products sub-sector. However, there is a necessity observed to stimulate pupil's interest in technical and science related subjects. For this reason a solid co-operation of a certain set of stakeholders of the sector is essential. The cooperation can serve as basis in order to meet the emergent skills needs also in the long run.

Table 14.8 Strategic options Metal and machinery workers

1. What is the maximum volume effect?	Maintain in electronics; increase in optical products	
2. What is the maximum change in skills?	10	
3. Do SMEs play a large role?	Yes	
4. Is the sector national/EU/global?	Global	
5. Is the workforce old?	Yes	
6. Is the workforce low educated?[18]	No	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, in order to meet general skills needs of this occupational function. Specific sector training needed.	C, E, I
B. Recruiting workers from other Member States	Yes, if language barrier can be bridged.	C, I
C. Recruiting workers from Non-Member States	Yes, if language barrier can be bridged.	C, I, G
D. Recruiting unemployed with or without re-training	Yes, together with sector specific training.	C, E, I
E. Recruiting young people from the education system	Yes	C, E
F. Training and re-training employed workers	Yes, especially needed in respect to emergent soft skills and up-to-date technical knowledge.	C, E
G. Changing work organisation	No	-
H. Outsourcing and offshoring	Yes, it is viable for production related functions if this fits into the business model. It is not viable if firm specialises in production.	C
I. Changing vocational education	No	-
J. Designing and offering new courses	Yes, in respect to soft and hard skills. Flexible forms of training are essential.	C, E, I
K. Providing information about emerging skills	Yes, especially in the optical sector	C, E, I, U
L. Improve the image of the sector	Yes, to meet the replacement demand.	C, S, E, G, I, U
M. Stronger cooperation between stakeholders	Yes, in order to match skills supply and demand.	C, S, E, G, I, U

Notes: 1. C (company), S (sector organisations and chambers of commerce), E (education & training), G (governments and regulators), I (intermediary organisation, public or private), U (trade unions).

[18] Independently from the ISCO classification the education level of metal and machinery workers differ from Member State to Member State: In the sector in the United Kingdom, for instance, primarily low skilled workers are employed whilst in Germany medium skilled workers are prevalent in the sector (compare ME-Analysen, 2003 and SEMTA, 2008: 96)

14.12 Electric and electronic equipment mechanics and fitters

Table 14.9 presents strategic options for electric and electronic equipment mechanics and fitters. The overall volume of this occupational function is expected to shrink in all sectors in both scenarios. Thus, the strategic options primarily need to address those skills gaps which were already identified for metal and machinery workers. In general, the strategic options are the same, but they are not as pressing as for the metal and machinery workers due to an expected decrease in this occupational function. Recruitment is increasingly being taken over by job agencies and these intermediary organisations can play an important role in the strategic options.

The main strategic choices are to train the existing workforce and recruit young people from the education system. In the latter case the biggest challenge is expected for attracting young people to the sector due to the poor image of the sector.

Technical knowledge is of key importance in this occupational function. Hence, training courses enabling workers to use new machinery and new technology are required to keep technical skills up-to-date. In addition, workers with excellent soft skills are increasing in importance especially since product cycles are shortened in time. Thus, team work skills, communication skills and the ability to react flexible should be integrated in new courses for electric and electronic equipment mechanics workers.

Table 14.9 Strategic options Electric and electronic mechanics and fitters

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SMEs play a large role? 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Decrease 10 Yes Global Yes No	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, in order to meet general skills needs of this occupational function. Specific sector training needed.	C, E, I
B. Recruiting workers from other Member States	Yes, if language barrier can be bridged.	C, I
C. Recruiting workers from Non-Member States	Yes, if language barrier can be bridged.	C, I, G
D. Recruiting unemployed with or without re-training	Yes, together with sector specific training.	C, E, I
E. Recruiting young people from the education system	Yes	C, E
F. Training and re-training employed workers	Yes, especially needed in respect to emergent soft skills and up-to-date technical knowledge.	C, E
G. Changing work organisation	No	-
H. Outsourcing and offshoring	Yes, it is viable for production related functions if this fits into the business model. It is not viable if firm specialises in production.	C
I. Changing vocational education	No	-
J. Designing and offering new courses	Yes, in respect to soft and hard skills. Flexible forms of training are essential.	C, E, I
K. Providing information about emerging skills	Yes, especially in the optical sector	C, E, I, U
L. Improve the image of the sector	Yes, to meet the replacement demand.	C, S, E, G, I
M. Stronger cooperation between stakeholders	Yes, in order to match skills supply and demand.	C, S, E, G, I, U

Notes: 1. C (company), S (sector organisations and chambers of commerce), E (education & training), G (governments and regulators), I (intermediary organisation, public or private), U (trade unions).

14.13 Precision workers and repairers

Precision workers and repairers are an occupational subgroup of precision, handicraft, craft printing and related trade workers. Precision makers are in general qualified technicians and have a higher education level that precision repairers. The volume of this occupational function is expected to rise in the optical products sector in both scenarios and remain stable in the other sub-sectors.

The strategic choices to meet skills needs for this occupational function are like those of the metal and machinery workers. However, since precision workers and repairers are primarily working on specific machines recruiting from other sectors could be difficult due to a high grade of specialisation, especially in the optical sector. Recruiting workers from other Member States and non-Member States is also less probable due to language barriers. Regular trainings on technical skills concerning the changing production processes are as essential for precision workers and repairers as sustaining the high quality within the production process.

Table 14.10 Strategic options Precision workers and repairers

1. What is the maximum volume effect?	Maintain, increase in optical products, especially in the shift to nano and micro-manufacturing	
2. What is the maximum change in skills?	11 (precision workers), 13 (precision repairers)	
3. Do SMEs play a large role?	Yes	
4. Is the sector national/EU/global?	Global	
5. Is the workforce old?	No	
6. Is the workforce low educated?	No, middle educated	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes from similar sectors (e.g. mechanical precision workers), in order to meet general skills needs of this occupational function. Specific sector training needed.	C, E, I
B. Recruiting workers from other Member States	Yes, if language barrier can be bridged.	C, I
C. Recruiting workers from Non-Member States	Yes, if language barrier can be bridged.	C, G, I
D. Recruiting unemployed with or without re-training	Yes, together with sector specific training and in-company training.	C, E, I
E. Recruiting young people from the education system	Yes	C, E
F. Training and re-training employed workers	Yes for related professions, especially needed in respect to emergent soft skills and up-to-date technical knowledge.	C, E
G. Changing work organisation	No	-
H. Outsourcing and offshoring	Yes, it is only a viable option if it fits into the business model. Depends on whether the firm specialises in the production.	C
I. Changing vocational education	Yes	C, E, G, S, I, U
J. Designing and offering new courses	Yes, in respect to soft and hard skills. Flexible forms of training are essential.	C, E, I
K. Providing information about emerging skills	Yes, especially in the optical sector	C, E, I, U
L. Improve the image of the sector	Yes, to meet the replacement demand.	C, S, E, G, I, U
M. Stronger cooperation between stakeholders	Yes, in order to match skills supply and demand.	C, S, E, G, I, U

Notes: 1. C (company), S (sector organisations and chambers of commerce), E (education & training), G (governments and regulators), I (intermediary organisation, public or private), U (trade unions).

14.14 Assemblers

The demand for assemblers is expected to increase in the High-end Customer Hi-Wi-Fi scenario whilst the demand is expected to remain as it is in the Hi-Wi-Fi for Everyone scenario. It is expected that assembling of standardised products will primarily be shifted towards countries in Eastern and South Eastern Europe. However, assembling of niche and high level products required in health care and optical industry will still be performed in Central Europe.

Assemblers have to keep pace with the technological change and, in particular, with the rising automation of production processes. Knowledge and hard skills required for this occupational function are of technical nature for the most part. However, skills should be upgraded in respect to new developments on an ongoing basis. For instance, updates on new materials are essential in brazing and soldering due to changing regulations of hazardous materials (e.g. lead). Skills upgrading is also crucial in respect to new equipments such as e.g. diagnostic tools for quality control. Training and adapting the workforce to new hard skills will take place 'on the job' to a great extent, performed by producers of technical equipment or supervisors and the trainees/employee.

Strategic choices to overcome skills shortages as well as skills gaps for assemblers are, firstly, recruiting workers from other sectors in cases where similar skills are required such as accuracy. Other options include the recruitment from other Member States and non-Member States (if hiring costs are low and language gaps can be bridged). The alternatives are to recruit unemployed by offering respective training or train the existing workforce, especially by strengthening the soft skills like multi-skilling and flexibility. Job agencies play a very important role in recruiting assemblers, also in recruiting workers from other Member States and from outside Europe. Human resource management tasks are increasingly outsourced to job agencies. Changing work organisation can help to meet skills demands in assembly as well. Work organisation can change because of mergers and acquisitions or because of automation of production processes. Outsourcing is another option to meet skills demands, which seems to have taken off recently.[19]

In order to attract more potential assemblers the visibility of the sector needs to increase. Information on occupational profiles and emerging skills needs to be provided. Hence, a stronger co-operation of relevant stakeholders is necessary.

[19] A special form of outsourcing is to use a chain of small subcontractors, more specifically home workers. Although no specific data is available, recent evidence would indicate that in the UK and the Netherlands a substantial part of the assembly process is done *at home* by home workers. Based on a question in the 1997 UK Labour Force Survey, rough estimates indicate that in the UK between 1.2 and 2 million people could be involved in assembling products at home and probably 15% is assembling electronic components. Home assembling is mainly organised via long and complex chains of subcontractors (communication by Prof. U. Huws at the Final Experts Workshop 20-21 November, Brussels).

Table 14.11 Strategic options Assemblers

1. What is the maximum volume effect?	Maintain/increase in high-end products, especially in optical and medical products sector and mainly in NMS.	
2. What is the maximum change in skills?	8	
3. Do SMEs play a large role?	Yes, for subcontractors and especially in EU-15	
4. Is the sector national/EU/global?	Global	
5. Is the workforce old?	No, not in NMS, but older in EU-15	
6. Is the workforce low educated?	Yes, but higher educated in NMS (or over qualified in combination with high unemployment rates) than in EU-15	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, together with sector specific training.	C, E, I
B. Recruiting workers from other Member States	Yes, if it is not too cost-intense and if languages barrier can be bridged	C, I
C. Recruiting workers from Non-Member States	Yes, if it is not too cost-intense and if languages barrier can be bridged	C, G, I
D. Recruiting unemployed with or without re-training	Yes, together with sector specific training	C, E, I
E. Recruiting young people from the education system	Yes	C, E
F. Training and re-training employed workers	Yes, especially regarding emergent soft skills	C, E,
G. Changing work organisation	Yes, automation of low skilled jobs. Many mergers & acquisitions in the sector is also important as means for recruitment	C
H. Outsourcing and offshoring	Yes	C
I. Changing vocational education	No not necessary	-
J. Designing and offering new courses	Yes, in respect to soft skills and sector specific skills (especially quality control). Flexible forms of training are essential.	C, E, I
K. Providing information about emerging skills	Yes, in order to match the skills supply and demand.	C, E, I, U
L. Improve the image of the sector	Yes, in order to attract more assemblers (which are needed in scenario Hi-Wi-Fi For All)	C, S, E, G, I, U
M. Stronger cooperation between stakeholders	Yes	C, S, E, G, I, U

Notes: 1. C (company), S (sector organisations and chambers of commerce), E (education & training), G (governments and regulators), I (intermediary organisation, public or private), U (trade unions).

14.15 Labourers and operators

Table 14.12 presents the strategic options for labourers. A strong decline is expected for this job function in future. Generally, there will be a demand for up-skilling and (re)training labourers to the level of production and repair as well as maintenance workers (or even higher), to move to other positions in the organisation. Those labourers who are to stay need to up-skill as well to be able to work together with other plant staff. In some cases as well as in some countries (e.g. in Germany) financial support is provided for up-skilling workers which are in danger of becoming unemployed. Governments as well as intermediate bodies such as the public employment services play a key role in this respect and are important partners in a solid cooperation of all stakeholders for this sector. Most labourers and operators are hired via job agencies.

Table 14.12 Strategic options Labourers and operators

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SMEs play a large role? 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Decreasing - No Global Yes Yes	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	No, not necessary	-
B. Recruiting workers from other Member States	No, not necessary	-
C. Recruiting workers from Non-Member States	No, not necessary	-
D. Recruiting unemployed with or without re-training	No, not necessary	-
E. Recruiting young people from the education system	Yes, in order to meet the continuous replacement demand	C
F. Training and re-training employed workers	Yes, in order to adapt to emergent skills needs of the existing workforce and to up-skill the workforce in order to meet the demand of emerging occupations.	C, E, I
G. Changing work organisation	No, not necessary	
H. Outsourcing and offshoring	No, not necessary	
I. Changing vocational education	No, not necessary	
J. Designing and offering new courses	No, not necessary	
K. Providing information about emerging skills	No, not necessary	
L. Improve the image of the sector	No, not necessary	
M. Stronger cooperation between stakeholders	No, not necessary	

Notes: 1. C (company), S (sector organisations and chambers of commerce), E (education & training), G (governments and regulators), I (intermediary organisation, public or private), U (trade unions).

14.16 Scenario implications, future skills and knowledge needs and possible solutions: summary and main conclusions

Implications of the scenarios in terms of expected volume changes in employment (jobs), future skills and knowledge needs as well as ways to address and solve these needs (strategic choices) have all been analysed so far for individual job functions. This section summarises the main implications and solutions for each of the functions presented in Chapters 12-14. It serves as a bridge to the next chapter where we shift from a micro perspective (job functions) to a meso (sector and policy) perspective.

		High-end Customer Hi-Wi-Fi	Hi-Wi-Fi For Everyone
Managers	1. Employment volume change	+, +*	0, 0/+
	2. Skills changes counted 1); 2)	18	
	3. Emerging skills needs	Entrepreneurship, Strategic& visionary skills, Change management, Self management, Social skills (communication, networking, language, intercultural skills), Knowledge (e-skills, supply chain management, Intellectual Property Management)	
	4. Most important solutions	Recruiting, Training and re-training, Designing & offering new courses, Providing information, Stronger cooperation between stakeholders	
	5. Most important actors	C, G, E, U	
IT system developers	1. Employment volume change	+, +	0/+, +
	2. Skills changes counted	15	
	3. Emerging skills needs	Knowledge (Imaging, System integration, Modelling & simulation, Programmes Languages), Problem solving skills (analytical skills, multi-skilling)	
	4. Most important solutions	Recruiting from other Member States, from non Member States and young people, Training and retraining, Changing vocational education, Designing and offering new courses, Providing information, Improving image, Stronger cooperation between stakeholders	
	5. Most important actors	C, G, E, I, S U	
IT system appliers and supporters	1. Employment volume change	0, 0	0, 0
	2. Skills changes counted	13	
	3. Emerging skills needs	Problem solving skills (especially analytical skills and multi-skilling), Self management (especially stress & time management), Knowledge (especially B2B IT platforms), Social skills (team working, communication)	
	4. Most important solutions	Recruiting from other sectors, other Member States, non Member States, young people and unemployed, Training and retraining, Outsourcing and offshoring, Changing vocational education, Designing and offering new courses, Providing information, Improving image, Stronger cooperation	
	5. Most important actors	C, G, E, I, S, U	
Production engineers	1. Employment volume change	0/+	0, 0
	2. Skills changes counted	14	
	3. Emerging skills needs	Problem solving skills, Self management (planning, stress & time management, flexibility), Knowledge (technical and e-skills), Process optimising, Quality management, Social skills (team working and communication)	
	4. Most important solutions	Recruiting from other sectors, other Member States, non Member States, unemployed, Training and retraining, Changing work organisation, Outsourcing and offshoring, Changing vocational education, Designing and offering new courses, Providing information, Improving image, Stronger cooperation between stakeholders	
	5. Most important actors	C, E, G, I S, U	

C=Companies; S=Sectoral organisations, U=trade Unions; E=Education and training institutes; G=Government (EU, Member State, regional, local). Notes: 1) The term 'skills' includes knowledge (needs). 2) The 2nd row 'skills changes counted' refers to the number of skills categories in the most extreme scenario. *) Assessment of volume changes for electronic components, computers, communication equipment and consumer electronics on the one hand and for the optical and medical products on the other hand.

		High-end Customer Hi-Wi-Fi	Hi-Wi-Fi For Everyone
R&D engineers	1. Employment volume change	+, +	0/+, +
	2. Skills changes counted	20	
	3. Emerging skills needs	Knowledge (technical, product development, system integration), Problem solving skills, Self management (planning, stress & time management, flexibility), Social skills (team working, communication, networking), Entrepreneurship (especially understanding customers and suppliers), Project management, Process optimising, Trendsetting and spotting skills, Strategic and visionary skills	
	4. Most important solutions	Recruiting from other sectors, other Member States, non Member States and unemployed, Training and retraining, Changing work organisation, Outsourcing and offshoring, Changing vocational education, Designing and offering new courses, Providing information, Improving image, Stronger cooperation between stakeholders	
	5. Most important actors	C, E, G, I S, U	
Accounting and Finance	1. Employment volume change	0/+	0, 0
	2. Skills changes counted	10	
	3. Emerging skills needs	Knowledge (legislative and regulatory, e-skills), Analytical skills, Self Management (stress & time management, flexibility, multi-tasking), Social skills (team working, language, intercultural skills), Process optimising	
	4. Most important solutions	Recruiting, Training and retraining, Outsourcing & offshoring	
	5. Most important actors	C, E, G, I	
Sales and Marketing	1. Employment volume change	+, +	0, 0
	2. Skills changes counted	20	
	3. Emerging skills needs	Entrepreneurship, Client relationship management, Social skills (especially intercultural), Self management, Knowledge (product), Problem solving skills (interdisciplinary, creativity), Project management	
	4. Most important solutions	Recruiting, Training and retraining, Changing work organisation, Outsourcing and offshoring, Designing and offering new courses, Providing information, Stronger cooperation between stakeholders	
	5. Most important actors	C, E, G, I, U, S	
Supply chain managers	1. Employment volume change	+, +	0/+, 0/+
	2. Skills changes counted	10	
	3. Emerging skills needs	Social skills (networking, language, intercultural), Knowledge, Analytical skills, Self management (stress and time management, flexibility)	
	4. Most important solutions	Recruiting, Training and retraining, Changing work organisation, Outsourcing and offshoring, Changing vocational education, Designing and offering new courses, Providing information, Stronger cooperation between stakeholders	
	5. Most important actors	C, E, G, I, S, U	
Support staff	1. Employment volume change	-, -	-, -
	2. Skills changes counted	9	
	3. Emerging skills needs	Self management (especially flexibility and multi-tasking), Initiative, Social skills (team working, communication, language, intercultural), Knowledge (e-skills)	
	4. Most important solutions	Recruiting, Training and retraining, Outsourcing and offshoring, Designing and offering new courses	
	5. Most important actors	C, E, I, G	

		High-end Customer Hi-Wi-Fi	Hi-Wi-Fi For Everyone
Metal and machinery workers	1. Employment volume change	0, 0/+	-, 0/+
	2. Skills changes counted	10	
	3. Emerging skills needs	Knowledge (especially technical and quality control), Social skills (team working and communication), Problem solving skills (initiative, multi-skilling), Flexibility	
	4. Most important solutions	Recruiting, Training and retraining, Outsourcing and offshoring, Designing and offering new courses, Providing information, Improving image, Stronger cooperation between stakeholders	
	5. Most important actors	C, E, I, G, U, S	
Electric and Electronic equipment mechanics and fitters	1. Employment volume change	-, -	-, -
	2. Skills changes counted	10	
	3. Emerging skills needs	Knowledge (especially technical), Social skills (team working and communication), Problem solving skills (initiative, multi-skilling), Flexibility	
	4. Most important solutions	Recruiting, Training and retraining, Outsourcing and offshoring, Designing and offering new courses, Providing information, Improving image, Stronger cooperation between stakeholders	
	5. Most important actors	C, E, I, G, S, U	
Precision workers and repairers	1. Employment volume change	0, +	0, +
	2. Skills changes counted	11 (precision makers), 13 (precision repairers)	
	3. Emerging skills needs	Knowledge (technical , product, quality control), Problem solving skills (especially analytical), Social skills (team working, communication, language, intercultural), Flexibility)	
	4. Most important solutions	Recruiting, Training and retraining, Outsourcing and offshoring, Changing vocational education, Designing and offering new courses, Providing information, Improving image, Stronger cooperation between stakeholders	
	5. Most important actors	C, E, I, G, S, U	
Assemblers	1. Employment volume change	0/+, +	-, 0
	2. Skills changes counted	11	
	3. Emerging skills needs	Knowledge (technical, product, e-skills), Social skills (team working, communication, language), Problem solving skills (initiative, multi-skilling), Self management (stress & time management, flexibility)	
	4. Most important solutions	Recruiting, Training and retraining, Changing work organisation, Outsourcing and offshoring, Designing and offering new courses, Providing information, Improving image, Stronger cooperation between stakeholders	
	5. Most important actors	C, E, I, G, S, U	
Labourers and operators	1. Employment volume change	-, -	-, -
	2. Skills changes counted	5	5
	3. Emerging skills needs	Knowledge (e-skills, technical knowledge, quality control), self management (stress & time management, flexibility	Knowledge (e-skills, technical knowledge, quality control), self management (stress & time management, flexibility
	4. Most important solutions	Recruiting young people from the education system (replacement demand); Training and retraining (up-skilling)	Recruiting young people from the education system (replacement demand); Training and retraining (up-skilling)
	5. Most important actors	C, E, I	C, E, I

15 Conclusions and recommendations for education and training

15.1 Introduction

This chapter presents the main conclusions and recommendations for education and training; chapter 16 presents the main other conclusions and recommendations. Whereas the earlier chapters very much take a *micro* perspective by focusing on job functions in terms of expected volume changes, skills and knowledge needs and ways to address and solve these needs (strategic choices), chapter 15 takes a *meso* or *sector* perspective. It addresses a number of issues, part of which coming already to the fore in earlier chapters, and part being 'new' issues although much related to those already raised. The conclusions and recommendations are mostly based on the results of the preceding chapters; they were discussed during the final workshop with social partners, the industry and other experts.

The recommendations contained in this chapter should not be seen as fully exhaustive. They rather form the basis for further discussion and elaboration at various decision-making levels, ranging from the European Union and the Member State to the regional and local level. Industry itself – firms – have an important role to play, as do education and training institutes, social partners and the government (EU, national, regional and local). In most cases action should be taken jointly, by involving various actors, sometimes even at different levels. Collaboration and co-operation as buzzwords in today's economy are easily coined. Making collaboration work in practice is, however, a challenge which requires mutual understanding, compromise and perseverance.

15.2 Conclusions and recommendations for education and training

1) Adapt and modernise vocational education and training (VET) and general education systems, but do this nationally rather than at the EU level

The rapid technological change and the pervasive globalisation of the supply chain have a strong impact on occupational functions as well as on the skills and knowledge needs in these functions. As the previous chapters highlight, the impact is strongest for high educated job functions. Nonetheless, similar conclusions might also be drawn for medium-skilled workers. Technological change and globalisation have led to adjustments in the organisation and production resulting in changes in the skills compositions (Bonser et al., 2006: 23) and will continue to do so. The 'half-life' of skills is getting shorter especially in the technological and software programming occupations. According to SEMTA technological development is the most important driver of emergent skills needs (SEMTA, 2008: 92). In the electronics industry technological changes happen so rapidly that disconnecting between the "long-term" education cycle and production development is a serious concern (EIGT, 2004: 147). Additionally, the globalisation of the production chain has led to stronger specialisation, also in European firms. This makes that even more specialist technical skills are demanded by the sector for all occupational levels (ME-Analysen, 2003: 13). This obviously creates a tension between the demand for practical, sector specific, fast changing skills on the one hand, and the need to train pupils with the more basic occupational skills on the other. Possible options to overcome this dichotomy are 1) to enhance the flexibility of the vocational educational training (VET) system by a stronger modularisation (see next point 2), 2) closer co-operation of the stakeholders to work on these options (see next point 4), and 3) better monitoring of research and development expenditure in firms, and more broadly, skills and knowledge training needs in firms as to respond more aptly to arising skills and knowledge needs (see next chapter).

Box 6. Vocational education and training– rich variety between Member States

A number of different systems in Vocational Education and Training (VET) as well as Initial and Continuing Vocational Education and Training (IVET and CVET) can be observed throughout the European Union. Various characteristics of these systems have to be taken into consideration when discussing possible specific implications for education and training. Existing VET-systems can be grouped into three main categories ('idealtypes'), (i) liberal, (ii) state-controlled and (iii) corporatist VET-systems, each having a different underlying rationale and distinguishing characteristics. Key in this distinction are those who decide about the structure and content of VET: business itself, the state or the state together with social partners (see Table below). The three VET-systems of Germany, France and the United Kingdom are of special importance as they can be taken as representative for each of the three 'idealtype' categorisations. They are evidence of the rich variations in existing VET systems and their implementation in Europe. The enterprise-based training system of Germany (the 'Dual System') is implemented by the social partners and the state. Next to this prevailing system other forms of VET exist. In France, a school-based training system is established and implemented by the state. Even though the full-time school-based training system competes to some extent with an upcoming apprenticeship training system, it is still the dominant form of vocational training in France. The system implemented in the UK, the national vocational qualification, is regulated and driven by market forces in several important segments. Although national vocational qualifications (NVQ) and general national vocational qualifications (GNVQ) are regulated at national level, the implementation of training is not yet regulated at national level. Commercial certification systems are still competing with national ones. Work-based, as well as full-time school-based training can be found. Special training schemes for unemployed, such as school-based schemes for unemployed youths or work social enterprises for long-term unemployed, are present in several European Member States. Besides these 'idealtypes' several mixed forms in Europe exist. In Spain, for example, one finds more informal forms of VET and in Central and East European countries the trend can be detected, that VET moves from a state centred model to a stronger corporatist model, while also business driven approaches exist in some sectors.

Table to Box 6. Three 'ideal-type' VET-models (elaborated from Clematide, 2005)

	A. Liberal	**B. State-controlled**	**C. Corporatist**
Decision maker	Business (and individuals)	State	State and social partner organisations
Rationale	Liberalistic competitive	Centralistic state-centred	Corporative – social consensus
Programmes	Business and individual	Education and citizen	Occupation
Content	Needs of business and individual, utility oriented, short term and specific	Politically determined, general knowledge, course-oriented, academic	Determined by social partners, occupation centred, traditions
Labour markets VET relates to	Internal (business) labour markets	Occupational and internal labour markets	Occupational labour markets
Strengths	Flexible, cheap for the state, close to the needs of production	Strong linkage to the education system, no lack of training places	Broad vocational educations with status equal to general education
Weaknesses	Under-investment in training and education	Weak linkage to the labour market	Inertia in the institutions
Representatives	United Kingdom, Ireland	France	Germany, Austria, Denmark
Trends	Stronger state involvement in certification and quality	"Dual system" emerging and stronger orientation on business needs	Internal labour markets Marketing of VET

These options imply several changes for the prevalent European initial vocational educational training systems (IVET) and VET systems (see Box 6). As VET systems in terms of strengths and weaknesses differ between Member States, and sector-specific challenges and hence employer needs do too, the necessary changes clearly differ from Member State to Member State.

2) Enhance the flexibility in education and training by promoting modularisation

Enhanced flexibility in education and training of especially technical occupations is needed. Flexibility in our sense refers to the capability of the VET System to adapt effectively to new training needs, both in quality and in quantity. A flexible VET-System is required in particular in circumstances in which profound changes take place and job functions and occupational profiles are modified quickly. In order to achieve more flexibility and to respond in-time with altering training contents and enhanced quantity a *modularisation* of education and training is recommended. Even if problems will occur in the modularisation of training in some IVET-Systems modular systems facilitate the building up of competences and ease the interaction between IVET and CVET Systems. Flexibility is also required for different forms of education and training. Enhanced flexibility and a modularisation of IVET is a big challenge for the state controlled and the corporatist systems. Liberal system will find their ways easier. However, the liberal market driven systems with their strong focus on technical on-the-job skills lack behind in general education which becomes an obstacle for up-skilling of the individual and a higher permeability of the education system. Besides, basic and generic skills are not obsolete but become more important as a basis for the ability to react on new training demands emerging from new technologies and changing production processes.

3) Stimulate targeted facilitation of Life-Long Learning (LLL)

Lifelong learning is essential to keep competitiveness and prevent less favourable scenarios. Sector organisations and trade unions together with public authorities and other relevant stakeholders such as training organisations and universities should develop joint programmes of lifelong learning in order to up-grade skills of the workforce in the sector. The programmes should be tailored to the specific needs of the SMEs in the sector. Governments should further develop the legal framework for supporting life long learning at all ages. Life long learning should encompass all skills levels aiming at raising social skills as well as technical sector skills. All possible international, national as well as to some extent also regional and local pathways should be used in order to finance lifelong learning. Employees should be made aware of the Life-Long Learning concept and their employability. Life-Long Learning should get into the mindset of individuals and they should become motivated in organising their own working career. Also older populations should be targeted, as they are very experienced and this experience and expertise should be kept in the sector. Specific attention is needed to e-skills. E-skills are very important for all job functions in the sector.

4) Strengthen collaboration between vocational training institutes and industry

VET systems are well-placed to play an important role in accommodating and supporting modular training and life-long learning needs of firms, employers and employees. This requires, however, important adaptations to prevailing VET systems. Currently, the corporatist and school based VET systems guarantee a universal initial vocational training and in the case of combined apprenticeships also a practical training on the job (dual system). However, the possibility of continuing training is mostly disregarded. The once applied qualification leads to a reposition on the achieved, with life-long learning being perceived as not necessary. Current VET structures are not able to quickly adapt to the new skills and

knowledge needs. What is needed is a *solid co-operation* between VET training institutes and industry (companies) in order to better match existing training packages to the skills and knowledge needs of the industry and to jointly think and design a modularised training structure that is flexible enough to accommodate to the needs of firms and workers throughout the working life cycle.

5) Strengthen knowledge networks in higher education

Internationally networked research and education institutes are key to improving training and education, just as close *informative ties* with the industry. What applies for the IVET and VET system applies also to the higher education system in engineering and technical studies more broadly. Technological change is enfolding rapidly. Due to longer education cycles, skills can outdate even faster (EIGT, 2004: 147). Furthermore, practice and specific sector skills are requested by employers. Universities and colleges cannot solve the problem on their own: Support from sector organisations and companies is needed. If companies demand sector specific knowledge from students (EIGT, 2003; ME-Analysen, 2003), one way to address this is to offer more in-company placement programmes for students and graduates. Additionally, universities of cooperative education ("Berufsakademien") could be set up in the sector. For example, the German company "Analytic Jena", operating in the optical sector, is offering places for a university of cooperative education to close the gap between specific and general skills in biotechnology for bio-analytic instruments. One important advantage of such cooperative education is that universities are kept updated on the skills demands of the industry. Another option is to promote the establishment of alumni networks in the respective disciplines such as mathematics, physics and engineering. Alumni can serve as role models for students by bringing in their practical know-how in lectures. While co-operation between large companies and universities already exists to some extent, SMEs are mostly not included. A joint training system especially for SMEs in regions with a high density of sector companies is an important measure to overcome some of the difficulties faced by SMEs such as the lack of resources.

6) Build on existing know-how transfer and establish learning networks alongside the value chain

Evidence shows that firms within the value chain can be important external suppliers of know-how transfer. This is, for example, what is observed for SMEs in the optical sector (VDI, 2004: 85). This potential could be exploited in a more structural and sustainable way by organising regional learning networks along side the value chain. Such networks could be tied to already existing cluster initiatives in the sector. VET suppliers can develop, organise and support such kind of networks for a sustainable know-how transfer. Training providers of the sector or intermediate organisation can investigate the main skills needs by interviewing companies in a structured way and organise training. This approach is confirmed in the same study by the finding that optical technology competence networks are of relative importance for gaining latest practical knowledge.

7) Enhance flexibility in learning forms – e-learning and blended learning

Flexibility is not only needed in the adaptation of the VET system, but also in the learning forms provided. For example, blended learning combining face-to-face and group-based learning with up-to-date offline media and online e-learning forms, as for example digital learning modules on websites, video conferences, joint learning applications, newsgroups and blogs for interactive online learning. Therewith, costs of further training are reduced and the flexibility to combine work with training is enhanced. Another positive side-effect on skills

of this learning form is the needed competences like self reflection, self motivation, and effectiveness of information processing.

8) Foster a culture of learning, innovation, openness and tolerance

Fostering a culture of learning and innovation – not only for the young in school, but throughout life - is a vital element in maintaining and further upgrading Europe's skills base. Fostering such a culture not only requires that schools consistently address the importance of learning to their pupils but also that the importance of life-long learning, of 'éducation permanente' is better incorporated in the mindsets and actual behaviour of people than is now the case. The media, government and social partners all have their role to play in this challenge. Openness and tolerance are a *conditio sine qua non* in establishing a culture of learning and innovation.

9) Strengthen basic skills early on and improve the quality of primary education

The reported lack of basic skills of technicians (machine workers, electrical workers, precision handcrafts) in mathematics and natural sciences (see, e.g., ILO, 2007: 89; EIGT, 2004: 142; EECA/ESIA, 2005: 35) and the poor image of respective courses, together with the high number of (especially female) pupils reluctant to go into technical and engineering occupations, make interventions at an early stage necessary (see also point 10 on image and attractivess). To overcome skills shortages and gaps until 2020, actions should be taken for the primary education system. Natural science and mathematics needs to be boosted and enriched in school curricula in order to strengthen basic skills. Moreover, the quality of primary education, in general, has to be improved. The responsibility for designing education curricula lies with authorities. However, even if curricula are adjusted, additional measures have to be taken in order to redirect large numbers of potential personnel to technical occupations. Hence, the industry itself has to set activities which go beyond supplying infrastructure.

In the United Kingdom, STEMNET[20] (Science, Technology, Mathematics Network) aims to increase the number of science, technology, engineering and mathematics related careers at all levels. The network actively brings natural science into schools and into curricula via a twofold way:

- Bringing science, technology, engineering and mathematics activities, experiences and excitement into classrooms throughout the UK, enhancing and enriching the national STEM curriculum.
- Linking those companies and other organisations that employ STEM educated people, and schools, in such a way that young people can get a clear idea of the diverse and exciting range of careers available to them.

The objectives are achieved through science engineers ambassadors (SEA) from companies, some of which are from the electronics and optical sector. The SEAs provide assistance to schools in terms of STEM related competitions, events, wards, clubs, mentoring, career guidance, work based placements. The SEAs act as role models for young learners. STEMNET also provides support for teachers via curriculum enhancement and enrichment. Partners of the network are companies and their representatives as well as schools. The network is supported by national funds.

[20] http://www.stemnet.org.uk/ (October 2008).

10) Promote the natural sciences and mathematics in schools and improve the image and visibility of technical and scientific job careers

In several European countries initiatives to improve the image of mathematics, physics and chemistry and to raise interest in science at early age are underway. The electronics and particularly the optical sector should actively be brought to school in order to reach young people with possible affinity to working in electronics. Not only primary schools have to be involved but also vocational education and universities (workshops, apprenticeships etc.). Focused provision should address not only students from technical universities, but also students from managerial/business, sales and marketing and accounting studies. Initiatives of this kind should be elaborated, expanded, and disseminated across Europe. New ways of learning combining basic education and scientific knowledge are required to enable the workforce in IT sectors to better understand and manage challenges brought forward by their technologies in the emergent knowledge-based economy of the information society. Europe could take countries like Korea and Taiwan as an example, where natural sciences and mathematics is part of daily life and culture and almost every student has at least a basic knowledge in these science fields. Mass media could help to bring science into daily life and culture. One of the recommendations by the Electra initiative[21] is that in all EU countries at least 25% of tertiary education students should be in technical, engineering and science education (Electra, 2008).

When discussing a lack of basic skills in mathematics and natural sciences as well as a negative image of technical and scientific professions, it is important to keep in mind the differences between the EU-15 and the new Member States. In the new Member States relatively more people are trained in mathematics and natural sciences than in EU-15, and the share of women with these skills is also larger. The image of the sector is in general also better in the new Member States than in EU-15. The computer, electronic and optical products industry is considered as a relatively stable and modern industry, which is attractive to work for.

11) Supply special courses dedicated to sector characteristics: supply change management, design engineering, nano-electronics and nano-optics

For some job functions special courses are needed. It is necessary to strike a balance between what is offered in the educational system and what is needed in the sector. Based on the scenarios and the literature review training needs are observed in the technical occupations such as engineering and mechanics as well as for business professionals (SCM - supply chain management). In the computer, electronic and optical products sector a great need for design engineers was identified. According to the study undertaken by the National Training Organisation for Engineering Manufacture (EMTA, 2001: 13) a profound understanding of design packages as well as of computer science, a good grounding in electronics with a reflective knowledge in mathematics and physics and subsector-specific knowledge (e.g. in circuit design or magnetic design) as well as project management is necessary. Similarly, nano-electronics is a field that is still developing posing future skill needs (Abicht et al., 2006). This also applies to the optical products sub-sector (nano-optics), optical measuring technology and optical information as well as communication technology. Another emerging

[21] Electra is a joint initiative by the EU's electrical and electronic engineering industry and the European Commission. It aims at addressing the EU's policy objectives on climate change, the creation of a strong, innovative electrical and electronic engineering industry in Europe as well as more and better jobs. Electra is a joint initiative by the EU's electrical and electronic engineering industry and the European Commission. It aims at addressing the EU's policy objectives on climate change, the creation of a strong, innovative electrical and electronic engineering industry in Europe as well as more and better jobs.

field with specific training needs is optical instruments in medicine and biotechnology (VDI, 2004: 76).

12) Supply special courses for older workers
The workforce in several occupational functions is ageing. Education and training institutions need to adjust their training programmes to the needs of an ageing population and workforce and develop specific courses. Older workers learn differently than younger workers (e.g., older learners often face challenges in theory-based, upfront teaching, which is only focused on examinations but better can exploit practical experience). The design of training, therefore, has to meet the demands of each specific target group (ZVEI, 2003).

13) Pay more attention to interdisciplinary and multidisciplinary studies
In vocational education and training more attention should be paid to inter- and multidisciplinary studies as different technical skills need to be combined with non-technical skill requirements. Although sound technical education still provides the basis, attention should also be paid to enhance other skills such as project management, languages and competencies in business development. Such elements should be an integral part of apprenticeship and traineeship programs.

14) Foster multi-skilling
As indicated by the scenarios, multi-skilling will become more important in the future improving the operating flexibility of firms. Multi-skilling – training employees to master different skills in order to fulfil a range of tasks – applies across job functions, but is especially relevant in the medium skilled job segment. To pursue multi-skilling and be able to offer applicable courses for the industry, not only co-operation between the training sector and companies is needed but also between different training providers. In several countries, stable co-operations between the industry and universities, colleges and other private training providers do already exist; these could be enhanced and further strengthened in order to provide combined and interlinked training modules for the sector.

16 Main other conclusions and recommendations

16.1 Introduction

This report concludes with a number of 'other' (i.e. going beyond education and training) conclusions and recommendations based on the results and insights gained during the course of this study. They include the results of an intensive two day workshop with various stakeholders and the European Commission during which the draft final results, including preliminary recommendations, were discussed. The conclusions and recommendations apply to the sector at large (including individual firms, sector organisations, chambers of commerce, social partners), intermediary organisations, education and training institutes, as well as policy-makers (EU, Member States, regions).

The recommendations point into viable and useful directions rather than that they represent ready-made proposals for change. Reflection and debate, and finding creative answers to plausible futures in skills and jobs is, in the absence of a crystal ball, the way forward. The bandwidth between the expected developments in the most extreme scenarios is indicative for the degree of uncertainty by which the future should be approached. Solutions to future skills

needs should therefore be flexible, smart and encompassing enough to address the differences between the various scenario outcomes, not knowing what real future will eventually emerge.

16.2 Main other recommendations

1) Foster collaboration between all stakeholders and between different geographical-political levels and stimulate Partnerships for Innovation and Job creation and Social Dialogue

The first recommendation to meet existing and emergent skills and knowledge needs for the electronic, computer and optical products sector is to support intensified co-operation between all relevant stakeholders in the sector. The challenge to overcome sectoral skill gaps and shortages can be met if industry, research, training providers, social partners and public authorities act in concert. Employers' organisations and trade unions in most countries are capable, in co-operation with training providers and educational institutes, to commonly and better address future skills and knowledge needs, and also set up funds for the training of employees. In order to make colloboration work, more interaction between the European, national and regional level is essential.

Enhanced investment in human capital is required. Cost sharing mechanisms between actors such as public authorities, companies and individuals need to be developed and learning throughout the life cycle promoted (LLL): learning must be made more attractive to all, e.g. via tax incentives, a change of attitudes in order to integrate learning into all phases of live and a lifecycle approach to work.

Collaboration is required to meet the skills and knowledge needs and support the development of sectoral learning strategies, but also to foster sustainable development, exchange best practices and promote R&D innovation, for instance by building on existing and establishing new *partnerships for innovation and job creation*. Establishing a broad *Social Dialogue*, both at Member State and European level, can serve to further discuss priorities and feasible actions. The already existing Social Dialogue Sectoral Committees also have an important role in proactively disseminating the importance of addressing future skills and knowledge needs.

2) Develop and cherish successful regional clusters

Developing and maintaining successful regional clusters is one of the challenges ahead. The presence of a world class scientific institute or technical university is a *conditio sine qua non* for such a cluster to arise. A dominant role of a large company may help to develop a successful regional cluster. What is also vital is a well-developed form of intermediation between large companies and SMEs, for instance along the idea of *open innovation*. Support in research/strategy development, public co-financing of VET (costs sharing) and flexibility of the education system, the ability to attract talent (e.g. by high-quality labour market intermediaries), a culture of innovation and trust, as well as excellent working and living (quality of life) conditions are all important, but are alone not decisive factors in developing successful regional clusters. Chances of copying – and the copy-ability of cluster concepts and ideas generally – are low, because of regional and sectoral specificities, amongst others. Good examples are manifold; prime locations such as Bangalore have their downsides, with very high job turnover and attrition rates (with many workers less than a year in one job) and hig general volatility. Secondary locations, like the example of Ericsson in Sri Lanka may be more promising.

3) Diversify the personnel base and recruitment scope

A key recommendation is to aim at diversifying personnel in all job functions. This goal is to be met through a broadening of the sector's recruitment scope in that *female workers as well as minorities and other groups* of potential workers will be better reached and facilitated. The computer, electronic and optical products industry in 2009 still is extremely male dominated. Personnel diversification, firstly, does make the sector more appealing to other groups. Since the sector is lacking competences, personnel diversification, secondly, can help to overcome the foreseen skills shortage in engineering. Personnel diversification would also enable companies to better develop business in new markets (new client groups or countries). Recruiting workers from different cultures assists in building up social skills (e.g. intercultural as well as language skills) which are needed in almost all job functions as stated in both most plausible scenarios.

4) Increase flexibility in the work organisation

Flexibility in the work organisation allows for training during less intense production times and intense working during production peaks. In the EU flexibility in work organisation predominantly lies with the social partners that make (company) specific agreements. Since flexibility in work organisation is still low in the sector, different schemes should be developed and implemented.

5) Increase intra- and intersectoral as well as transnational mobility and promote international and intersectoral acknowledgement of certificates

For some job functions mobility – national (between sectors, regions) and international - is an important option to meet future skills needs. To increase the viability of this option improving the acknowledgement of certificates between sectors and countries is essential, with adequate accreditation provisions. Improving acknowledgement applies also to in-house trainings, as several trainings are not yet certified. One of the reasons why mobility of the workforce is sub-optimal and matching of skills demand and supply is difficult is a lack of transparency of skills. Educational and training institutes which provide widely accepted certificates could considerably increase their value added for students. However, they often rely on governments to build effective acknowledgement systems. Certification of vocational training in the sector could be expanded. Due to the fact that external training providers are neither providing necessary cutting-edge skills nor are flexible enough to update rapidly evolving requirements of the sector, training was and still is mainly organised in-house by own staff (ILO, 2007: 89). Certification in the sector started with the individual need of IT companies to validate their own staff. For this reason it developed their own qualification and certification system (ILO, 2007: 89; European Commission, 2004a). The training is undertaken in the company, but testing and certification is undertaken by other certification companies. With the computing technology association (CompTIA) vendor neutral certificates are established and tertiary education has taken up this kind of certificates to some extend. The certificates have a date of expiry. Due to the fact that this system lies outside the educational system it is neither monitored nor broadly evaluated, but the certificates are accepted by the companies and comprise programming and technical skills. There are several national and European initiatives to develop independent certification systems as well as embedding the certifications into national qualifications frameworks (European Commission, 2004a).

6) Promote the intra-sectoral, intersectoral and transnational acknowledgement of IT skills by introducing an *IT driver's licence*

To promote IT-skills or e-skills and their acknowledgement throughout the EU, by establishing an "IT driver's licence" (for instance modelled after the example set by Finland), would be an important step. The European E-Skills Forum also points at the necessity to converge the various European initiatives into one European e-skills framework to increase transparency and comparability of e-skills, in order to enhance the e-skilled workforce and to increase workforce mobility across Europe (European Commission, 2004a).

7) Provide better career guidance for those in search of a job, supported by skills assessment schemes

Improving career guidance is an important option, especially to 1) support the redirection of pupils and students to engineering occupations in the sector, and 2) to assist in supporting placement of mature workers which are threatened of becoming unemployed. In the sector scenarios it is expected that low skilled occupations like labourers and support staff as well as medium-skilled electric and electronic equipment mechanics and fitters will decrease either by natural fluctuation or by layoffs. Career guidance assists in finding new job possibilities within or outside the sector. In combining career guidance with skills assessments as well as with the recognition of soft skills the scope for placements can be expanded.

Career guidance for mature lower-skilled workers could be *supported by an assessment of those skills* which are not certified or documented so far. Systems for the recognition of prior learning (RPL) support the determination to what extent people possess necessary competences for a new job (Duarte, 2004). The integration of RPL in career guidance and targeted training bridges the gap of hidden competences especially for mature workers. Some Member States included RPL in their system. In Portugal, for instance, a National System of Recognising, Validating and Certifying Prior Learning (RVCC) is implemented through a network of centres. Adults, whether employed or unemployed, are offered a three-tiered service, namely information, counselling and complementary training, including the accreditation of competencies (OECD/European Communities, 2004: 31). The centres are supported by the Ministry of Education and are run by training organisations or universities. The certification and validation of skills is undertaken by a jury with an external evaluator.

Career guidance can be supported by user friendly online-tools, also for self guidance. A good example in this respect is the German website http://www.think-ing.de/ (October 2008) in which information about educational and training pathways, and the relevant occupations they lead to is shown. In addition, other information about the sector is published online. Career guidance is undertaken in most countries by several different actors such as schools, training organisations, public employment authorities and related career information centres, unions, universities, sector organisations and companies. To enhance career guidance a solid regional co-ordination between different stakeholders can be very effective, in particular in those cases, where the relevant target group can be addressed directly. This is for example the case in the "science-truck"[22], a mobile career information centre of the technical university of Aachen.

[22] http://www.rwth-aachen.de/go/id/hhx/ (October 2008)

8) Increase co-operation to improve the information systems on skills and knowledge needs and job opportunities

Information asymmetry is not only an issue for labour market entrants, but also for school leavers searching for further education pathways. Consequently, a mismatch between actual VET supply and demand in quality as well as - to a lower extent - in quantity is observed for some occupational functions. Information systems at the sectoral level as well as at the regional, the national and the European level can assist in minimising information asymmetries in order to overcome skills gaps resulting from information deficits. Facilitating students by entering the labour market and finding a suitable occupation is just as important as assisting employees to find new job opportunities based on their existing skills or guiding them in finding the fitting vocational training course.

A close collaboration between all relevant stakeholders, such as companies, education and training organisations, social partner organisations, research institutions and public authorities, supports minimizing information deficits on current and emergent skills needs. The old system has to adapt to the new situation and collaboration is an effective instrument to stimulate the implementation of changes in VET. A strong linkage between industry and education and training is recommended in state driven full-time school-based VET-Systems (Koch and Reuling, 1998).

An example of a way to overcome the information gap and resulting mismatch between available and required qualifications in technical and R&D occupations is to take a stronger look at *research and development expenditure* in the sector. ILO (ILO 2002: 21) is convinced that by doing so the mismatch can be overcome. One idea is to build up structured and detailed reporting systems about research and development (R&D) expenditure for the sector. Emerging technical skill needs can therewith be detected quite early. Training institutions and universities can use this information for redirecting their curricula.

In all countries and, in particular, in the new Member States, co-operation are essential to improve the practical orientation in VET (Skjølstrup and Mayen, 2007). The 'Sector skills councils'[23] in the United Kingdom and the 'FreQueNz' research network[24]are examples of such.

The 'Sector skill councils' in UK are funded by the Department for Innovation, Universities and Skills and are part of the government's skills strategy for the 21st century. The councils ensure that individuals gain the skills they need so that persons with fitting skills are available. Sector skills strategies are defined for each sector based on the analysis of present and future skills needs.

FreQueNz is a research network located in Germany and funded by public means. The network comprises scientific institutes, education and training organisations, social partner organisations, companies and public authorities and contributes to early identification of qualification needs. This network has conducted a number of evaluative research projects on human and ICT resources, staff qualifications, tests, career guidance for adults, computerised career guidance programmes, and beneficiaries of guidance services.

[23] www.sscalliance.org
[24] www.frequenz.net

Annex I. Contributors to this study

This report appears in a series of 11 sector reports on the future jobs and skills commissioned by the European Commission and executed by a core consortium of TNO (Delft/Leiden, the Netherlands), SEOR Erasmus University (Rotterdam, the Netherlands) and ZSI - Zentrum für Soziale Innovation (Vienna, Austria). The consortium was led by Dr F.A. van der Zee (TNO Innovation Policy group; TNO Innovation & Environment).

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Annex III Strategic options – a detailed description

A. Recruiting workers from other sectors
A possible solution to meet skill needs is to recruit workers from other sectors, which have and can provide the skills and knowledge needs of the sector and more specifically the firm. Whether or not this is a desirable option depends, amongst others, on the job function under consideration. For managers of large corporations it is quite usual to bring their general know-how to bear in different sectors. Also for business professionals (e.g. financial analysts, software engineers) sector specificities are of lesser importance. Sector mobility of low skilled workers is much more limited than the mobility of higher educated employees. The lesser the grade of sector specialisation of the occupational profile, the easier employees are able to change between sectors. In other cases recruiting workers from other sectors will need training of sector specific skills. In some cases it will also be possible for highly specialised workers to change sectors.

B. Recruiting workers from other Member States
Recruiting workers from other Member States could be in some cases a possibility to overcome skills problems. However, owing to language, cultural and other problems, including certain entrance barriers left to the Member States, mobility within the European Union is still underdeveloped. Border regions are attracting workers from other countries mainly because of wage advantages and in this way can succeed in solving their skills shortages and gaps. However, regions that face such outward migration (e.g. Poland, East Germany, Parts of Austria, Hungary, Czech Republic, Slovenia, Bulgaria) at the same time face serious problems in meeting their labour market demands. Some have responded by recruiting workers from non-Member States. Even if this might appear a temporary problem, from a longer term perspective, such developments could have serious consequences for the growth of the regional economy – in what might be termed a 'skills drain' (cf. 'brain drain").

C. Recruiting workers from non-Member States
Recruiting workers from non-Member States is not a zero-sum game for the European economy. Yet this strategic choice is as limited in its overall impact as the strategic choice that proposes to recruit workers from other Member States. On top of this, such recruitment is much more difficult that recruitment from within the EU. In all Member States significant barriers for entering the labour market for workers from outside the EU exist, even for temporary workers. To increase the influx of these workers by, e.g. increasing the immigration quota several political hurdles have to be mastered. Action can be taken here at Member State as well as at EU level, the recent 'blue card' proposal and negotiations serving as an example.

D. Recruiting unemployed workers with or without training
Recruiting unemployed workers without training is a strategic option, especially in case of skill shortages if there are not enough skilled workers to meet the employers demand). This option should in these cases be combined with adequate training. Unemployed workers might have various placement handicaps, especially skills deficits and poor levels of basic qualifications. Low educated groups are still representing the majority of the unemployed labour force, but also highly skilled workers like engineers could be threatened by unemployment.

E. Recruiting young people coming from the education system, with or without re-training
This strategic choice is always a possibility to overcome skill shortages as well as skill gaps. But demographic change should be taken into account too. While in the next few years, until around 2015, there will be a continuous inflow of students entering the labour market, a significant reduction is expected in 2020. In some EU regions there is already a need for young qualified and skilled workers and apprentices. Even where sectors may pay relatively high wages and offer stable carrier prospects, it is not easy to attract enough labour in critical occupational functions. While in the last years labour in business and finance professionals as well as administrative staff and customer services could be attracted the situation in technical occupations (engineers/technicians, construction workers, plant operators) is still critical. Hence, the recruiting of young people can only be successful, if this measure is supported with the other strategic options such as "Improving the image of the sector" and "Stronger cooperation within the industry". To be more precise, a stronger cooperation between schools, university, training organisations, career managers on the one hand and the industry on the other is needed. The principal aim should be to overcome the mismatch of requirements and wishes of individuals on the one hand and the economy on the other.

F. Training employed workers
In some cases training and re-training could also constitute a strategic choice to meet skill demands. In this case, the employee will be trained for a new working place or task. In general, re-training ends with a formal graduation or certificate. Re-training is an option if the work place or the occupational function is not needed any more. But re-training is only one option. Further education or further training, refresher training and updating courses, or advanced vocational qualification to adapt the workforce to emergent skills needs are also options, which should be taken into account. Re-training or further training of employees can encompass all levels of skills. Training and qualification could be done in-house and on the job as well as by an external education institution. It is more likely that less fundamental variations of up-skilling or re-training will be a strategic choice because re-training has to be regarded as a long term and quite expensive measure compared to the other vocational education forms.

G. Changing the work organisation
Work organisation can be defined in different ways. First, it can be defined as a system of work organisation (e.g. Taylorims, Fordism and Post-Fordism) and second, as a form of division of labour and specialisation. In modern economies productivity is based on the division of labour which by definition implies also a division of skills. There are several instruments of work organisation to react on skill shortages and gaps. Thus, changes in the work organisation can help to overcome skill gaps. In general, work can be reorganised in the following possible ways:

- Group work: A group is a limited number of people who work together over a longer period with a frequent, direct interaction. A group is defined through the differentiation of roles and joint values. Groups are able to produce better results than single persons due to the combination of different competencies and experiences, the reduction of wrong decisions, stronger work motivation, the direct use of information, new insights and creativity and a better acceptance of decisions, just to mention a few of the many advantages. There are several kinds of group work, like project groups, quality groups and learning circles, as well as committees.
- Job rotation: Within this type of work organisation several people change their work places in a planned alteration. Job rotation enhances the overview of the different

production processes, the understanding of different tasks and the feeling for group work. Additionally, monotony and dissatisfaction are reduced.

- Job enlargement: Extension of the scope of work through the combination of several structurally equal or similar tasks. It can produce similar effects as job rotation.
- Job enrichment: Extension of the scope of work through the combination of several structurally different tasks. The scope of decision making and self-control increases, as well as the quality and quantity of work. In general, up skilling of the employee is necessary, but this is also implemented on the job.

Under the influence of new technologies, like information and communication technologies, virtual forms of work organisation, which substitute hierarchies through a horizontal network co-ordination, are also possible. In this sense, mergers and acquisitions as well as project based business colloboration are also available options to change the work organisation. Both measures are strategic possibilities to get access to needed resources or to incorporate new skills. Modern (communication) technology can support the co-ordination and co-operation of labourers working at different places and in combining their respective strengths.

H. Outsourcing and offshoring

In public discussion the terms outsourcing and offshoring are mainly used together, yet it must be emphasised that they describe different technical approaches. While outsourcing means the transfer of management or day-to-day execution of business functions or processes (production, manufacturing, services) to an external service provider, offshoring describes the relocation of business functions or processes from one country to another. Both could be applied as a strategic choice on company level to meet skill needs, by integrating the knowledge, experience and competences of the other firm in the production process.

Outsourcing of personnel as a result of technological change and economic pressure was and still is an ongoing trend. Due to de-regulation and privatisation several tasks and with it skills and competences in the sector were outsourced and in some countries dislocated to other countries to increase labour productivity. Several occupational functions in the production chain have been outsourced nowadays. Skill gaps can be closed by hiring subcontractors with the needed knowledge and competences. If one considers this strategic option to meet skill needs, it has to be taken into account that for subcontracting firms, freelance or contractual workers continuing vocational training often plays a marginal role, because employees are all too often indispensible. One should also bear in mind that freelancers are not available at any time and in unlimited numbers. Outsourcing and offshoring is therefore a limited strategic option to overcome skill gaps. It seems to be more adequate to overcome skill shortages.

I. Changing vocational education

Changing vocational education has a long-term effect. It must be taken into account that changes will have a substantial impact in quality and quantity starting at the earliest within three years time after the changes. The process of changing initial vocational education in content or in structure takes itself several years. The process from defining the needs and problems to the implementation of a new curriculum involves several stakeholders from different expert levels like companies, social partner organisations, training institutes as well as representatives of national and regional education administration. These bargaining processes could take several years and are dependent of the VET-system of the European Member State. Hence, this strategic choice will only be drawn if major structural changes are expected.

Despite these facts, possible changes can be seen in a stronger modularisation of curricula of initial vocational training as well as in building up or strengthening interplant and

interregional training infrastructure. The first option could in the long run help to overcome identified skill needs in a sound, flexible and a relatively quick way. The second option is amongst others a possibility to provide the latest high-value equipment for training quickly by sharing resources of several partners.

J. Designing and offering new courses (continuing vocational education and training)
Once it is clear that the current content of vocational training is not up to date and therefore does not address the demands, the development of new courses for continuing vocational education and training could be a strategic option with a short term impact (see also *M. Stronger cooperation between stakeholders).*

K. Providing information about jobs and (emerging) skills
There is still a lack of transparency concerning current and emerging skill needs and job opportunities in different economic sectors. Information systems on regional, sectoral, national or European level could help to minimise information asymmetries and in that way overcome skill gaps resulting from information deficits. As a consequence, it could prove highly effective in helping students to enter the labour market and find a suitable occupation, just as much as in assisting employees to find new job opportunities based on existing skills or guide them in finding the suitable vocational training course.
Career guidance impacts rather short term. Therefore, it can help to overcome the mismatch between the needs and interest of the individual and those of the prevailing economy. The basic assumption of this strategic choice is that there already exist people who are equipped with the required skills and qualifications, but, due to a lack of information about the labour market possibilities, do not apply for these jobs. Career guidance for students and employees can help to overcome this mismatch. In this respect there can be a clear connection to training. Systems for recognition of prior learning (RPL) can help to determine to what extent people possess necessary competences for a new job. Targeted training can bridge the gap for the failing competences.

L. Improving the image of the sector
Improving the image of the sector could be an easy and suitable measure especially to overcome skill and labour market shortages and attract new employees. Several instruments could be implemented by sector organisations in co-operation with different non sector actors like schools, career management organisations, training organisation, public employment services, and public administration. Instruments could be company visits for pupils, offering internships for pupils and enhanced public relation. Especially in sectors where framework conditions and occupational functions changed fundamentally, due to technological or organisational restructuring or low wage levels, this offers a possibility to overcome stereotypes as much as old fashioned views and to attract more labour. Moreover, this measure does not only provide a chance to overcome stereotypes in relation to the sector but also to some occupational functions. The effect of this strategic option is long-term. In consideration of the apprenticeship system, which can take up five to seven years (if the specialisation of high qualified jobs in the sector is taken into account) until the volume effect is reached, one must arrive at the conclusion that in some occupational functions it has to be initiated right now.

M. Stronger cooperation with the industry

A stronger co-operation between industry and training institutes on a regular basis is one possibility to meet the skill needs in the sector. In some sectors and countries training of employees does not seem to be in line with the industry's emerging needs. New training and teaching solutions are to be developed between the industry, sector representatives, education institutions and research centres, public bodies, etc. Information exchange and a stable cooperation between the relevant stakeholders could improve the matching of training needs and demands. In the long run it will enhance the efficiency of training output, strengthen the quality of training and maximize the individual potential. To build up this kind of cooperation takes time, but in the long run it might well be capable to provide accurate solutions for problems. Networks and partnerships between these stakeholders to forecast skill needs in the sectors also present a long term measure. They could help to define emergent skill needs. While knowledge about the development of skill supply is quite high, the knowledge about the development of skill demand in different sectors is still improvable. These kinds of networks can cooperatively detect the need for action and contribute to the development of recommendation of actions.

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Glossary

Apprenticeship. Systematic, long-term training alternating periods at the workplace and in an educational institution or training centre. The apprentice is contractually linked to the employer and receives remuneration (wage or allowance). The employer assumes responsibility for providing the trainee with training leading to a specific occupation. (Cedefop, 2004)

Competence. Competence refers to the proven ability to use knowledge, skills and personal, social and/ or methodological abilities, in work or study situations and in professional and personal development. In the context of the European Qualifications Framework, competence is described in terms of responsibility and autonomy;

Compulsory education. The minimal legal standards and duration of obligatory schooling. (ILO, 1998)

Concentration index. The concentration index assesses the relative contribution of a specific sector to the national economy compared to a greater entity, such as the EU, thereby correcting for the size of the country. In more general terms, the concentration index is a measure of comparative advantage, with changes over time revealing changes in the production structure of a country. An increase of the concentration index for a sector signifies relatively fast growth of that particular sector in the country concerned compared to the same sector in the EU. How does the concentration index work in practice? A few (hypothetical) examples: if sector x represents a 5% share of the German economy and a 5% share of the EU economy, the concentration index of sector x equals a 100. If sector x represents 5% of the German economy, but 10% of the EU economy, the concentration index of sector x is 50. If the same sector x represents 10% of the German economy and 5% of the EU economy, the concentration index of sector x is 200.

The concentration index concept can be applied using different indicators (variables). In our study we measure the concentration index using employment, value added and trade, in order to make a distinction between the relative performance of countries EU-wide. We distinguish between four country groupings, each signifying a different sector performance over time. If a sector in a country has a strong position (hence showing a concentration index higher than 100) and has experienced a clear index growth over the last years, the sector is defined as winning in that country. If the sector has a strong position, but experienced a decline of the concentration index, we say the sector is losing momentum. If the sector has a weak position, but gained in the past, we say that the sector in that country is upcoming. If the sector has a weak position and experienced a decline of the index, we say that the sector is retreating.

Employability. The degree of adaptability an individual demonstrates in finding and keeping a job, and updating occupational competences. (Cedefop, 2000)

European Credit system for Vocational Education and Training (ECVET). A device in which qualifications are expressed in units of learning outcomes to which credit points are attached, and which is combined with a procedure for validating learning outcomes. The aim of this system is to promote:

- mobility of people undertaking training;
- accumulation, transfer and validation and recognition of learning outcomes (either formal, non-formal or informal) acquired in different countries;

- implementation of lifelong learning;
- transparency of qualifications;
- mutual trust and cooperation between vocational training and education providers in Europe. (Cedefop)

European Qualification Framework for life-long learning (EQF). A reference tool for the description and comparison of qualifi cation levels in qualifi cations systems developed at national, international or sectoral level. (Cedefop)

Full-time Employment. Traditionally means a 'regular job'. Work that is about eight hours a day, five days a week and forty-eight weeks of the year with four weeks paid leave.

Informal learning. Learning resulting from daily activities related to work, family or leisure. It is not organised or structured in terms of objectives, time or learning support. Informal learning is in most cases unintentional from the learner's perspective. (Cedefop, 2008)

Interdisciplinary (multidisciplinary). Interdisciplinary refers to research or study that integrates concepts from different disciplines resulting in a synthesised or co-ordinated coherent whole. New disciplines have arisen as a result of such syntheses. For instance, quantum information processing amalgamates elements of quantum physics and computer science. Bioinformatics combines molecular biology with computer science. An interdisciplinary team is a team of people with training in different fields. Interdisciplinary teams are common in complex environments such as health care.

Job mobility. Any change of job, regardless of where the new job is located.

Knowledge. Knowledge refers to the outcome of the accumulation of information through learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of work or study. In the context of the European Qualifications Framework, knowledge is described as theoretical and/or factual.

Knowledge society. A society whose processes and practices are based on the production, distribution and use of knowledge. (Cedefop, 2008)

Learning outcomes. Learning outcomes refer to statements of what a learner knows, understands and is able to do on completion of a learning process, which are defined in terms of knowledge, skills and competence.

Lifelong learning. All learning activity undertaken throughout life, with the aim of improving knowledge, skills/competences and/or qualifications for personal, social and/or professional reasons. (Cedefop, 2008)

Low, medium, high educated. See also under qualifications. The Labour Force Survey (LFS) collects data for a number of characteristics of employees, one being the level of education of an employee. The LFS is is based on the ISCED 1997 classification (International Standard Classification of Education).

- Low-educated encloses all levels up to the compulsory education (ISCED 1+2). ISCED 1: primary education or first stage of basic education. ISCED 2: lower secondary education or second stage of basic education.
- Medium-educated comprises all the post compulsory education not tertiary (ISCED 3+4). ISCED 3: (upper) secondary education. ISCED 4: post-secondary non tertiary education

- High-educated comprises all tertiary education including university education (ISCED 5+6). ISCED 5: first stage of tertiary education). ISCED 6: second stage of tertiary education (leading to an advanced research qualification).

Low, medium, high skilled. In general this classification refers to the skills required for a specific occupation that an employee currently holds. In existing taxonomies skills levels are usually proxied by educational attainment (see low, medium, high educated).

Mobility, see job mobility.

Multi-skilling. Multi-skilling refers to training an employee to cover a range of different jobs in one workplace. A multiskilled worker is an individual who possesses or acquires a range of skills and knowledge and applies them to work tasks that may fall outside the traditional boundaries of his or her original training. This does not necessarily mean that a worker obtains or possesses high-level skills in multiple technology areas. However, the worker can be an effective and productive contributor to the work output of several traditional training disciplines.

Multi-tasking. The ability of a person to perform more than one task at the same time.

Profession. An occupation which requires knowledge gained through academic study, such as law, medicine or teaching.

Qualification. Qualification refers to a formal outcome of an assessment and validation process which is obtained hen a competent body determines that an individual has achieved learning outcomes to given standards.

Qualifications, Comparability of -. The extent to which it is possible to establish equivalence between the level and content of qualifications (certificates, diplomas or titles) at sectoral, regional, national or international levels. (Cedefop, 2000)

Qualification, level of -. Low: at most lower secondary (ISCED 0-2); medium: upper secondary (ISCED 3-4); high: Tertiary (ISCED 5-6).

Qualification framework. An instrument for the development and classification of qualifications (e.g. at national or sectoral level) according to a set of criteria (e.g. using descriptors) applicable to specified levels of learning outcomes. (OECD, 2007)

Retraining. Training enabling individuals to acquire new skills giving access either to a new occupation or to new professional activities. (Cedefop, 2004)

Revealed Comparative Advantage (RCA). Relative comparative advantage compares the relative contribution of sector x to the comparative advantage of the national economy with other sectors. It is calculated as follows:

$$RCA = \tanh (\ln ((\text{Exports S} / \text{Imports S}) / (\text{Exports C} / \text{Imports C}))) \times 100$$

Interpretation: 0 = the comparative advantage of sector x equals the average of the comparative advantage of the entire national economy. Near -100: the sector contributes nothing to the comparative advantage of that country. Near + 100: the sector contributes strongly to the comparative advantage of the country.

The use and logic of the country groupings winning, losing momentum, upcoming and retreating in combination with revealed comparative advantage is similar to the concentration index (see above).

Skills. Skills refer to the ability to apply knowledge and use know-how to complete tasks and solve problems. In the context of the European Qualifications Framework, skills are described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments).

Skills gaps. Skills gaps arise where an employee does not fully meet the skills requirements for a specific job function but is nevertheless hired. This skills gap needs to be closed through training. Skills gaps can arise where new entrants to the labour market are hired and although apparently trained and qualified for occupations still lack some of the skills required.

Skills needs, emergent -. Emergent skills needs are defined in this study as the change in skills that is needed to adequately fulfil a certain job function in the future. Addressing emergent skills is needed in order to avoid skills shortages and/or skills gaps in the future.

Skills shortages. Skills shortages exist where there is a genuine lack of adequately skilled individuals available in the accessible labour market. A skill shortage arises when an employer has a vacancy that is hard-to-fill because applicants lack the necessary skills, qualifications or experience.

Tertiary education. Tertiary education refers, in most settings to non-compulsory education provided via a specialist institution once secondary schooling is completed, usually labelled as a college, polytechnic or university (in English) with variants of these in other languages. Tertiary education may be delivered virtually or at a distance.

Trade balance. Exports minus imports.

Training. The development of skills or knowledge through instruction or practice; a kind of vocational learning such as an apprenticeship or traineeship which includes both formal education and on-the-job experience.

Unskilled work. Work which lacks specialist training or ability and generally involves simple manual operations which can be learned in a short time.

Up-skilling. Short-term targeted training typically provided following initial education or training, and aimed at supplementing, improving or updating knowledge, skills and/or competences acquired during previous training. (Cedefop, 2004)

Vocational Education and Training (VET). Education and training which aims to equip people with skills and competences that can be used on the labour market. (adapted from ETF, 1997).