Investing in the Future of Jobs and Skills

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

Sector Report
Chemicals, Pharmaceuticals, Rubber & Plastic Products

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Table of Contents

1 Preface

This report presents the final results of the study *Comprehensive analysis of emerging competences and economic activities in the European Union in the chemicals, pharmaceuticals, rubber and plastic 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 chemicals sector (broadly defined) has been executed by core team staff in close collaboration with MICORD (Radboud University of Nijmegen, subcontractor) (see annex 1 for team composition).

The study was carried out during the period January 2008-April 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 professor Jan de Wit (former R&D director Akzo-Nobel, now MICORD, Radboud University Nijmegen), Armand Smits (MICORD researcher chemicals & business management, Radboud University Nijmegen), professor Alex van Herk (Department of Chemical Engineering and Chemistry, Technical University Eindhoven), professor Ton de Boer (dean and professor Department of Pharmaceutical Sciences, University Utrecht) and dr Tim Bowmer (lead chemicals expert TNO) for their participation in a first external workshop in Delft on scenarios and their implications in August 2008. A draft final version of this report was validated and complemented during a second external, final workshop in Brussels on 30 and 31 October 2008. The final workshop brought together an apt mixture of different European and national sector experts representing the industry, European social partners, various other 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 April 2009

Dr Frans A. van der Zee (overall project leader)

2 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 chemicals, pharmaceuticals, rubber and plastic 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-April 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 chemicals sector broadly defined. Step 1 delineates and defines the sector. Step 2 starts with a mapping exercise, covering the main economic and employment trends and changes in structure of activities and 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 identifies and 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.

3 Defining the sector

The chemicals industry is a major contributor to the EU economy in terms of output, value added, employment, and (net) exports. The sector supplies products to almost all downstream industry sectors and is an important engine for innovation for the wider economy. It plays a key role in facilitating and improving product performance and new applications in various industries. Examples are high performing plastics used in light weight constructions saving transport energy and new materials increasing efficiency of photovoltaic cells. Despite being a global leader in exports, the EU chemicals industry's competitiveness is under threat due to relatively high cost of production, low market growth, delocalisation of user industries and the build-up of efficient large-scale capacity elsewhere in the world. Globalisation means global competition. Yet globalisation also provides new opportunities for the sector and society in Europe, as does climate change. Innovation and the search for sustainability are key drivers in maintaining competitiveness. The design and manufacturing of high value added products and increased eco-efficiency are major challenges for European industry that will continue to exist in the near future, with the chemicals sector as a key solutions provider.

The importance and integration with other industry sectors makes it difficult to draw clear lines between the various chemical activities which range from petrochemicals and pharmaceuticals to rubber and plastic products. This report focuses on the chemicals, the pharmaceuticals and the rubber and plastic products sector, defined by statistical NACE categories 24 and 25 (see Table 2.1), and referred to in the remainder as the 'chemicals sector broadly defined'.

Table 3.1 Definition of the chemicals sector: NACE classification Rev 1.1 and Rev 2

NACE Rev 1.1	Description	NACE Rev 2
24	Manufacture of chemicals and chemical products	20
	Manufacture of basic pharmaceutical products and pharmaceutical preparations	21
25	Manufacture of rubber and plastic products	22

What is statistically understood as the 'manufacture of chemicals and chemical products' (NACE 20 Rev 2, see Table 2.1) and labelled as the 'chemicals sector narrowly defined' in the remainder of this study, is what is normally defined as the chemicals industry in standing industry practice. The High Level Group (HLG) on the competitiveness of the European chemicals industry, in line with Cefic, the European Chemical Industry Council representing the European chemical industry, defines the chemicals industry as consisting of five main sub-sectors: petrochemicals, basic inorganics, polymers, specialties and consumer chemicals (HLG, 2009). Based on production characteristics, the chemicals sector narrowly defined can be grouped into two sub-sectors: basic chemicals and fine chemicals. Basic chemicals correspond by and large with Cefic's categories of petrochemicals, basic inorganics and polymers, whereas fine chemicals include specialty and consumer chemicals. Basic (also referred to as bulk) chemicals are mostly produced in large volumes and sold to the industry itself or to other industries, and are characterised as an 'upstream' commodities sub-sector. Specialty chemicals are produced for specialised uses and in lower volumes, and forms a

highly heterogeneous sub-sector. It includes active ingredients and coformulants for the pharmaceuticals industry, ditto for the crop protection industry, dyes and pigments, paints and inks, adhesives and auxiliaries including products for industrial processes in textiles and paper manufacturing. Consumer chemicals - sold to the final consumer – include soaps, detergents, perfumes and cosmetics.

The pharmaceuticals and rubber and plastic products[1] industry can like fine chemicals be characterised as downstream user industries (Figure 3.1) Just like the chemicals sector narrowly defined, the rubber and plastic products sector comprises various segments, ranging from high-tech rubber to mass produced PET packaging. Plastics converters (sometimes called "processors") are the heart of the plastics industry and manufacture plastics semi-finished and finished products for an extremely wide range of industrial and consumer markets (inter alia: automotive, electrical and electronic, packaging, construction and healthcare industries).

Data in this report is still based on the NACE Rev 1.1 classification, as under the recent NACE Rev 2 classification, which entered into force as per January 2008 no time series are available yet. NACE Rev 1.1 distinguishes between two large sub-sectors, chemicals and chemical products (24) and rubber and plastic products (25), with 24 including the pharmaceuticals industry (i.e. pharmaceutical, medical chemicals and botanical products). The new NACE Rev 2 distinguishes three sub-sectors: chemicals and chemical products (20), basic pharmaceutical products and pharmaceutical preparations (21), and rubber and plastic products (22). The sub-sectors photographic chemical materials and prepared unrecorded media previously classified under chemicals and chemical products have been reclassified. No other additions or changes have been made. The NACE reclassification not only better reflects the important differences and growing divergence between the chemicals sector and the pharmaceuticals sector, observed in the ongoing trend of restructuring (mergers and acquisitions), focus on core business and, related, the further specialisation in different segments of the chemicals sector at large.

4 Structural characteristics of the sector: past and present

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

The chemicals, pharmaceuticals, rubber and plastic products manufacturing sector accounted for approximately 100,000 enterprises in the EU-27 in 2006 and employed 3.75 million persons, equalling 1.7% of overall employment in the EU and 10.9% of total EU manufacturing employment. Total sales in the chemicals industry broadly defined amounted to € 799 bn, with the chemicals industry being the largest sector representing 46.4%, and the pharmaceuticals and rubber and plastic products sector accounting for 23.1% and 30.5% of total sales, respectively (see Table 3.1). The chemicals, pharmaceuticals, rubber and plastic products manufacturing sector generated € 322 bn of value added, which is equivalent to 2.8% of EU GDP in 2006 (see Table 3.3).

Over the past years, developments in the chemicals sector and the pharmaceuticals sector have tended to “decouple”, with diverging trends in growth of output, value added,

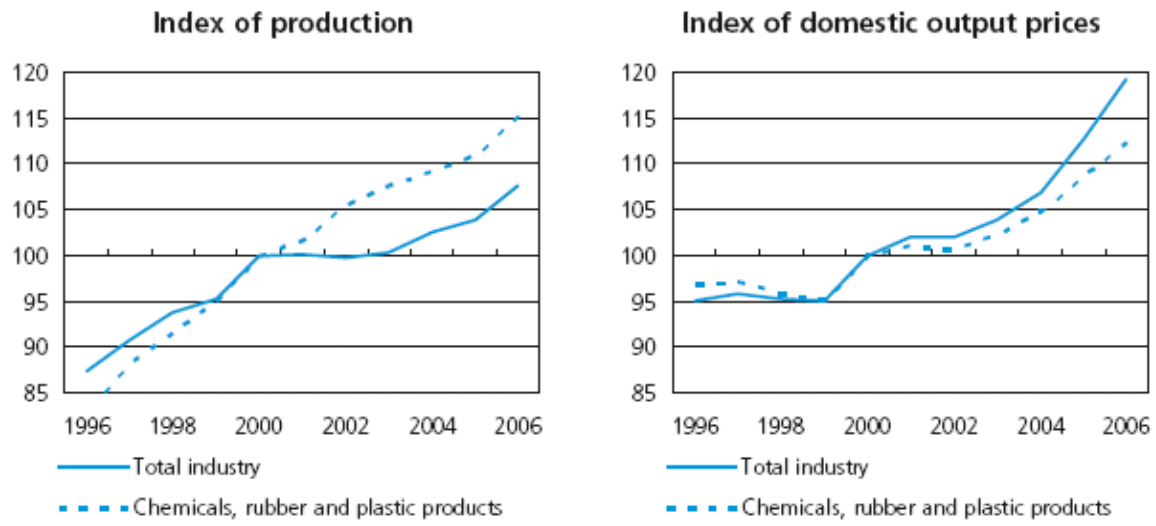
[1] This refers to the manufacture of rubber and plastic products, not to be confused with rubber and plastic chemicals (polymers, synthetic rubber, etc.) being a sub-segment of basic chemicals.

employment and trade. Over the last decade growth in chemicals output has been lower than in the pharmaceuticals industry. While the overall trade surplus is still increasing, the trade surplus in pharmaceuticals has grown much faster, increasing its share from 23% in 1990 to 40% in 2002 and almost 50% in 2006 (CEFIC, 2002; Eurostat, 2007). This "decoupling" of the chemicals and pharmaceuticals industry is the result of a number of factors. These include the introduction of new technologies, different approaches to innovation, changes in downstream markets, growth perspectives, drivers of success, and changing shareholder expectations (CEFIC, 2002). What is observed is a reconfiguration of the industry driven by a strategic repositioning of firms and a (renewed) search for core competences.

Table 4.1 Sales EU chemicals, pharmaceuticals, rubber and plastic products, 2006

		Share	Sales 2006 €bn
Basic chemicals	Plastics & synthetic rubber	13.9%	111.1
	Man-made fibres	1.5%	11.7
	Other basic inorganics	3.3%	26.6
	Industrial gases	1.4%	11.2
	Fertilizers	2.0%	16.0
Fine chemicals	Other specialty chemicals	10.0%	80.0
	Paints & inks	4.8%	38.5
	Crop protection	1.1%	8.7
	Soaps & detergents	3.7%	29.3
	Perfumes & cosmetics	4.7%	37.3
	Pharmaceuticals	23.1%	184.5
Rubber & Plastic Products	Rubber products	7.2%	57.6
	Plastics & synthetic rubber products	23.3%	186.2
NACE Rev 2	Chemicals	46.4%	370.2
	Pharmaceuticals	23.1%	184.5
	Rubber and plastic products	30.5%	243.8
Source: Eurostat, CEFIC		100.0%	798.6

Figure 4.1 Production and price index EU-27, 1996-2006 (2000=100)



Source: Eurostat, 2007

Trends in production

During the last ten years, EU-27 production of chemicals, pharmaceuticals, rubber and plastic products manufactures has risen steadily and continuously up and until 2006. The rate of growth outpaced the industrial average with an average of 4.0 % compared to 2.3 % per annum overall (Eurostat, 2007).

Germany is the largest chemicals producer in Europe by output, followed by France, Italy and the UK. Together, these four countries produced 62% of EU chemicals output in 2006. Adding Belgium, Spain, the Netherlands and Ireland raises the share to 88%. In almost all of these countries employment in the chemicals industry has decreased in the last decade (1994-2004), sometimes dramatically like in Germany (-22%) and the UK (-14%). In the ten new Member States (NMS) the chemicals industry is still rather small in comparison to the old Member States although, for instance, Poland represents 1.8% of total EU-25 chemical sales, which is more than Austria, Finland and Portugal (European Commission, 2006).

Table 4.2 Value added chemicals, pharmaceuticals, rubber and plastic products, 1995-2006

	Sector				Overall economy			
	Level	**95-00**	**00-06**	**95-06**	**Level**	**95-00**	**00-06**	**95-06**
EU	322 322	4.6	3.5	4.0	11 468 970	2.8	2.0	2.3
EU-15	306 629	4.6	3.3	3.9	10 883 245	2.8	1.9	2.3
NMS	15 693	5.1	6.9	6.1	585 725	2.7	3.7	3.2
Winning	48 875	12.9	11.2	11.9	661 979	3.3	4.1	3.8
Losing momentum	93 659	2.7	3.1	2.9	2 728 730	2.2	1.2	1.6
Upcoming	80 726	8.8	4.3	6.3	3 088 469	2.9	1.9	2.3
Retreating	98 644	2.3	0.6	1.4	4 955 940	3.0	2.1	2.5
Definition	Value added	Annual average growth[2]			GDP	Annual average growth		
	Million euro 2006	% 1995-2000	% 2000-2006	% 1995-2006	Million euro 2006	% 1995-2000	% 2000-2006	% 1995-2006

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

Source: Eurostat/TNO. NMS: new Member States. GDP: Gross Domestic Product.

[2] 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%.

The strongest expansions in EU-27 output occurred in the pharmaceuticals industry, showing an increase of on average 6.1% per annum in ten years up to 2006. Another strong grower was the manufacture of basic chemicals, which rose by an average 3.7% per annum. In contrast, there were notable contractions in the EU-27 production indices of pesticides and other agro-chemical products, and man-made fibres during the same period (both falling 2.4 % per annum on average), although most of the declines came in the period between 2001 and 2005 (Eurostat, 2007). Output of rubber and plastic products went down slightly by 0.7% in 2001 compared with the previous year, followed by a positive and accelerating development until 2006, with annual growth rates ranging between 0.2% in 2002 and 4.1% in 2006 (Eurostat, 2007).

Trends in value added

The lion share of value added in the chemicals and rubber and plastic products sector in the EU (€322 322 m) is generated by the EU-15 (95%), while only 5% is generated by the new Member States (see Table 3.3 for details). Nevertheless, although starting from a lower base the new Member States have grown much faster (+6.1%) than the EU-15 (+3.9%) in the period 1995-2006. Furthermore, while growth has slowed in the period 2000-2006 in the EU-15 (+3.3%), it has accelerated in the new Member States compared to the period 1995-2000 (+6.9%).

Especially France, Sweden and Ireland stood out with a 7.4%, 7.5% and 14.5% increase in value added, respectively. Greece lost by -5.5%, and the UK slightly by -0.1%. Compared to the overall economy, the chemicals and rubber and plastic products sector grew much faster in value added across country groups. On average almost twice as fast, driven by an expanding European and world economy.

Box 2. 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*.

Measured in terms of growth over the time period 1995-2006 and concentration index – a measure for relative comparative advantage (see Box 2 for details), various countries do particularly well. The front group of winners that have a high concentration index combined with high growth rates consists of the Czech Republic, Ireland, Lithuania, Slovenia and Sweden, with average growth rates in value added of 12%. Upcoming countries are France, the Netherlands, Austria, Denmark, Estonia and Poland. Retreating countries, with a low growth rate and a concentration index lower than 100, include Greece and the UK, but also others such as Italy, Finland, Portugal and Spain.

Table 4.3 Value added chemicals, pharmaceuticals, rubber and plastic products, 1995-2006

	Share in country		Share in EU		Concentration index	
	Level	**Change**	**Level**	**Change**	**Level**	**Change**
EU	2.8	0.4	100	0	100	0
EU-15	2.8	0.4	95	-1	100	0
NMS	2.6	0.5	5	1	93	5
Winning	7.0	3.5	14	7	252	105
Losing momentum	3.4	0.4	29	-3	122	-4
Upcoming	2.5	0.7	25	4	92	16
Retreating	2.0	-0.2	32	-8	74	-21
Definition	Share in national GDP	Total change in share	Share in value added sector EU	Total change in share	Share in country divided by share in EU	Total change in index
	2006	1995-2006	2006	1995-2006	2006	1995-2006

Source: Eurostat/TNO

The picture is more differentiated at the sub-sector level. In the chemical products and pharmaceuticals sector value added grew strong in the EU-15 at 4.5% compared to the overall economy (2.8%). In the NMS value added growth is on par with the overall economy, with the sector retreating in many new Member States except for Lithuania and Slovenia. In contrast, the rubber and plastic products sector grows on par with the overall economy in the EU-15 with many countries retreating in this sub-sector. Winners in the EU-15 are France, Germany and Austria. The new Member States expand strongly in rubber and plastic products, with winners being the Czech Republic, Hungary, Poland, Slovakia, Slovenia.

Trends in employment

The EU chemicals employed 3.75 million people in 2006, 1.92 million of which working in the chemicals and pharmaceuticals industry and 1.83 million in the rubber and plastic products industry. The largest share of employment, in line with production and value added, is concentrated in the 'old' EU-15 (81%). However, compared to the share of value added (5%) the new Member States have a much higher share of employment (19%). For the period 1995-2006 annual employment growth was slightly negative in the EU-15 (-0.4%) compared to positive growth in the new Member States (+1.6%). Clear winners in employment performance as measured by concentration index and employment growth during the period 1995-2006 were France, Italy, Denmark, Ireland and the Czech Republic. Upcoming countries (employment growth but a concentration index still below 100) were Greece, Spain, Sweden,

and most new Member States. Countries losing momentum are Belgium, Germany, Luxemburg and Slovenia: decreasing employment, but a concentration index above average.

Table 4.4 Employment[3] chemicals, pharmaceuticals, rubber and plastic products, 1995-2006

	Level	Annual growth	Share in EU	Change in share
EU	3 746 869	-0.1	100	0
EU15	3 027 272	-0.4	81	-1
NMS	719 597	1.6	19	1
Winning	1 236 714	1.8	33	4
Losing momentum	985 632	-0.6	26	-1
Upcoming	734 427	1.7	20	2
Retreating	790 096	-3.6	21	-5
Definition	Level	Average annual growth (%)	Share of EU employment of the sector (%)	Change in share in EU employment sector (%)
	2006	1995-2006	2006	1995-2006

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

Source: Eurostat/TNO

The picture of employment growth is more differentiated at the sub-sector level, reflecting the different dynamics in each of the sub-sectors. Employment in the manufacture of chemicals and chemical products declined steadily in the EU-27 during the period 1995-2006, at an average rate of 1.5% per annum, in line with the overall industrial average. In contrast, employment in the manufacture of rubber and plastic products grew at an average rate of 0.7% per annum. This growth occurred predominantly in the period up to 2000; since then levels have remained relatively steady. The pharmaceuticals sector has shown considerable employment growth over the last decade (EFPIA, 2007).

Similar to production, Germany, France and Italy represent the largest share of employment in the sector (48%) with 1.84m people. Interestingly the share between EU Member States remains fairly stable, apart from the UK which lost the highest shares in employment. While output contracted in Greece, it nevertheless was one of the biggest winners in terms of employment (+2.9%) within the EU-15 followed by Denmark (+2.5%) and Sweden (+2.4%). In the new Member States, a general trend of employment decline in the chemicals sector was observed. This trend, however, was generally overcompensated by employment growth in the rubber and plastic products sector.

[3] Throughout this report employment is measured in working persons and concerns both employers and employees.

The regional specialisation in employment of the chemicals and pharmaceuticals (NACE 24), and the rubber and plastic products manufacturing sector (NACE 25) are shown in Figure 4.2 and Figure 4.3, respectively.

Figure 4.2 Vertical shares: employment in the chemicals and pharmaceuticals sector as share of total employment by NUTS 2 region, 2006

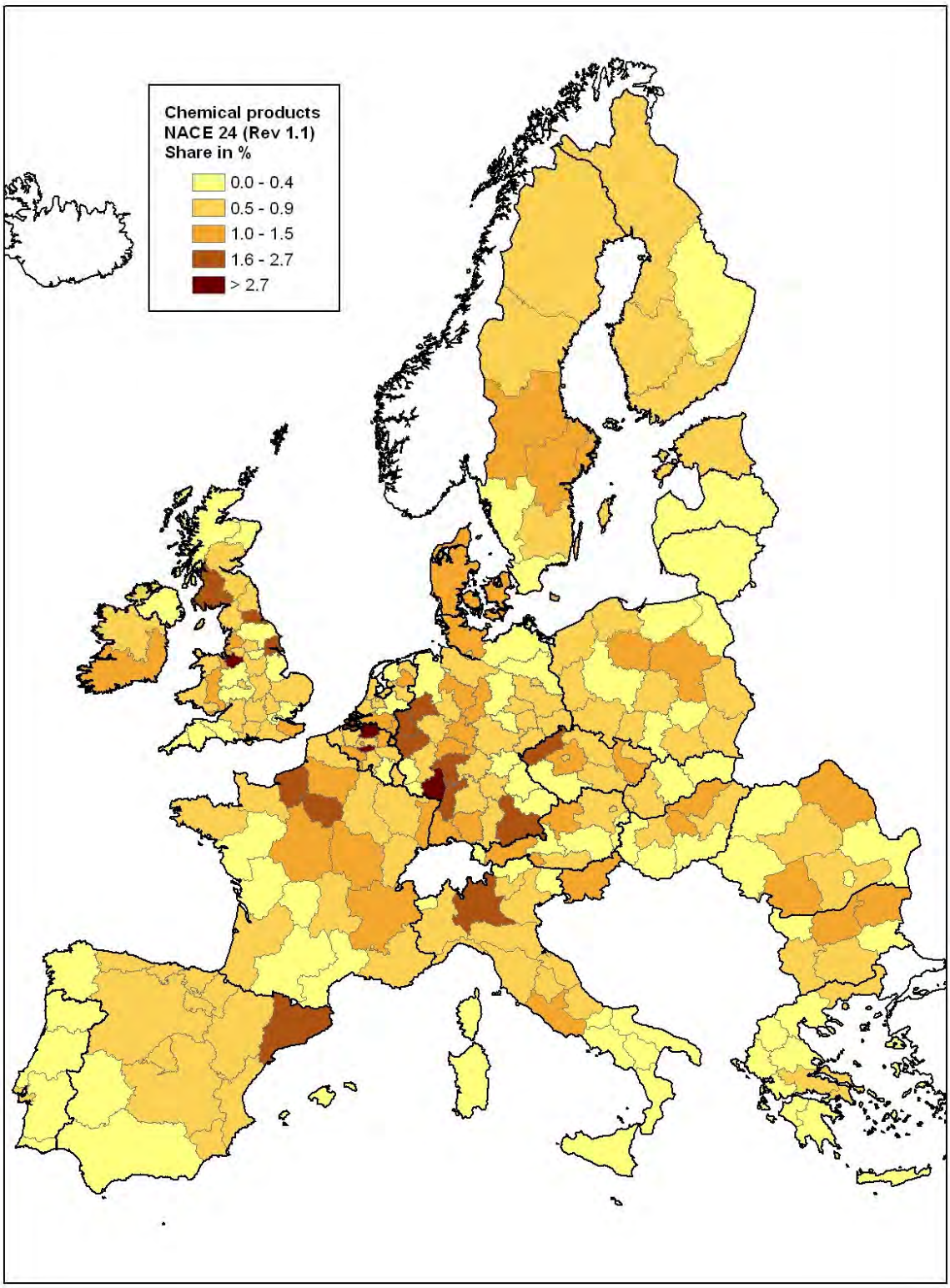
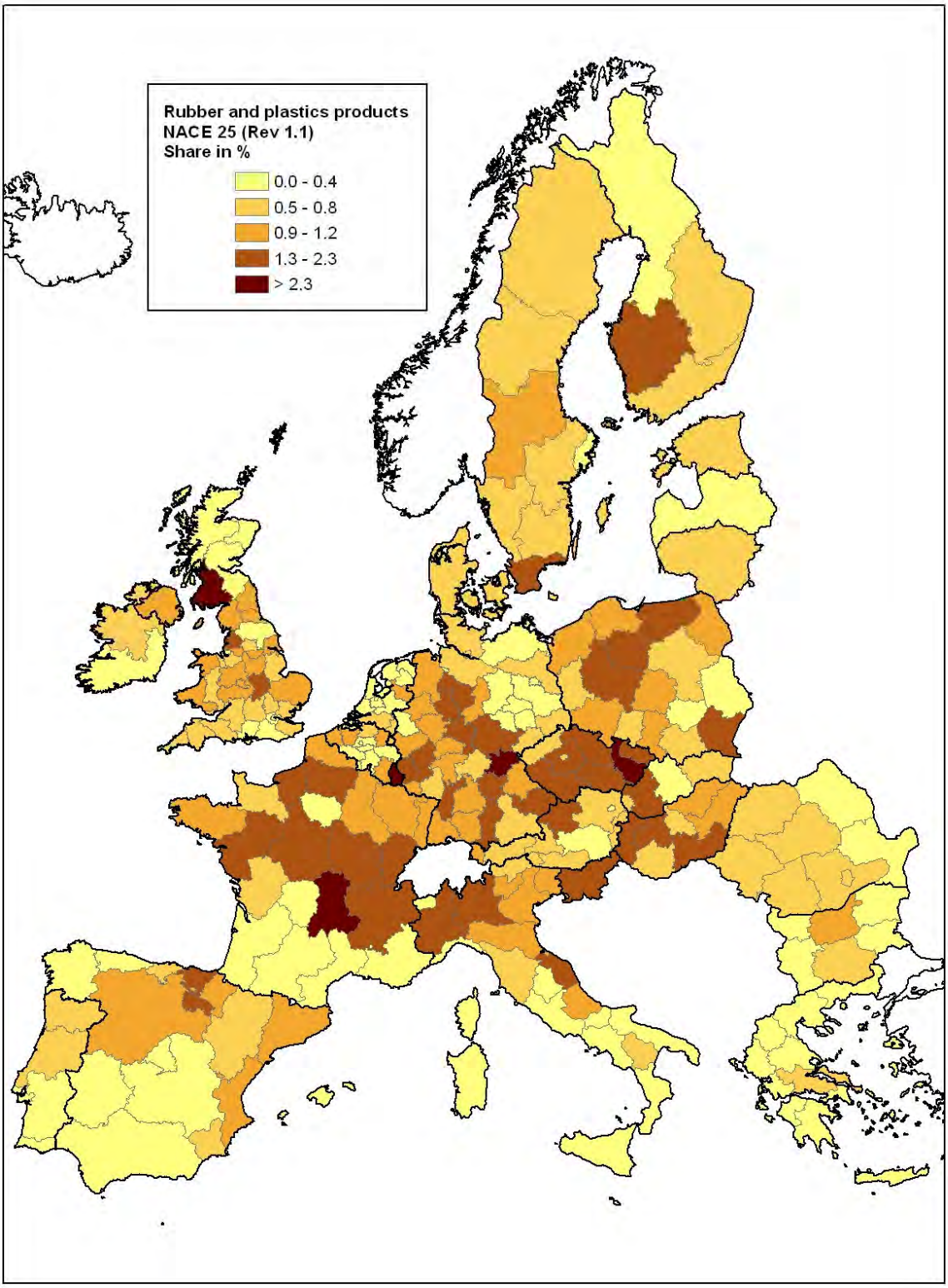
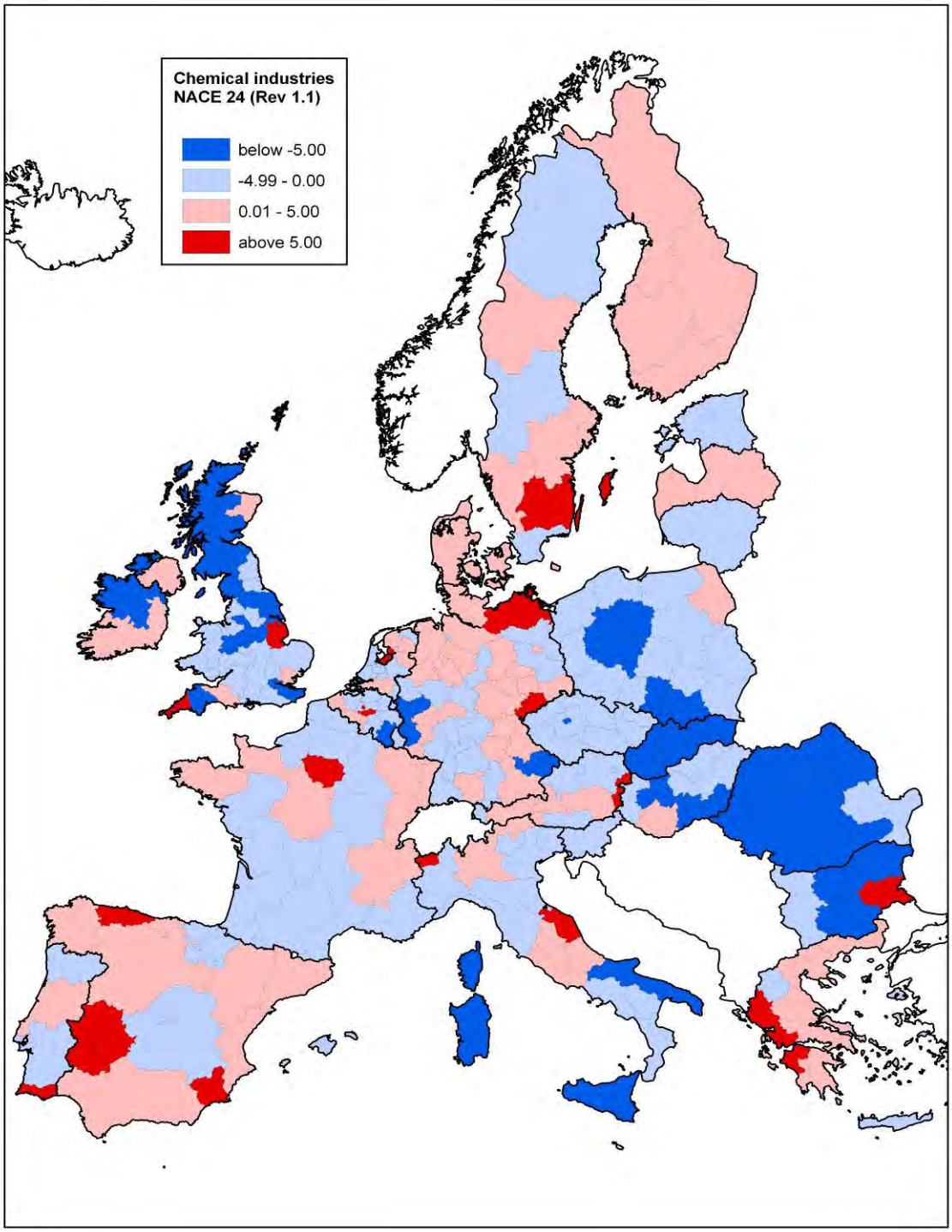


Figure 4.3 Vertical shares: employment in the rubber and plastic products sector as share of total employment, by NUTS 2 region, 2006



The most specialised region in 2007 at the NUTS 2 level was Rheinhessen-Pfalz in Germany followed by Alsace and Auvergne in France, with regions in France and Germany occupying fourteen of the top twenty places[4] (Eurostat, 2007).

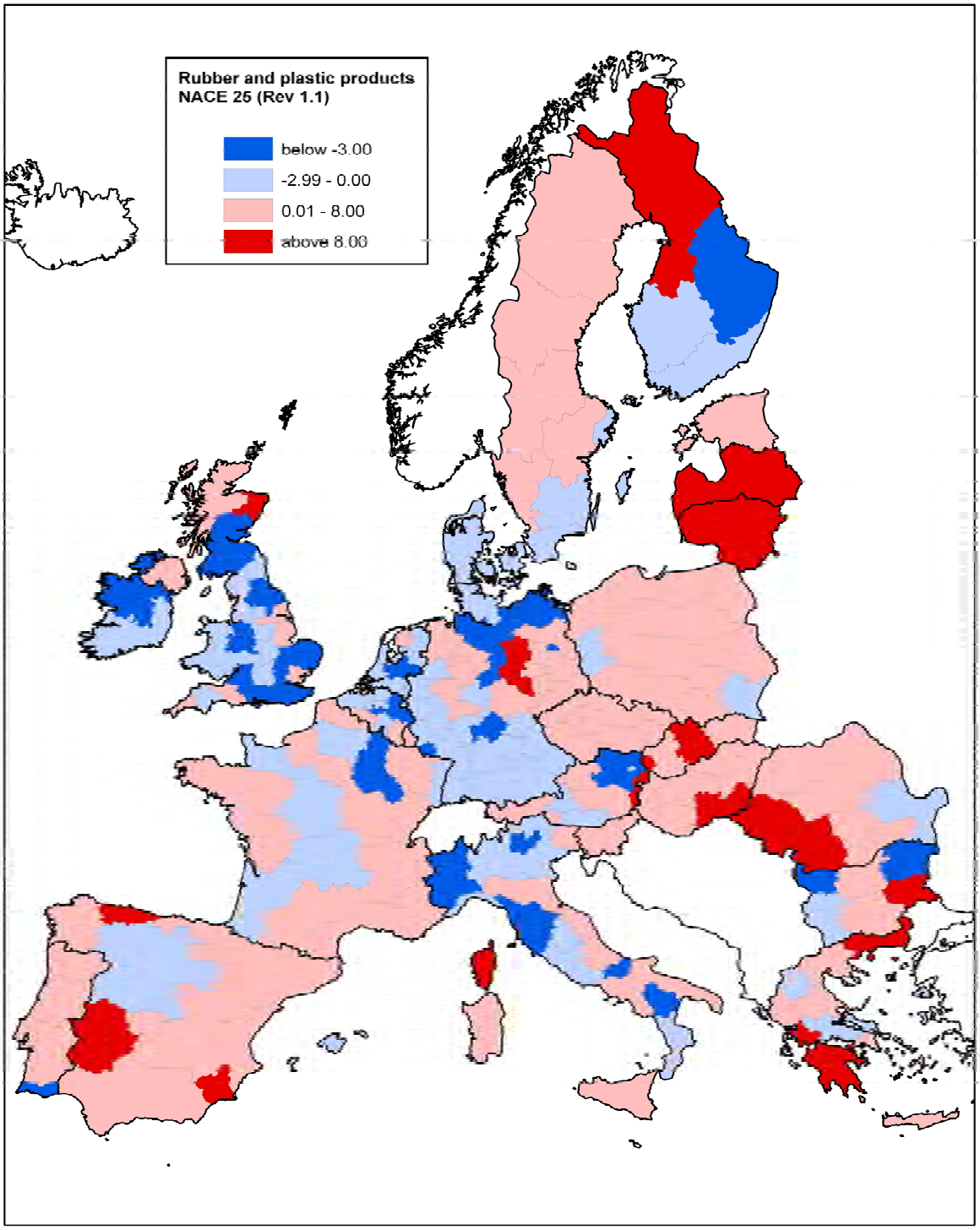
Figure 4.4 Changes in employment in the chemicals and pharmaceuticals sector by region, 1999-2005 (% per annum change)



[4] Note that data is confidential for the regions of Koblenz and Weser-Ems in Germany, although the proportion of their non-financial business economy employment coming from chemical, rubber and plastics activities was among the highest in terms of regional specialisation (Eurostat, 2007).

What the figures clearly show is that the chemicals, pharmaceuticals and rubber and plastic products sector is an important sector in terms for employment for most regions across the EU. Employment is most concentrated in a number of geographical clusters, predominantly located in the west of Germany, France, Belgium and Northern Italy.

Figure 4.5 Changes in employment in the rubber and plastic products sector by region, 1999-2005 (% per annum change)



In addition to the regional specialization, Figure 4.4 shows the annual changes in employment in the chemicals and pharmaceuticals sector at regional level. Strong growth is exhibited in

the South of Sweden, North-Eastern German, certain parts of Spain, Greece, and France. The most important regions in decline are in the UK, Southern Italy, Poland, Bulgaria and Romania. However, the growth rates need to be seen in context of the regional specialisation exhibit in the previous maps as high growth regions often improve from a low base. Figure 4.5 similarly displays the annual changes in employment in the rubber and plastic products sector at regional level, giving a rather different pattern with strong growth regions predominantly in Central and Eastern Europe (Baltic states!), Finland Sweden and Spain and employment declines in the UK, Ireland, Northern Germany, the Benelux, Finland, and Italy.

4.2 Value added and employment EU compared to US, Japan and BRICs

Amongst Europe's main competitors in the chemicals markets broadly defined are traditional ones, most importantly the US and Japan which experience similar structural pressures as Europe, and new emerging competitors such as the BRICs (primarily China, to a lesser extent also Russia) and the Middle East.

Table 4.5 Employment and value added trends[1]: EU, USA & Japan, 1995-2005

	Employment growth	Change in share of employment of manufacturing total	Value added growth	Change in value added share	Value added growth per employee
Europe (EU-15)	**3.4%**	**0.5%**	**30.1%**	**0.2%**	**25.7%**
Basic Chemicals	-7.9%	-0.2%	15.5%	0.5%	25.5%
Fine Chemicals [2]	3.2%	0.2%	39.7%	2.8%	35.1%
Rubber and Plastics [3]	8.8%	0.5%	33.1%	2.0%	22.4%
United States[2]	**-15.4%**	**0.5%**	**25.0%**	**1.9%**	**47.8%**
Basic Chemicals	-17.8%	0.0%	12.3%	0.0%	36.5%
Fine Chemicals	-11.5%	0.3%	41.2%	2.0%	59.6%
Rubber and Plastics	-16.9%	0.2%	9.2%	-0.1%	31.4%
Japan[3]	**-14.1%**	**1.5%**	**-15.2%**	**1.9%**	**-1.3%**
Basic Chemicals	-29.3%	0.1%	-27.0%	-0.1%	-5.6%
Fine Chemicals	-16.0%	0.3%	-11.3%	1.2%	5.6%
Rubber and Plastics	-11.2%	1.1%	-11.3%	0.8%	-0.1%

Source: TNO, based on UNIDO data (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] Fine Chemicals comprises 'Other chemicals' (ISIC 242) and 'Man-Made fibres' (ISIC 2430). Pharmaceuticals are part of 'Other chemicals' (ISIC 242). [3] Rubber and Plastics comprises 'Rubber products' (ISIC 251) and 'Plastic products' (ISIC 252)

Comparing the TRIAD regions in terms of employment growth in the chemicals sector broadly defined for the period 1995-2005 (see Table 3.5), the EU-15 clearly outperformed the US and Japan with employment growth of 3.4% compared to declines of 15.4% and 14.1% in the US and Japan respectively. This positive comparative performance of Europe in terms of employment growth is observed across all sub-sectors. Despite the decline in employment in the US and Japan, the share of chemicals in overall manufacturing employment in these countries actually increased much stronger compared to Europe, showing that other manufacturing sectors elsewhere have experienced even stronger employment declines than Europe in the same period. Whether employment growth is actually a positive sign from a

competitiveness perspective remains to be seen, however. A strong growth in value added of 30% compared to 25% and -15% for the US and Japan respectively, seems to indicate that it is indeed a strength rather than a weakness. Having said that, however, the US has increased its value added per employee much stronger than Europe which indicates a relative gain in competitive advantage.

Table 4.6 Employment and value added trends: BRICs[4], 1995-2005

	Employment growth*	Change in share of employment of manufacturing total	Value added growth*	Change in value added share	Value added growth per employee
Brazil	**27.2%**	**0.1%**	**10.2%**	**-2.0%**	**-13.4%**
Basic Chemicals	20.3%	-0.1%	29.3%	0.2%	7.5%
Fine Chemicals	18.8%	-0.2%	-2.0%	-1.8%	-17.5%
Rubber and Plastics	36.4%	0.4%	13.4%	-0.4%	-16.9%
Russia[5]	**-8.1%**	**0.3%**	**224.8%**	**0.1%**	**253.6%**
Basic Chemicals	-26.9%	-0.8%	318.5%	1.6%	472.7%
Fine Chemicals	-10.1%	0.0%	69.9%	-1.6%	89.0%
Rubber and Plastics	43.0%	1.0%	544.3%	0.9%	555.6%
India	**4.5%**	**0.2%**	**23.2%**	**-7.3%**	**18.0%**
Basic Chemicals	-10.0%	-0.4%	5.7%	-4.6%	17.4%
Fine Chemicals	8.6%	0.4%	32.4%	-2.5%	21.8%
Rubber and Plastics	8.0%	0.2%	56.3%	-0.2%	44.7%
China[6]	**3.0%**	**0.2%**	**347.6%**	**-1.0%**	**334.7%**
Basic Chemicals	-8.3%	-1.1%	333.6%	-1.3%	372.8%
Fine Chemicals	N.A.	N.A.	N.A.	N.A.	N.A.
Rubber and Plastics	41.3%	1.2%	423.7%	0.3%	270.5%

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

[4] Brazil: 1996-2005, Russia: 2001-2005; India: 1998-2004. [5] Russia: due to lack of data 'Value added growth', 'Change in value added share' and 'VA growth per employee'only includes 'Rubber products' (ISIC 251). [6] Data for China based on ISIC Rev 2; Basic chemicals is composed of 'Industrial chemics' (ISIC 351) and 'Petroleum refineries' (ISIC 353); Rubber and Plastics is composed of 'Rubber products' (ISIC 355) and 'Plastic products (ISIC 356); Totals of China do not contain data on 'Fine Chemicals'

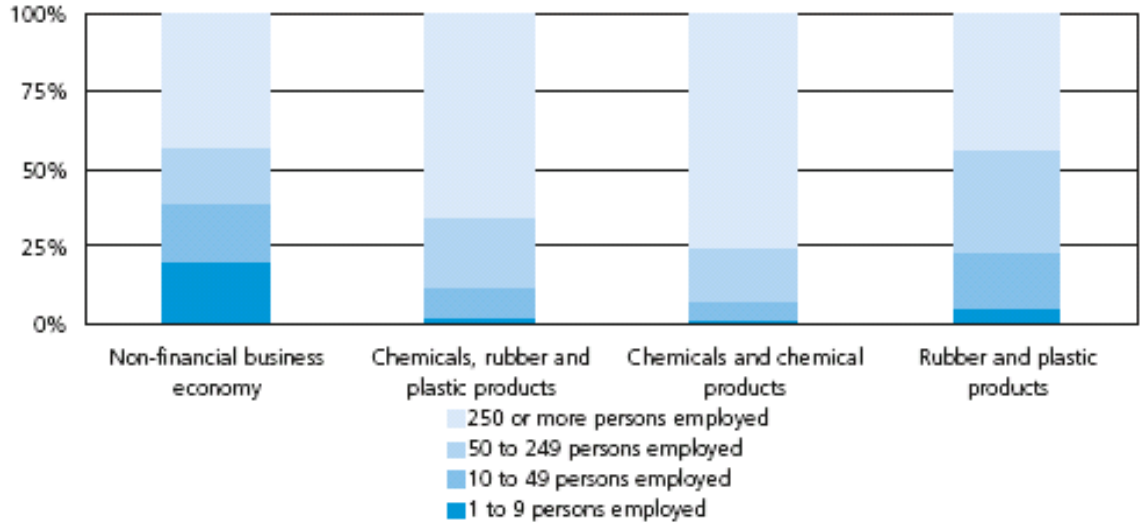
In comparison to the BRICs – which together with the Middle East and other Asian countries have built up considerable production capacities in the sector adding to employment - the picture is much more differentiated (see Table 3.6). While Brazil experienced the largest employment growth of all (20%), we at the same time observe a declining value added per employee meaning a decline in relative competitiveness. Russia and China with their communist past and economic restructuring stand out with massive increases in value added growth (225% and 348% respectively), particularly in basic chemicals and rubber and plastic products, based on cheap availability of feedstock (Russia) and strong growth in regional demand. Nevertheless, employment in China has only experienced a slight increase (3.0%) while in Russia employment even declined (-8.1%). In summary, while large parts of global production growth can be observed in emerging economies - which is reflected in strong value added growth rates - productivity in the sector has increased faster, with employment in basic chemicals generally decreasing, not fully set off by employment growth in fine chemicals.

4.3 Employment structure and work organisation

Firm size

The manufacture of chemicals, pharmaceuticals, rubber and plastic products in the EU-27 was not only concentrated in the larger Member States, it was also focussed within the large enterprises (employing >250 persons). SMEs (employing <250 persons) accounted for only one third (33.6%) of the value added generated in 2004 (Eurostat, 2007). Within the sub-sector of manufacture of chemicals and chemical products large enterprises dominated even more, accounting for a little over three quarters of the value added generated (75.9%). The importance of large enterprises was particularly marked in Ireland, accounting for over four fifths (85.1%) of all value added in chemicals, pharmaceuticals, rubber and plastic products manufacturing. This share was also over 70% in Belgium, Germany, Denmark, Hungary and Slovenia. In contrast, a majority of value added in the sector was generated by SMEs in Italy (55.5%), in Portugal (62.9%, 2003) and Latvia (67.3%, 2003) (Eurostat, 2007). Despite the industry being dominated by large firms, the large firms, which used to be vertically integrated, have been very active in reconfiguring, restructuring and specialising over the last decade, focussing more on core activities and specific segments to exploit scale advantages.

Figure 4.6 Share of value added by enterprise class, EU-27, 2004



Source: Eurostat (SBS)

Table 4.7 Share of total enterprises by enterprise size

	Shares, 2005			Total share changes, 1999-2005		
	<50 employees	50-249 employees	>250 employees	<50 employees	50-249 employees	>250 employees
EU	87.8	9.8	2.4	-0.3	0.6	-0.3
EU15	86.5	10.8	2.8	-0.3	0.6	-0.3
NMS	91.3	7.1	1.5	-0.9	1.1	-0.2
Winning	89.0	8.7	2.3	-1.6	1.3	0.2
Losing momentum	78.4	16.8	4.8	-0.2	0.6	-0.4
Upcoming	91.4	7.2	1.4	0.0	0.3	-0.3
Retreating	87.2	10.3	2.6	1.3	-0.2	-1.1

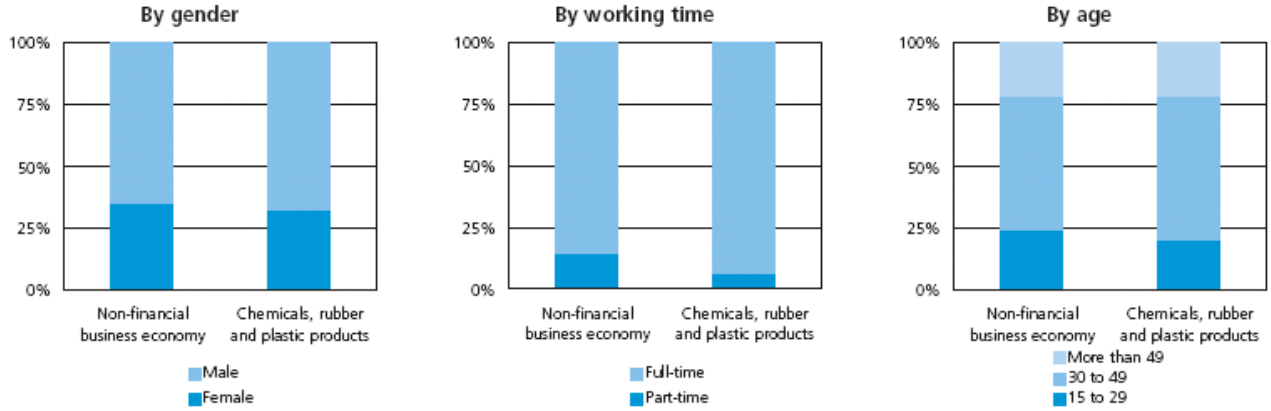
Source: Eurostat/TNO

While the generation of value added is clearly concentrated in large enterprises in the chemicals and chemicals products sector, the share of large enterprises differs between country groups. While large firms (>250 employees) are most concentrated in the EU-15 and more specifically the country group losing momentum (i.e. in employment performance!), it is the winning and upcoming country groups that have an above average share of small enterprises. One interesting trend across country groups is the declining share of small and large enterprises, whereas medium-sized enterprises expand their share.

Gender structure

The share of male workers in the chemicals, pharmaceuticals and rubber and plastic products sector is similar to the overall economy (68% vs 65%). However, the share of males is much higher in rubber and plastic products sector (72%) than in chemicals and pharmaceuticals sectors (64%). Large differences also exist between countries. Shares of male employees are relatively low in Cyprus (50%), Denmark (54%), Slovenia (56%), and high in the Czech Republic (56%), Lithuania (76%) and the Netherlands (80%) (Eurostat, 2007).

Figure 4.7 Labour force characteristics EU-27, 2006



Source: Eurostat, 2007

Employment, part-time work and self-employment by sub-sector

The chemicals, pharmaceuticals and rubber and plastic products sector is characterized by a high degree of full time jobs, with 93% of all employment being classified as full time compared to 86% for the economy as a whole (see Figure 4.7). The low share of part time work – often associated with lower pay – is complemented with high average pay for the overall sector (€39k, 2004) compared to the economy average (Eurostat, 2007).

The high average pay is sustained by high labour productivity levels in the different sub-sectors. Pay levels differ substantially between sub-sectors, with the pharmaceuticals sector paying € 53k per worker being highest and the plastic products sector with € 29k being lowest in rank (Eurostat, 2007). Furthermore, the sector has very low levels of entrepreneurial and self-employed activity with 6% of the workforce self-employed in the chemicals and pharmaceuticals sector (NACE 24) and 8% in the rubber and plastic products sector (NACE 25) (see Table 4.8 and Table 4.9 respectively). This can be explained by the maturity of the sector, where employment is concentrated in large and medium sized enterprises. For detailed data of the sub-sectors, see the Tables xx 2.5.1 and 2.5.2 in the data annex.

Table 4.8 Employment and share of self-employed and part-time work in chemicals and pharmaceuticals, 2006

	Total employment (persons)	Share of total employment (%)	Share of employees (%)	Share of self-employed (%)	Share of part time employment (%)
EU	1 915 063	100	94	6	6
EU15	1 628 865	85	95	5	7
NMS	286 198	15	92	8	1
Winning	625 015	33	90	10	5
Losing momentum	542 894	28	97	3	10
Upcoming	156 543	8	98	2	1
Retreating	593 308	31	95	5	6

Source: Eurostat/TNO. Note: Due to statistical differences, the sum of employment the categories winning, etc is slightly different from the employment numbers stated for the EU as a whole.

Table 4.9 Employment and share of self-employed and part-time work in rubber and plastic products, 2006

	Total employment (persons)	Share of total employment (%)	Share of employees (%)	Share of self-employed (%)	Share of part time employment (%)
EU	1 831 806	100	92	8	5
EU15	1 398 407	76	94	6	6
NMS	433 400	24	84	16	2
Winning	586 777	32	87	13	3
Losing momentum	629 447	34	93	7	7
Upcoming	270 445	15	94	6	3
Retreating	347 906	19	97	3	8

Source: Eurostat/TNO. See note table 3.8.

Age structure of industry and changes in age structure by job function

Compared to the age structure of the overall economy, the chemicals, pharmaceuticals and rubber and plastic products sector has a below average share of younger employees (15-29 years) of 20% compared to 24% in the overall economy (see Figure 3.7). However, large differences between sub-sectors exist. While only 18% of the employees in the chemicals and pharmaceuticals sector fall in the 15-29 years category this applies to 24% in the rubber and plastic products sector (Eurostat, 2007). Consequently, the overall sector had a correspondingly higher proportion aged between 30 and 49 years (58.2%) compared to overall economy (54.2%).

Interesting patterns can also be observed when we look at the age structure of different job functions. Firstly, large differences exist between the old and new Member States. In the new Member States (EU-12) the age segment 15-39 years (y) shows the highest growth across job functions. This can largely be attributed to the restructuring dynamics since 1990 that has created opportunities for younger people to take on job functions, particularly in management,

that in the EU-15 are occupied by more senior age groups. In the EU-15 a shift in the high professional job functions from the 15-39y to the 40-49y segment can be observed, whereas in manual and technical functions a shift to the 50-65y and 40-49y segment has occurred. This is indication that the EU-15 workforce in the sector is structurally older. This is likely to have been caused by the restructuring over the last decade that led to a negative employment growth, limiting the demand for young people moving in the industry. As many technical functions require tacit knowledge, this potentially poses a skills gap when the older generation is retiring over the coming years.

4.4 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.[5]. 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.

Employment by occupation: state-of-play and main changes

Plant and machine operators represent the largest share of employees in both the EU-15 (21%) and new Member States (23%) (see Table 3.7). Other important occupations are engineers, business and other professionals, secretaries and labourers. Low occupation shares are represented by service workers and computing professionals. Interestingly is the share of technical executing occupations (metal, machinery, precision to labourers) which is with 55% much higher in the new Member States than in the EU-15 (44%). This could be an indication of higher production intensity in the new Member States with support and professional functions located in the EU-15. Both winning and losing momentum countries have large shares of engineers (15%). However, whereas winning countries also have a much higher share of plant and machine operators, losing countries do not. Retreating countries have a much higher share of managers (16%), a high share of labourers (11%). This imbalance could explain their performance as retreating countries. Low occupation shares are represented by service workers and computing professionals. Interestingly is the share of technical executing

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

occupations (metal, machinery, precision to labourers) which is with 55% much higher in the new Member States than in the EU-15 (44%). This could be an indication of higher production intensity in the new Member States with support and professional functions located in the EU-15. Both winning and losing momentum countries have large shares of engineers (15%). However, whereas winning countries also have a much higher share of plant and machine operators, losing countries do not. Retreating countries have a much higher share of managers (16%), a high share of labourers (11%). This imbalance could explain their performance as retreating countries.

Table 4.7 Occupation shares chemicals broadly defined, 2006

	EU-15	NMS	EU	Winning	Losing momentum	Upcoming	Retreating
Managers	10	9	10	7	8	10	16
Computing professionals	2	1	2	2	2	1	2
Engineers	13	11	13	15	15	9	9
Business professionals	8	6	7	5	7	11	8
Other professionals	11	11	11	12	10	12	9
Office clerks and secretaries	12	7	11	10	14	9	9
Service workers	1	2	2	1	1	2	2
Metal, machinery, precision workers	7	10	8	9	8	8	7
Craft, trades	4	5	4	4	3	4	4
Chemical prod machine operators	1	3	1	1	1	2	2
Rubber, plastic prod. mach. operators	2	2	2	2	1	3	1
Plant, machine operators	21	23	21	26	20	18	19
Labourers	9	12	9	6	9	12	11

Note: The country grouping (Winning, Losing momentum, Upcoming and Retreating) is based on value added (Table 3.2)
Source: Eurostat/TNO

Table 4.8 Changes occupation shares chemicals broadly defined, 2000-2006

	EU-15	NMS	EU	Winning	Losing momentum	Upcoming	Retreating
Managers	0	0	0	1	0	0	0
Computing professionals	1	3	1	3	0	0	1
Engineers	1	3	1	-1	2	-1	3
Business professionals	2	-7	0	4	0	0	-5
Other professionals	-2	-2	-2	-4	1	-3	-5
Office clerks and secretaries	0	0	0	-1	0	0	0
Service workers	0	0	0	1	-1	0	0
Metal, machinery ,precision	0	1	0	0	-1	0	1
Craft, trades	0	0	0	0	0	1	1
Chemical prod machine oper.	0	1	0	1	0	1	0
Rubber, plastic prod. mach. oper.	-1	5	0	-1	-1	3	4
Plant, machine operators	-1	-3	-1	-2	-1	-1	-1
Labourers	1	1	1	0	1	1	1
Total	1	1	1	0	1	1	1

Note: The country grouping (Winning, Losing momentum, Upcoming and Retreating) is based on value added (Table 3.2)
Source: Eurostat/TNO

Overall, there have been few major changes in shares of occupations between 2000-2006 (see Table 3.8). Noticeably the share of business professionals (-7%) and other professionals (-2%) has declined in the new Member States, while engineers (+3%), computing professional (+3%) and rubber and plastic product machine operators (+5%) have expanded their shares. This is clear indication of ongoing restructuring in the new Member States. In the EU-15, changes are much less pronounced, although the share of machine operators and other professionals has shrunk, whereas that of business professionals, engineers and computing professionals has expanded.

Occupations and education level

Almost all chemicals and rubber and plastic products occupations show negative trends for low educated employees (see Table 3.9). This is most pronounced in the occupations that were traditionally occupied by low educated workers. These are the technical executive job functions from metal, machinery, precision to labourers.

Table 4.9 Changes occupation shares low educated employees, 2000-2006

	EU-15	NMS	EU	Winning	Losing momentum	Upcoming	Retreating
Managers	-1	-1	-1	-3	-2	-6	1
Computing professionals	-4	0	-4	-10	-1	-13	0
Engineers	1	0	0	2	-1	-2	1
Business professionals	0	0	-1	0	3	-8	-2
Other professionals	-1	-3	-1	-1	1	-8	-1
Office clerks and secretaries	-2	-1	-2	4	-2	-10	-4
Service workers	-14	-6	-12	-19	-22	-12	-6
Metal, machinery ,precision	-1	-4	-2	-10	1	-12	-7
Craft, trades	-2	-8	-4	-8	2	-5	-14
Chemical prod machine oper.	2	-14	-6	-4	9	-29	-15
Rubber, plastic prod. mach. oper.	-9	-39	-16	-13	-20	-16	-6
Plant, machine operators	-5	-11	-7	-8	-2	-26	-12
Labourers	-8	-12	-9	-3	-2	-25	-14
Total	-4	-7	-5	-5	-2	-13	-5

Note: The country grouping (Winning, Losing momentum, Upcoming and Retreating) is based on employment (Table 3.4)
Source: Eurostat/TNO

While in the EU-15 service workers in the chemicals industry broadly defined experienced the highest losses (-14%), it was the chemical and rubber and plastic products machine operators in the low-educated segment that shrunk dramatically in the new Member States. While the decreasing shares in service workers can be explained with outsourcing activities, the reduced share of low educated workers operating machines and crafts can be explained with a general trend of up-skilling in these occupations. This becomes clear when comparing the data of low educated workers with mid-educated workers (see Table 3.10), that shows that the occupations in strongest decline for low educated workers are in strong expansion in occupations of mid-educated workers.

Table 4.10 Changes occupation shares mid-educated employees, 2000-2006

	EU-15	NMS	EU	Winning	Losing momentum	Upcoming	Retreating
Managers	1	2	2	8	1	6	0
Computing professionals	-10	-8	-10	-18	-7	-24	1
Engineers	4	-14	3	3	5	16	0
Business professionals	-3	-27	-5	-6	3	-5	-4
Other professionals	-2	-1	-4	-1	1	-3	-6
Office clerks and secretaries	0	-1	0	-4	5	6	-6
Service workers	5	-13	1	3	18	7	-1
Metal, machinery ,precision	0	4	2	5	3	15	8
Craft, trades	4	13	7	13	0	18	11
Chemical prod machine oper.	-4	14	4	4	-9	25	15
Rubber, plastic prod. mach. oper.	7	37	13	12	20	10	4
Plant, machine operators	3	12	6	7	1	26	10
Labourers	7	12	8	2	4	32	10
Total	1	3	2	2	2	13	3

Source: Eurostat/TNO. Note: The country grouping (Winning, Losing momentum, Upcoming and Retreating) is based on employment (Table 4.4)

Similarly, the occupations of mid-educated workers in strongest decline are business professionals (-27%) and engineers (-14%) in the new Member States and computing professionals (-10%) in the EU-15. These are also occupations that are increasing in share of high educated workers. This is further evidence of trend of up-skilling of functions previously occupied by mid-educated workers. This up-skilling trend becomes also clearer from the data of occupation shares of high educated employees (see Table 3.11). Almost all occupations experience an expanding share of high educated workers, particularly computer professionals, service workers and other higher skilled occupations.

Table 4.11 Changes occupation shares high educated employees, 2000-2006

	EU-15	NMS	EU	Winning	Losing momentum	Upcoming	Retreating
Managers	0	-1	0	-5	1	0	-1
Computing professionals	15	8	13	28	8	37	-1
Engineers	-5	14	-3	-5	-4	-14	-1
Business professionals	3	27	6	6	-5	13	6
Other professionals	3	4	5	2	-2	11	7
Office clerks and secretaries	2	2	2	0	-3	4	10
Service workers	9	20	12	15	5	4	7
Metal, machinery ,precision	1	0	1	5	-4	-4	-1
Craft, trades	-2	-4	-3	-5	-2	-12	4
Chemical prod machine oper.	2	0	1	0	0	4	0
Rubber, plastic prod. mach. oper.	2	2	2	1	0	7	1
Plant, machine operators	2	0	2	1	1	-1	2
Labourers	1	0	1	1	-2	-6	4
Total	3	4	3	3	0	0	2

Source: Eurostat/TNO. Note: The country grouping (Winning, Losing momentum, Upcoming and Retreating) is based on employment (Table 3.4)

Most noticeable is this up-skilling trend in the new Member States as well as in the upcoming country group. Overall, the trend of higher skill requirements is visible across country groups, shifting from low to mid-skilled in the production occupations and from mid to high educated in the organisational occupation functions.

4.5 Productivity and labour costs

The apparent labour productivity – defined as value added divided by the number of persons employed - of the chemicals, rubber and plastic products manufacturing sector of the EU-27 was € 66 500 per person employed in 2004. The apparent labour productivity of those working in the manufacture of basic chemicals and the manufacture of pharmaceuticals was particularly high (both about € 100 000 per person employed). In contrast, the apparent labour productivity of plastic products manufacturing and rubber products manufacturing were much closer to the average level of the non-financial business economy (€ 40 900). Average personnel costs across the sector (€ 39 000 per employee) was relatively high (41.3% above the non-financial business economy average). However, the value added per person employed created within the EU-27's chemicals, pharmaceuticals, rubber and plastic products sector covered average personnel costs by 171% in 2004, this level of wage adjusted labour productivity being notably higher than the average across the non-financial business economy (148%). Overall, the wage adjusted labour productivity ranged from 145% (rubber and plastic products) to 206% (basic chemicals, pesticides and other agro-chemical products) (Eurostat, 2007). The wage adjusted labour productivity ratio 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.

Table 4.12 Labour productivity, 2004

	Apparent labour productivity (in k€)	Average personnel costs (in k€)	Wage adjusted labour productivity (in %)
Chemicals and rubber and plastic products	66.5	39.0	171.0
Chemicals and chemical products	90.0	47.0	186.0
- Basic chemicals; pesticides and other agro-chemical products	100.0	48.0	206.0
- Pharmaceuticals, medicinal chemicals and botanical products	100.9	52.7	191.7
- Miscellaneous chemical products	67.0	41.5	160.0
- Man-made fibres	55.0	37.0	149.0
Rubber and plastic products	43.2	29.8	144.9
- Rubber products	47.6	33.0	145.0
- Plastic products	42.0	29.0	145.0

Source: Eurostat (2007)

4.6 Industrial relations

The social partners of the European chemicals industry include the European Mine, Chemical and Energy Workers' Federation (EMCEF) and the European Chemical Employers Group (ECEG). EMCEF, a member of the ETUC, was founded in 1996 and represents 2.5 million workers in 35 countries which include apart from the chemicals industry also mining, energy

and several process industries. ECEG, founded in 2002, is an independent federation within the CEFIC (European Chemical Industry Council) family of organisations representing the EU chemicals industry in many areas (see, e.g., Sector Social Dialogue Committee Chemical Industry, 2008). Cefic represents, directly or indirectly, about 29,000 large, medium and small chemical companies which employ about 1.3 million people and account for nearly a third of world chemical production. Industry representation in the plastic products industry includes the polymer producers (represented by PlasticsEurope), the plastics converters (represented by EuPC) and the machine manufacturers (represented by EUROMAP).

Precise levels of unionisation in the chemicals, pharmaceuticals and rubber and plastic products sector could not be established as the data is dispersed and classifications of the sector vary considerably between Member States. Traditionally labour relations differ substantially between Member States with more consensus oriented relations in the Nordic (Scandinavia) and Northern European countries (Germany, the Netherlands). However, as with other manufacturing sectors it is likely that the level of unionisation is above the national average. It is unlikely though that the negative trend experienced across sectors does not apply to the chemicals sector. The weakening degree of unionisation across sectors is an important factor for future employment and skills as the social partners play an important role in setting education and skill requirements. While certain parts of the labour force benefit from weakening unionisation, as they can negotiate their employment benefits on an individual basis, it is unclear how this trend impacts the future skill development particularly where on the job learning / life long learning becomes increasingly important. According to the Federation of European Employers (FedEE), over the last twenty years there has been a widespread decline in trade union membership throughout most of Western Europe. Especially in the new Member States unionization has decreased substantially after 1998. In only 8 EU Member States more than half of the employed population is unionised. The EU's most populated states in contrast have modest levels of unionisation, with Italy at 30%, the UK 29%, Germany 27% and France at only 9%. Furthermore, in every EU country outside Scandinavia, except Belgium, trade union membership is either static or continues to decline (FedEE, 2008).

4.7 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.[6] 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.[7] 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 e.g. networks of excellence, technology platforms, etc. have a specific thematic focus (in this case innovation in research and development).

[6] 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.
[7] 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).

- *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 for innovation, skills and jobs in chemicals: SusChem

The European Technology Platform for Sustainable Chemistry (SusChem) "seeks to boost chemistry, biotechnology and chemical engineering research development and innovation in Europe" (www.suschem.org). The platform was initiated by the European Chemicals industry Council (CEFIC) and the European Association for Bio-Industries (EuropaBio). Members of the platform are representatives of enterprises and enterprise associations, research organisations and European and national public administration.

The overall objectives of the platform are:

- to maintain and strengthen the competitiveness of the chemicals industry in Europe based on technology leadership
- to meet society's needs in close cooperation with all stakeholders
- to boost and sustain chemistry research in Europe;
- to improve economic and regulatory EU-framework conditions to inspire chemical innovation; and
- to contribute to sustainable development in Europe.

The main focus of the platform is to generate and foster environmental sustainable technological innovations for the sector. Neither skills adaptation and development for new demands nor job creation are in the centre of the platform's attention so far. As many other sectoral technology platforms addressing technological innovation the platform is funded by the 7th European research framework programme (FP7).

The SusChem platform has established the following three working groups:

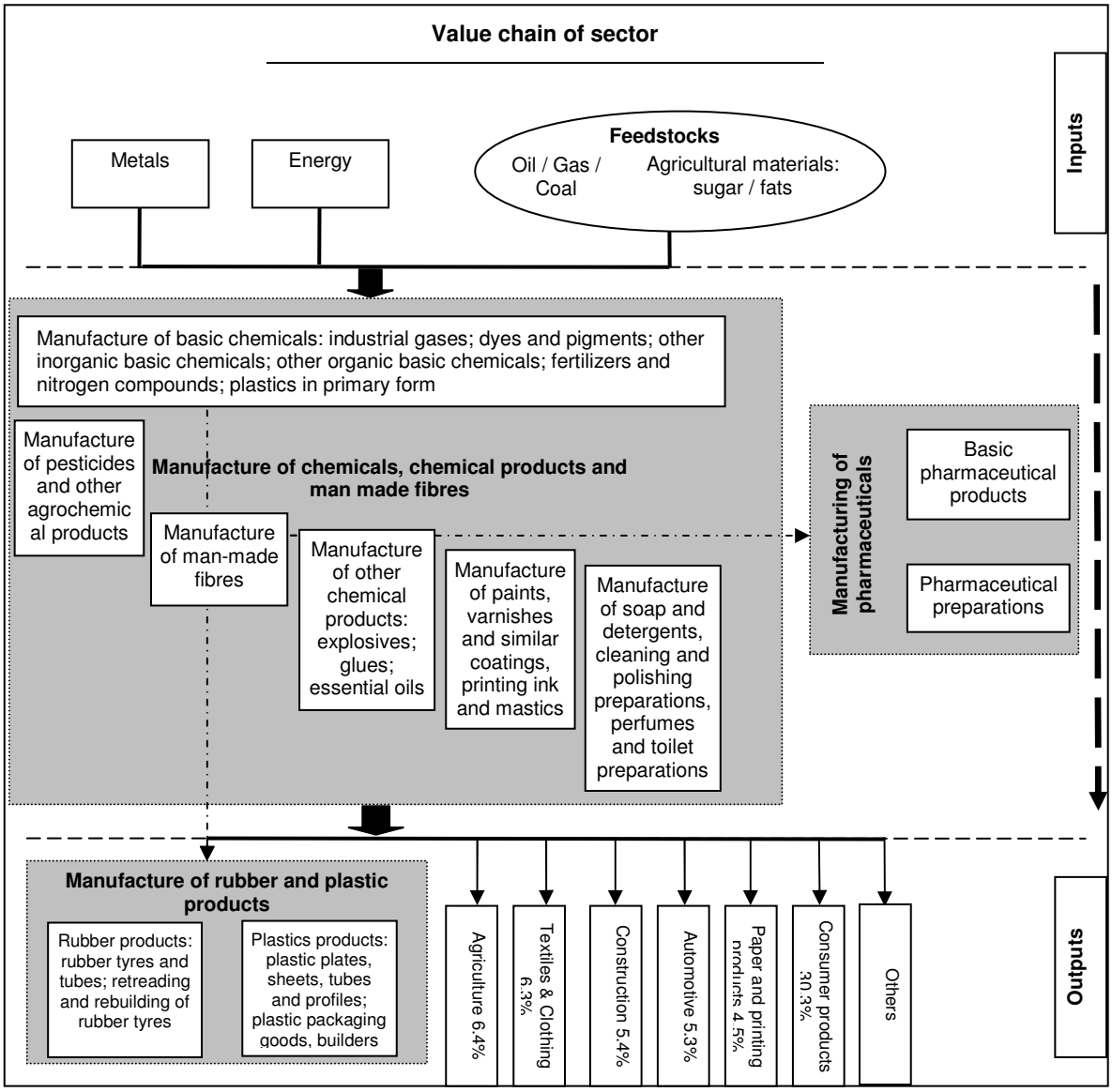
- The research, development and innovation group is working on three different technology sections and gives scientific input to visionary projects.
- The advocacy / outreach group addresses barriers and constraints such as research infrastructure and innovation.
- A third working group, the co-operation group, coordinates and steers work with other initiatives that are of importance to SusChem, such as the initiatives of ERA-nets and national platforms. The goals are to avoid duplication of work and to best use synergies.

5 Value chains, networks and actors

5.1 Analysis of the value chain

The chemicals industry converts raw materials such as oil, natural gas, metals, minerals, water and air into more than 70,000 different products. European product output (EU-15) ranges from basic chemicals (37.7% share), through specialty and fine chemicals (26.8%), and pharmaceuticals (23.3%), to consumer chemicals (10.2%) (SusChem, 2005). The wide range of products is supplied to almost all other sectors of the economy. A major share (27%) of primary chemical products is further processed within the industry itself, while only 30% of output is produced for consumer products (SusChem, 2005). Major industrial customers include the rubber and plastic products sector; agriculture; textiles and clothing; construction; automotive; and pulp and paper as displayed in the value chain of the sector. The boundaries of value chain are not fixed, but are moving, as new products, new users and new customers emerge. Keeping the value chain in Europe is vital to the future of the chemicals industry in Europe (e.g. HLG, 2009).

Figure 5.1 The value chain structure of the chemicals industry broadly defined



Networks and clusters

The value chain of the European basic and other chemicals sector is far less fragmented then other globalised sectors such as the electronics and ICT sector. One of the strengths that characterise the EU chemicals industry is its regional clusters benefiting from close integration of production processes reducing transport costs, increasing on-plant efficiency and improving the scope for recycling. Inputs (feedstock) and outputs (chemical products) are, however, bought and sold globally. While basic and intermediate chemicals are produced and refined in Europe, the raw materials – mostly fossil carbon resources – are imported and sourced globally. Furthermore, the chemicals and particularly the pharmaceuticals sector being strong export sectors, supply many different sectors and countries with their outputs. Key chemicals clusters are mainly located in West-Germany, France, Belgium and Northern Italy, with most specialised regions of Rheinhessen-Pfalz, Koblenz and Weser-Ems in Germany as well as Alsace and Auvergne in France. Overall, 14 out of the 20 most specialised regions[8] in Europe are located in France and Germany.

Integration of manufacturing processes – interdependencies between suppliers & buyers

Evolving from the quality improvement movements in the 1970s and 1980s, close ties between suppliers and buyers based on servicizing the supply chain have emerged. Chemicals manufacturers increasingly define their business models not along the simple provision of chemicals to their buyers but along the provision of services (Reiskin et al., 2000). Based on changed incentive mechanisms this is beneficial for both suppliers and buyers as efficiency increases and knowledge exchange / sharing are enabled, where previously chemicals suppliers were only interested in increasing volume sales.

While there is case study evidence that closer buyer-supplier relationships are emerging in the chemicals sector, there is no systematic overview of supplier-buyer relationships of the overall (sub)sector(s). Some studies only looked at a small number of case studies of large U.S. firms (Reiskin et al., 2000), whereas others conducting a more systematic survey only looked at SMEs of which only a small number operate in the chemicals sector (Walter et al., 2001). While the case study evidence indicates that close working relationships between actors along the supply chain become increasingly crucial for market success not only in terms of innovation under the open innovation paradigm, the lack of a systematic analysis of the overall sector means that it is not possible to generalise the results. Supplier-buyer relationships tend to differ between sub-sectors, as for example in the pharmaceuticals sector and plastic and rubber products sub-sector.

Interlinkages with services sectors

Interlinkages of the chemicals, pharmaceuticals and rubber and plastic products sector with the services sectors are limited compared to the importance of linkages with other manufacturing sectors and consumer end markets. The chemicals sector is primarily an input sector for other manufacturing sectors requiring strong linkages between firms from the different sectors. For the pharmaceuticals sector contract research is an important source for innovation.

5.2 Restructuring and change

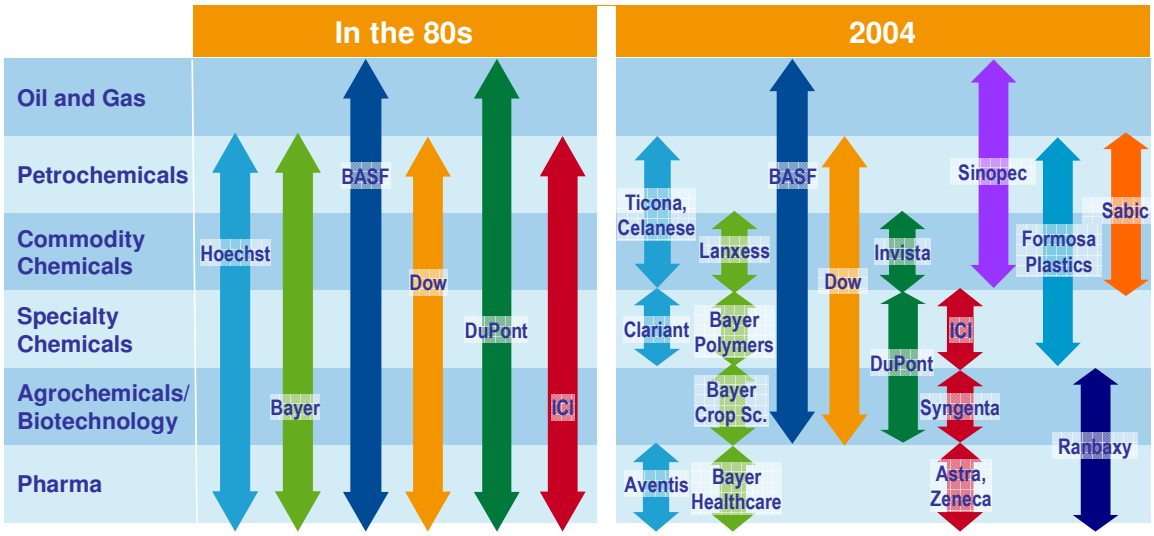
In response to globalisation and international competition the structure of the industry has changed considerably over the last decades. Globalisation has fuelled the search for scale

[8] Nuts 2 level – specialisation as measured by concentration of employment.

efficiencies and new market opportunities, on the one hand leading to further specialisation and consolidation and on the other hand to disintegration of the value chain. Unlike in other sectors relocation of production is not a main driving force for restructuring, however. At the level of the firm, these developments have manifested themselves in the form of a strategic repositioning of firms and a (renewed) search for core competences. Figure 4.2 gives a clear illustration of these trends which firms disintegrating along the value chain. In the pharmaceuticals sector this has led to large chemical firms divesting their pharmaceutical activities triggering a consolidation wave in the sector. This trend is likely to continue further as the pharmaceuticals sector at the global scale is still fragmented (PwC, 2007).

The figure also shows that European and US firms have tended to exit the oil/gas and petrochemical segments, with new Arabic and Asian players such as Sinopec and Sabic entering these market segments. Overall, the trend of restructuring can therefore be summarised as focusing on specific market segments aiming for scale efficiencies within segments rather than searching for horizontal integration efficiencies. The search for segmentation and specialisation by European firms is focused on higher value added sector activities.

Figure 5.2 Restructuring and vertical disintegration of large chemicals firms



Source: BASF

With the enfolding economic crisis the recent wave of consolidation, driven by mergers and acquisitions (M&A's) has come to an abrupt end with the year 2006 marking the top, witnessing record deals. Examples are BASF's acquisition of Engelhard (est. $5.6bn) and Linde's acquisition of BOC group (GBP 8.2bn) (Frost & Sullivan, 2007). A special role in the last cycle was played by private equity investors.

Role of Private Equity

Low real interest rates over the last decade have led to a boom in private equity investment, also in the chemicals sector. Previously private equity investors had stayed out of the chemicals sector, as a good understanding of the business model and raw material cycle are needed. In addition, the pay-back periods and investment cycles are long making acquisitions difficult to fund. Nevertheless, there has been an increasing interest by private equity in the sector since 2000, especially in the segment of specialty chemicals and chemicals distribution

(Frost & Sullivan, 2007; ICIS, 2008). For instance, out of the top 10 deals in the 2006 nearly 50% of the buyers were private equity firms, against a mere 5% in 2000 (ICIS, 2008). These firms include Carlyle Group, BC Partners, Advent, Apollo, CVC and Blackstone (Frost & Sullivan, 2007).

Risk for private equity firms has now become acute with refinancing conditions severely deteriorating due the credit crunch and economic crisis as well as plummeting demand. The risk is further exacerbated by many assets sitting on the balance sheets of private equity companies during the interest-rate cycle when financing costs were low. Now there is little equity left in these assets. With a backlog of exits having built up and the industry having entered a downward cycle, private equity firms are at risk if industry assets have not been properly restructured (FT, 2007). They must now either hold and improve value in the next two to four years, before a return to higher levels of IPO activity is likely as they otherwise will have to sell at a substantial loss during the down cycle (FT, 2007).

Due to the credit crunch and economic downturn private equity managers forecast that defaults of private equity owned companies will rise for businesses bought at over-inflated prices and too high leverage (FT, 2008). This will affect the chemicals sector in two ways. First, chemical firms with too high debt loads will have to cut costs (including labour) and minimise capital investments (FT, 2007). This includes investments in new, more efficient plants and plant upgrades as well as R&D. Second, with a number of private equity investors having overpaid for their acquisitions, these firms might have to file for bankruptcy in the down cycle. This may have large repercussions for the employees of these firms. On the other hand this also will pose take-over opportunities for strategic investors with sufficient capital, which could lead to further consolidation of the sector. This particularly applies to the segments where private equity investors where active, namely chemicals distribution and specialty chemicals. First examples of such development are LyondellBasell filing for bankruptcy protection, due to a heavy debt load exposing it to rapid price changes (Steffy, 2009). Meanwhile, industry stalwarts such as BASF, Dow and DuPont have curtailed output in response to a sudden decline in demand posing substantial consequences for employment in the sector. Whether these jobs will come back in the next upturn is at least questionable.

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

The chemicals, pharmaceuticals, and rubber and plastic products industries can be characterised as mature industries. Particularly the chemicals and pharmaceuticals industry is characterised by large firms. Being science-based, traditionally key innovations in the sector originate from the research labs of large firms in collaboration with university labs. For the pharmaceuticals industry biotechnology has become a crucial sector, that is driven by smaller, innovative start-ups compared to the chemicals industry. However, the costly clinical trials and economic power of the large firms means that often smaller, innovative firms are bought by the large firms when it comes to the commercialisation of new products.

Research and innovation as source for competitive growth

Unlike emerging competitors in the Middle East and South-East Asia, Europe cannot base its future growth on cheap natural resources or abundant cheap labour. Knowledge and a strong

research basis are essential to create knowledge-based competitive growth (HLG, 2007a). R&D intensity of the European chemicals industry has slightly decreased over the last ten years, at a level which is considerably lower than in Japan but similar to the US, being close to 2% of sales. The R&D intensity of the pharmaceuticals industry is much higher, with often firms spending as much as 20% of sales (Pedersen, 2007). Due to the international activities of the large European firms and the tendency to relocate development activities close to customer markets, European firms have tended to gradually move closer to the large emerging markets (EMCC, 2005). According to the High Level Group on the competitiveness of the chemicals industry one important reason behind the relatively low R&D intensity is the fact that even today base chemicals – which require a rather low investment in research – represent almost 60% of sales of the European chemicals industry. The fact that base chemicals have a considerable weight in sales of the European chemicals (broadly defined) industry as a whole masks much higher R&D investments in fine chemicals, advanced materials and other higher-tech sub-sectors (HLG, 2007a, p.9). Other sources see the focus on financial performance, frequent restructuring and increasing regulatory costs as limiting R&D spending in industry (SusChem, 2005). At the same time the EU is relatively weak in bringing innovations to the market (HLG, 2009).

Differences in R&D and innovation activities between sectors

Historically, the chemicals sector and particularly the pharmaceuticals sector are science-based sectors, relying on innovations originating from basic research carried out in universities, public research organisations and corporate research centres (Pedersen, 2007). R&D investments are hence seen as a crucial factor affecting future competitiveness. R&D spending varies substantially between sub-sectors. In 2003, chemicals and chemical products accounted for 8% (€7.9bn) of EU manufacturing R&D of €98.5bn. The pharmaceuticals sector however is spending twice as much on R&D (€15.6bn) while the rubber and plastic products sector only spent 2% (€2.2bn) of EU manufacturing R&D (CEFIC, 2007a). The pharmaceuticals sector therefore takes a special role in terms of R&D investments and intensity. Furthermore, these statistics only include R&D investments by firms with pharmaceuticals manufacturing as main activity. Research carried out by independent research institutes, such as spin-off laboratories of universities, are classified separately. Actual R&D investments are therefore higher than official statistics would tend to suggest (Eurostat, 2005).

Importance of biotechnology for future innovation

Bio- and nano-technology are crucial for the future innovation potential of the chemicals, pharmaceuticals, rubber and plastic products sector, and particularly so the pharmaceuticals sector. Biotechnology is a research intensive activity spending one thirds of its resources on R&D (EMCC, 2005). This does not only mean that the sector provides important growth opportunities and high skilled employment but is also important for the traditional chemicals sectors providing higher performance products and more efficient processes. Both factors are important for market success. Examples of biotechnology sub-sectors relevant for the manufacture of chemicals are white biotechnology and green biotechnology:

- white biotechnology: industrial and environmental products and processes, such as bio-cleaning, bioremediation, environmental and industrial diagnostics, water and effluent treatment, as well as recycling; (EMCC, 2005)
- green biotechnology: veterinary healthcare, bio-pesticides, plant agriculture, food technology and processing; (EMCC, 2005).

Innovations in white biotechnology will change the chemicals industry structure and output, by enabling production minimising hazardous materials, waste and emissions and operating at more benign conditions of temperatures, pressures, pH as well as using novel auxiliary materials and solvents. Currently, biotechnology already plays a significant role in the pharmaceuticals sector (red biotechnology), to which statistics on biotechnology normally refer to. For white biotechnology, however, there are only single examples with most publications referring to the future potential in the sector (Suschem, 2005). This has to do with large differences between sub-sectors applying biocatalysis in industrial production processes, such as the production of fine and bulk chemicals, detergents, textiles, pulp and paper, and bioethanol. Adoption rates of biocatalysis vary between 100% for individual textile finishing steps and certain fine chemical compounds, and 0.4% for polymer production (Papatryfon, 2008). This also means that aggregated data for the sector is available.

But one of the challenges for implementation is the much slower development of biotechnology than envisaged by experts at the turn of millennium (EMCC, 2005). The frequently cited McKinsey study forecasted a 10-20% penetration of biotechnology processes in the chemicals sector by 2010, with fine chemicals the most important growth sector (up to 60%) (Bachmann, 2002). Today it has become clear that this take longer to be put into practice, but this does not reduce the potential impact of biotechnology on the sector.

Product development and innovation – links with user industries

Research and development (R&D) is of outstanding importance in the chemicals and pharmaceuticals industry, particularly for the downstream industries such as the fine chemicals, advanced materials and other higher-tech sub-sectors. Chemical products are intermediate goods that are incorporated in client industries products, from semi-finished metal products, consumer electronics and machinery and equipment, to domestic appliances and furniture. The stimulus for innovation comes from the development of products, as well as from joint R&D projects with client companies in other industry sectors (ZEW/NIW in EMCC, 2005). However, this close interaction with downstream users means that over time production may tend to follow user industries in relocation movements, followed by development and research activities. This could have important consequences for employment, production and future development of the sector. Examples from the past are the textiles and electrical components industries.

Commoditisation of specialty chemicals

An important strategy of European firms over the last decade to counteract competitive pressures from South-East Asia and the Middle East was to focus on specialty chemicals. Specialty chemicals are research intensive and provide higher value added. Higher value added provides European firms a chance to compete on performance attributes rather than costs, where Europe is at a structurally competitive disadvantage. However, specialty chemicals frequently become commoditized over the product life cycle and hence loose their advantages for European firms. Furthermore, retailers and consumers demand constantly lower prices (CCIC, 2007). This creates a constant pressure for specialty chemical firms to innovate and provide better performing products to sustain the high value added ratios. Additionally, innovation also in specialty chemicals benefits from close interactions along the supply chain. For the future of specialty chemicals the presence of basic chemicals development and production in clusters is therefore perceived of vital importance for the competitiveness of the European chemicals industry.

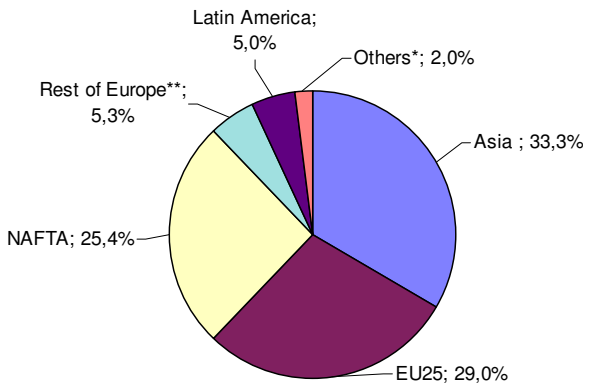
7 Trade, globalization and international competition

The chemicals sector is one of the most important trading sectors in European manufacturing, and accounts for an important and persistent trade surplus. Output and trade at the global scale have almost doubled from € 962 bn in 1996 to € 1,641 bn in 2006 (Mills, 2008). With sales of € 476 bn (29% of global output), the EU chemicals industry is still in a leading position, but has lost its first place in the ranking to Asia (including China and Japan), mainly due to the rise of China and India. Over the last decade China and India have joined the ranks of the world's ten largest chemical producers, with a third and ninth place, respectively, in 2005. Over the same time period the dominating share of global output by Europe has gradually declined and shifted to Asia (CCIC, 2007).

7.1 International competition

In terms of production output, over time Europe has been replaced as the leading chemicals producer by Asia including Japan. Key growth region over the last decade was Asia driven by industrialisation in China, creating structural shifts in global chemicals production (CCIC, 2007). The production output of the chemicals industry in 2006 by world regions is displayed in Figure 5.1, with Asia having replace Europe as the EU as the most important chemicals producer.

Figure 7.1 Global chemicals production[9] by region, 2006 (overall €1,641bn)

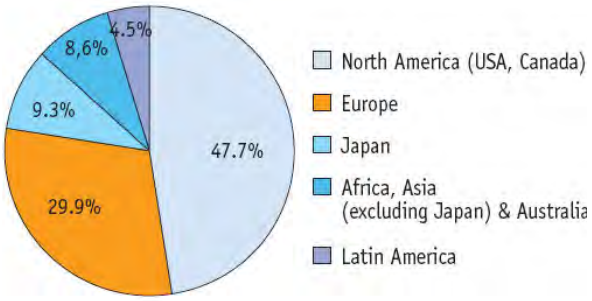


Source: CEFIC (2007)

Global sales by world region for the pharmaceuticals industry are displayed in Figure 5.2. North America is by far the largest market followed by Europe and Japan. For Europe the US and Switzerland represent a key export market for pharmaceutical products.

[9] Excluding pharmaceuticals; including petrochemicals; Asia including Japan.

Figure 7.2 Global pharmaceuticals sales by region, 2006 (overall €484bn)



Source: EFPIA (2007)

Key location factors

The chemicals, pharmaceuticals and rubber and plastic products sector is a global sector with strong international competition exposed via low tariffs. Three key factors play a decisive role for location decisions: 1) raw materials and energy prices play an extremely important role for the competitiveness and hence location, representing large production cost blocks. Countries with access to lower priced raw materials and labour costs have therefore a structural advantage; 2) user industries play an important role in location decisions as production and development of chemical products in the long-run follow user industries; 3) activity tends to shift to growth markets to satisfy demand. This begins with exports from developed to growth markets, followed by relocation of production, and in the long run also development and research, if the markets provide the necessary framework conditions.

An indicator for this development is the investment pattern by chemicals firms. Over the last decade the investment base in the EU has declined. Although cyclical patterns can be observed – see CEFIC data for annual time series data – the overall trend in the EU shows a decline. As the data clearly indicates (see Table 5.1), new investments particularly focus on emerging countries in Asia, mainly China, where market growth takes place and in the Middle East where feedstock is cheap (European Commission, 2006).

Table 7.1 Capital spending in the chemicals* industries, 1996-2006

Capital spending (in % of sales)	1996-2001	2001-2006	1996-2006
NAFTA	5.8	4.3	5.1
Latin America	3.5	2.8	3.1
EU	5.6	4.1	4.8
Central/Eastern Europe	4.7	5.4	5.0
Africa & Middle East	6.9	6.9	6.9
Asia/Pacific**	11.1	12.9	12.0
World	7.2	6.5	6.9

* including pharmaceuticals; excluding rubber and plastic products.
**Asia-Pacific includes Japan, China, India, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand, Pakistan, Bangladesh and Australia

Source: CEFIC (2007)

Investment developments in the pharmaceuticals and rubber and plastic products sectors are less clear and show a more diverse investment pattern. Based on the research intensiveness and regulation in the pharmaceuticals sector, however, competition in this sub-sector does not so much originate from Asia but from the traditional competitors such as the US and Switzerland being based on technological advances.

Production location vs attributing economic gains

So far Europe has greatly benefitted from the emerging markets as they demanded large parts of the increased production outputs over the last decade. Even if production is shifting to emerging markets this does not mean that European firms do not participate in the economic gains. The Table below shows that the chemicals sector globally is still dominated by TRIAD firms with only five companies from the emerging markets breaking into the global top 30 firms. However, one has to acknowledge that his can change over the coming years with Chinese and Middle Eastern firms growing faster than their TRIAD competitors. Furthermore, the relocation of production, while offering the chance to capture economic gains, has more complex repercussions on European employment in this sector.

Table 7.2 Top 30 chemical firms in the world, 2006

Headquarters	Number	Global sales €bn	Share of top 30	Share of global sales
EU	14	260	49%	15.8%
USA	6	138	26%	8.4%
Japan	5	60	11%	3.7%
Other	5	68	13%	4.1%
Total	30	526	100%	32%

Top 10 by name: BASF (GER), Dow Chemical (USA), Exxon Mobil (USA), Bayer* (GER), Shell (NED), Ineos (GBR), Sinopec (PRC), DuPont (USA), Total (FRA), Sabic (KSA). Data based on companies with sales of chemical products greater than $10 billion dollars in fiscal year 2006. For companies with additional activities only the sales relating to chemicals are calculated. Pharmaceutical and Rubber and plastic sector excluded. Global sales 2006 € 1,641 bn.

Source: CEFIC (2008). * including pharmaceuticals

For the pharmaceuticals sector international competition as previously outlined is not so much affected by emerging economies but the traditional TRIAD competitors. The leading region is clearly the US followed by Europe although, Switzerland not being part of the EU plays a vital role for in the sector, particularly compared to the size of its economy.

Table 7.3 Top 30 pharmaceutical firms in the world, 2006

Headquarters	Number	Healthcare revenue (US$ m)	Healthcare R&D (US$ m)	Employees
USA	13	259 148	39.52	782 281
EU	9	183 232	23 208	508 934
Japan	4	30 875	5.44	73 706
Switzerland	3	74 831	10 607	213 517
Other	1	8 408	0.495	26.67
Total	30	556 494	79.27	1 605 108

Top 10 by name: Johnson & Johnson (USA); Pfizer (USA), Bayer (GER), GlaxoSmithKline (UK), Novartis (SUI); Sanofi-Aventis (FRA), Hoffmann-LaRoche (SUI), AstraZeneca (UK), Merck & Co (USA), Abbott Laboratories (USA)

Source: MedAdNews (2007)

Competition from Asia and the Middle East

In terms of investments, large manufacturing capacities for bulk chemicals in China, the Middle East and Russia have been set up in 2005 and 2006 alone. In China more than 6

million tons of ethylene capacity was added in the same time period. While global turnover of chemical companies in this segment increased from € 400.1 bn to € 660.7 bn between 1995 and 2006, turnover in China increased from € 40.6 bn to € 204.6 bn at the same time (Deutsche Bank, 2007). China is expected to more than double its turnover by 2015 compared to 2006, thereby increasing its market share from 9 % to 14%, while the EU is expected to increase turnover by 35%. Furthermore, in the next 10 years, the ethylene capacity of the Middle East region is expected to increase by another 300%, whereas China is likely to increase its ethylene capacity by more than 200%. The high rate of cracker investment in the Middle East and in Asian countries means that more and more ethylene derivate capacity from the Middle East will need to find markets outside Asia, with Europe and Africa being obvious export markets (ECRN, 2007). Increased feedstock prices and particularly energy costs make it more and more difficult to develop bulk chemistry in Europe. Despite the expected lower future market shares of the traditional chemical regions EU, US and Japan, due to the internationalisation of European chemical firms, these are expected to be able to defend their market leadership (Deutsche Bank, 2007).

7.2 Trade

Exports in the chemicals, pharmaceuticals and rubber and plastic products sector have reached € 627.3 bn in 2006 of which 94% of exports are accounted for by the EU-15 compared to 6% of exports by the new Member States. Important to note here is that exports comprise intra-European exports (!) for comparative reasons with other trading blocks. Average annual growth rates have been much higher than economic growth with average rates of 7.7% in the EU-15 and 11.2% in the new Member States for the period 1995-2006.

Table 7.4 Exports, export growth and exports as share of value added, 1995-2006

	Exports	Average annual growth in exports 1995-2006	Exports as percentage of value added	Change in percentage of value added 1995-2006
	million € 2006	%	%	%
EU	627 303	7.9	195	49
EU-15	592 342	7.7	193	48
NMS	34 960	11.2	223	80

Source: Eurostat/TNO

Table 7.5 Imports, import growth and trade balance, 1995-2006

	Imports	Average annual growth in imports 1995-2006
	Million euro 2006	%
EU	546 001	7.6
EU-15	492 812	7.2
NMS	53 189	11.9

	Trade balance 2006	Change in trade balance 1995-2006
	Million euro 2006	*Million euro 2006*
EU	81 302	45 123
EU-15	99 530	54 123
NMS	-18 229	-9 000

Source: Eurostat/TNO

This fast export growth is also reflected in the increasing share of exports to value added. Interestingly, the export growth rates have been very similar across winning, losing momentum and upcoming country groups. The only country group with a slower but still high positive export growth rate is the group of retreating countries.

Imports are growing at similar rates as exports with 7.2% in the EU-15 and 11.9% in the new Member States. With imports being smaller than exports, the EU has sustained a positive trade balance for years. In 2006 the total trade balance for the chemicals and rubber and plastic products sector has increased to € 81.3 bn; a plus of € 45 bn compared to 1995. This trade is generated by the EU-15, with the new Member States despite having the fastest export growth rate, having a negative trade balance in the sector. This negative trade balance widened by € 9 bn from 1995 to 2006.

The key trading regions in 2007 were the EU, Asia (including China and Japan) and North America. Despite losing in relative share of global output over the last decade, the EU remained the world's leading exporter and importer of chemicals, accounting for more than half of worldwide trade in 2005[10] (CCIC, 2007). Furthermore, in comparison to the USA and Japan, Europe is the only traditional trading block that sustained a positive trade balance in chemicals, pharmaceuticals, rubber and plastic products compared with the USA having a negative trade balance since 2002 and Japan experiencing a growing trade deficit over the last ten years (CCIC, 2007). With 26% of the total European manufacturing trade surplus in 2005 accounted for by chemicals (CCIC, 2007), it is also the extent of the trade surplus compared to Japan and the USA that marks the importance of this sector to the European economy.

Table 7.6 Revealed comparative advantage and absolute change, 1995-2006

	Revealed comparative advantage *2006*	1995-2006 *Total absolute change*
EU	13	6
EU-15	17	8
NMS	-39	-10
Winning	30	17
Losing momentum	14	-12
Upcoming	-12	26
Retreating	-45	-23

Source: Eurostat/TNO

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

[10] This data comprises intra-EU trade mainly for comparative reasons, as figures for other regions also include intra-trade data. (CCIC, 2007, p.6)

7.3 Trade issues of relevance and importance to the sector

Chemicals

The cornerstone as regards tariffs for the chemicals industry is the Chemical Tariff Harmonisation Agreement (CTHA), which provides for the reduction of chemicals tariffs to 0%, 5.5% or 6.5% (European Commission, 2008b). The agreement now being applied by 50 WTO members came into force in 1995. As a result tariffs on chemical products are low in the OECD at an 4% average (HLG, 2008a). The EU market is generally very open with comparatively low tariffs and non-tariff barriers. EU exporters on the other hand, according to the European Commission's DG Trade, face a number of obstacles. These include complex standards and technical regulations governing chemicals, weak IPR protection and unnecessary or burdensome and costly registration, licensing and certification procedures for pharmaceuticals and high tariffs on cosmetics (European Commission, 2008c). The distribution system remains a major obstacle to penetrating the local market dominated by domestic producers in many Far Eastern countries.

Pharmaceuticals

Similar to the chemicals sector, tariffs do not constitute a major obstacle to trade. However, there are several non-tariff trade barriers. With the sector being highly controlled by national health services, prices often depend on national statutory systems and discriminatory taxes. Together with an overall lack of transparency this is a potential factor discouraging research and innovation (European Commission, 2008d). Another major trade impediment originates in a variety of unnecessary, burdensome or costly registration, licensing and certification procedures for pharmaceuticals. According to the European Commission this is a main problem i.e. in Japan, Russia, Taiwan, Korea or Vietnam although Mutual Recognition Agreements or equivalent agreements are designed to facilitate EU exports. Furthermore, with its high R&D intensity the enforcement of IPR is of major concern. A lack of progress to better protect IPR is experienced by industry in many third countries i.e. India, Brazil, Taiwan (European Commission, 2008d).

Import prices of energy and raw materials for chemicals

With the European chemicals industry being one of the most energy-intensive industrial sectors, firms are exposed to trade issues from energy pricing. This is particularly important for sub-sectors such as basic and bulk chemicals where energy costs represent up to 60% of operating costs (CCIC, 2007). Predictable and competitive energy prices are thus vital for the sector, making it highly sensitive to energy costs and energy instability. This, however, applies to a lesser extent to the high value added segments such as pharmaceuticals that are exposed less to energy inputs. The European chemicals industry is affected on two fronts by energy prices. On the one hand, the EU chemicals industry is exposed to double pricing from hidden subsidies mainly in gas and oil producing countries (CCIC, 2007). Raw materials and energy prices are structurally cheaper in the surrounding regions of oil and gas producing countries. These price advantages play a crucial role in location decisions of energy intensive sub-sectors. On the other hand, the EUs integrated energy market still needs to be properly developed (CCIC, 2007). The lack of a functioning internal energy market means that also compared to competitors such as the US energy prices are structurally higher lowering competitiveness for energy intensive products and processes in the EU.

Tariffs on renewable raw materials

With generally low tariffs for chemicals, new challenges arise from the use of renewable raw materials, which are classified as agricultural produce rather than chemical products. Agricultural products are exposed to much higher tariffs between 30% and 60% (HLG, 2008a, Quick). New developing areas such as white biotechnology relying on renewable inputs as feedstock, operate at a severe cost disadvantage that cannot be passed on to end consumers as the market for end products is exposed to international competition and not protected by tariffs. This cost disadvantage can only be compensated by focussing on high value added products where prices sensitivity of customers is lower. While this area of chemicals production is currently fairly small – a total of 8% of feedstock used in the chemicals industry come from renewable sources (sugar, starch, ethanol, etc.) – this sector is expected to grow substantially over the coming years in response to the climate change and energy challenge, even though as feedstock carbon fossils might be preferred over renewables because of certain product characteristics (HLG, 2007). The High Level Group (HLG, 2009) concludes that:

"(w)hile in principle a large amount of chemical substances can be produced from renewable raw materials, the technical and logistical difficulties must not be underestimated. Industrial production needs a reliable flow of high quantities of feedstock of constant quality. This requirement represents an important difference from the use of renewable raw materials to generate energy and some fuels, where chemical composition and purity are less of a concern. Technological developments may alleviate some of these problems. At present, it seems too early to make a robust assessment of the economic viability of renewable feedstock in the chemicals industry as a replacement for fossil feedstocks. But the expected large potential available in the longer term provides sufficient justification to continue research and industrial development activities as a priority."

Natural conditions in Europe, at least for the production of first generation bio-feedstock, are in general less favourable than in some other parts of the world because of limited area available for domestic production. Another main problem and major cost factor in the use of bio-based raw materials, is suitable infrastructure (HLG, 2009). High tariffs on renewable raw materials, particularly sugar and derivatives such as ethanol, currently curb bio-feedstock production from taking off.

7.4 Externalisation strategies - outsourcing and offshoring

International sourcing in manufacturing and the chemicals sector is not new, yet the scale and pace at which relocation of production has occurred over the last decade appears to have increased. Relatively new phenomena are the emergence of global production networks and the take-off of international sourcing in services, including R&D (Van der Zee & Brandes, 2007). A crucial enabling factor behind both developments is the increased ability to fragment or divide production processes into increasingly smaller components (Krugman, 1995; OECD, 2005a; Evans et al., 2006). Recent technological developments, which have resulted in important decreases in communication, computing and transport costs and an increased ability to monitor, manage and control have enabled firms to fragment and spatially separate various stages of production at different locations exploiting cost differentials.

According to an AT Kearney survey among large firms, the key reason to offshore and outsource is to reduce costs. However, this is not limited to labour costs exclusively but total costs including financial costs, management, advertising, communication, transport etc. (OECD, 2007). When looking at firm investments as an indicator of focus of economic activity, it is important to distinguish between vertical and horizontal investments as they are

driven by different motives. Vertical investments relate to search for cost differentials and are important in relation to relocation and offshoring, whereas horizontal investments are more motivated by market access and are less likely to affect employment in the home market (OECD, 2007).

Box 3. 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.

Offshoring in the chemicals industry

Evidence for relocation and outsourcing is a difficult subject due to definition and measurement issues (for details and definition and measurement issues see Annex 1). For that reason competing numbers are used in the relocation debate. According to the European Restructuring Monitor (ERM) 16.4% of total job losses in the chemicals sector were related to offshoring in 2005. This is the third highest percentage for a sector after business services and the textiles sector (OECD, 2007, p.94). However, these numbers have to be used with care as they are mostly based on (newspaper) announcements of firms directly relating job cuts to relocation. The Sector Social Dialogue Committee Chemical Industry (2008:6) concludes that relocation is not the main driving force for restructuring in the chemicals industry. Overall, offshoring is not a widespread phenomenon in the chemicals sector as large capital investments and high capital intensity prohibit short term relocation of production facilities. However, as user industries have emerged in and moved to South and East Asia, new production capacities are built up in the emerging markets rather than Europe, leading to a creeping relocation of production capacities.

Statistically the share of employment in manufacturing sectors turns out to be decreasing steadily in comparison with the share of employment in service sectors. With unequal decline between sectors, the most influential factor behind this development appears to be productivity growth and not relocation (Van der Zee et al., 2007). Looking at the high productivity increases in the chemicals industry this could be used as an indicator of future employment decline. This is furthermore likely due to the slow growth of chemicals demand within Europe, with global production output growth in the past decade largely driven by emerging economies.

Outsourcing and offshoring in the pharmaceuticals industry

In comparison to the chemicals industry outsourcing is an important factor in the pharmaceuticals industry. Competition from generics and pricing pressures in the healthcare market create pressures for cost reduction in all parts of the pharmaceutical value chain.

According to PwC, outsourcing to lower cost but highly effective companies in Asia has become a common response to these pressures. According to a survey 56% of companies does not see outsourcing in a sufficiently dynamic way and is missing opportunities for shared development, learning and improvement (PwC, 2007). So far much of the focus has been on outsourcing drug manufacturing but increasingly, companies are turning their attention to R&D and clinical trials. Furthermore, outsourcing of functions outside firms core competences is widespread with shared services such as finance and human resource functions being outsourced as reported by Accenture (Accenture, 2007). Because of this the pharmaceutical landscape is likely to look radically different in the medium term. In the future PwC expects global pharmaceutical firms to focus on sales and marketing with other activities outsourced, requiring firms to engage in strategic partnerships (PwC, 2007).

8 Regulation

The chemicals sector is exposed to various environmental, safety and security issues and risks. With industrial plants often being located near populated areas, and chemical transports taking place all over Europe, and with chemicals being associated with risk in production and use, the chemicals industry is confronted by extensive regulation. The Consultative Commission on Industrial Change (CCIC) claims that in general, the current EU regulatory environment does not overly support the competitiveness of the EU chemicals industry. The impact and role of regulation on innovation and competitiveness is not clear-cut, however. Where further rules concerning the greening of the industry and innovation may go together (but not necessarily so), other forms of regulation may hamper innovation and competitiveness. Environmental regulation is considered a key factor (driver) for the chemicals industry.

The pharmaceuticals sector is not subject to environmental regulation. Most important regulations for the pharmaceuticals sector stem from health and safety regulation. This applies to the approval of new substances and drugs, which have to pass several stages of pre-clinical development and clinical trials, as well as the commitment to ongoing safety monitoring. This requires large investments before product can be launched, making drug development very expensive. With national approval and regulatory bodies this is a major cost driver for the pharmaceuticals industry.

Whereas the quality of regulation is important, regulation needs also proper implementation. This applies throughout the EU, with similar degrees of enforcement and effectiveness being applied across Member States, as to maintain a level playing field.

Stifling or supporting innovation and competitiveness?

The High Level Group (HLG) on the competitiveness of the European chemicals industry highlights that regulation has both direct and indirect effects. As a direct effect regulation causes costs of compliance, may delay market introductions but may as well create markets for innovations (e.g. substitutes for CFCs). Regulation also has indirect effects; it may (a) create first mover advantages, (b) provide new competences which can become a competitive advantage (c) lead to relocation to countries with lower environmental standards, but also (d) create trust among the public (HLG, 2007a). Yet opposing views exist on the overall impact of regulation on innovation, especially with regard to SMEs.

Several important regulations are currently affecting the chemicals industry or are about to be implemented with unknown future implications: These include REACH legislation, the environmental liability Directive and several other rules and regulations related to climate change and energy policy. Other regulations related to the chemicals industry are occupational and workplace regulations and parts of other existing environmental and health regulations, notably the legislation on pesticides, biocides, waste, water, climate change and air pollution. An example is the VOC (volatile organic compounds) Directive important for the paint, ink and coatings sub-sector (European Commission, 2006).

REACH

REACH, a new system of Registration, Evaluation and Authorisation/restriction for new and existing chemical substances has been adopted in 2007. REACH requires chemical 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 (European Commission, 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, 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 chemicals industry and mainly SMEs in a disadvantageous position (CCIC, 2007). The impact on employment however is difficult to foresee.

Environmental Liability Directive (ELD)

The Environmental Liability Directive (ELD) sets out requirements that Member States must enact to prevent and remedy environmental damage. Its aim is to hold operators whose activities have caused environmental damage financially liable for remedying the damage. The underlying principle is “the polluter pays”. This means that, for example, an operator could be liable to remediate land that it owns itself. If full repair or replacement is not possible, the remediation of the lost environment with identical, equivalent or similar natural assets must be undertaken. The ELD is not retrospective, so does not cover damage caused before it is due to be implemented. The ELD was due to be implemented by Member States by 30 April 2007. However, many Member States missed this deadline, including the UK. On 26 June 2008, the European Commission announced that it was referring nine Member States to the European Court of Justice for failure to implement the ELD. The nine are: Austria, Belgium, Greece, Finland, France, Ireland, Luxembourg, Slovenia and the UK. Some Member States, when implementing the Directive, have made environmental liability insurance compulsory for operators, or are considering doing so. With the directive only shortly implemented there is little evidence on the impact on the chemicals industry. Before 30 April 2010, the Commission is required to present a report on the ELD’s effectiveness (Lloyds, 2009). With additional insurance premiums, administrative costs and potentially high liability claims the costs of doing business for the sector in Europe increase and put the industry at a relative cost disadvantage to other regions.

Climate change and energy legislation

The chemicals industry being a very energy intensive industry consuming 12% of European energy consumption with proportional greenhouse gas (GHG) emissions is particularly affected by planned energy and climate change policy and regulation. To achieve the GHG emission reduction targets the European Commission has recently proposed a revised Emission Trading System (ETS) Directive in 2007 extending the coverage of industry sectors as well as making auctioning the primary means of allocation of emission certificates (HLG, 2008, Fallmann). This reflects the polluter pays principle and is expected to increase energy costs in Europe.

While the ETS is designed to be used when an international agreement on GHG emission will be implemented, the legislation is currently planned to be adopted regardless of other world regions CO_2 pricing plans. Such unilateral implementation could put the European industry at a structural disadvantage of higher energy prices compared to international competitors. This could particularly affect chemical exports to regions without CO_2 pricing, but also put imports from such regions at a cost advantage. Using tariffs to reduce the expected impacts will be problematic under WTO rules. Imposing a carbon related tariff is likely to cause retaliatory trade measures from competitors (EurActive, 2008). This is most likely to adversely affect the most energy intensive sub-sectors of the chemicals industry such as basic chemicals. While these sub-sectors already operate very efficiently in Europe – the EU chemicals industry having reduced its GHG intensity by 50% since 1990 compared to the US reductions of 30% (CCIC, 2007) - there is little potential for increasing future efficiency while competitors are expected to close the gap (HLG, 2008a). Relocation of these sub-sectors is therefore possible if energy prices will be substantially higher in Europe, particularly in light of the cheap energy in oil and gas producing countries outlined in previous section. Furthermore, energy liberalisation in Europe for gas and electricity has not yielded the expected objective of delivering energy at competitive prices. See also the report on the Electricity, Gas, Water and Waste sectors in the same series as this report (Dijkgraaf et al., 2009). Many EU regions lack truly liberalised and competitive markets (European Commission, 2006). This is a further factor affecting energy prices for European chemical firms in the long run influencing location and investment decisions.

9 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). The SWOT analysis covers the chemicals, pharmaceuticals, rubber and plastic products sector. Where relevant, specific sub-sector level elements are added.

Strengths and opportunities

Overall, the EU chemicals industry has a strong global track record and is continually challenged by global competition at the same time. The strengths and opportunities give a favourable outlook to the sector. In particular the strong internationalisation of EU firms, scientific base within Europe, coupled with a successful clustering in chemicals and a high export base in specialty chemicals are strengths. In terms of opportunities the emerging markets with their industrialisation will continue to be a large user of chemicals, and overtime with increasing wealth also demand more pharmaceuticals. The environmental challenges and climate change will require environmental technologies relying on chemicals and material solutions posing a significant opportunity particularly for Europe with its strict environmental regulation. With the increasing prices of fossil energy an opportunity also lies with the development of substitute materials based on raw materials. Lastly, biotechnology and nano-technology play an important role for the aforementioned opportunities to develop technological solutions.

Weaknesses and threats

Nevertheless, are there also weaknesses and threats, particularly at the sub-sector level. In particular the structurally higher energy costs are a significant competitive disadvantage for the energy intensive sub-sectors producing basic chemicals. This is coupled with older and smaller plant (less efficient) sizes compared to the new investments in Asia. High labour costs in Europe mean that lower value added activities (plastic products) are located in lower wage countries, but also the new Member States. Europe has a bad track in innovation, i.e. in bringing new goods and services to the market. The position of EU university education and research is considered to be weakening relative to competing countries. Lastly, compared to the US, Europe is weak in biotechnology research which is of importance for the future of the pharmaceutical and chemicals sector.

Threats for the sector originate from competition from the emerging economies – BRICs as well as the Middle East - that over time will also develop strengths in R&D. Furthermore, Asia is one of the key growth markets attracting investments in production and research that overtime will challenge the exports of Europe and even provide imports. This is most likely to happen for basic chemicals over the coming decade and in the long term also for more specialised chemicals. The research intensity of pharmaceuticals and importance of TRIAD markets make it unlikely that similar developments in the pharmaceuticals sector will happen soon. For the chemicals sector an important threat is any unilaterally imposed regulation related to climate change that will structurally increase energy costs in Europe posing a competitive disadvantage compared to imports such as the planned ETS, at least for the high energy intensive sub-sectors. While IPR violations are a general threat, notably in third markets, they are particularly threatening pharmaceuticals with very low marginal production costs and generic drugs. Lastly, the shrinking labour supply expected from an ageing workforce potentially poses a skills gap. With a structurally older workforce and tacit knowledge in production processes, this is most acute for the chemicals sector.

Table 8. Analysis of Strengths, Weaknesses, Opportunities and Threats - Chemicals

Strengths	Weaknesses
• Strong internationalisation of firms; competitive • Historically strong research base – high quality engineers / university research • Research intensity pharma / biotech • Technology leader (efficiency) • Close integration / clustering of chemicals activities creating a favourable locus and infrastructure for production and innovation • Strong in specialty chemicals / pharmaceuticals • Low cost production locations in NMS close to EU-15 markets (rubber and plastic products) • Capital intensity – prevents short term relocation of production activities	• Lagging innovation performance in terms bringing new products successfully to the market • Comparatively weak biotech research compared to US – important for pharmaceuticals sector • Structurally higher resource costs (oil, gas, energy) • High labour costs for low skilled jobs (rubber / plastic products manufacturing) • Ageing work force, few young newcomers • Single European market for chemicals and energy still largely lacking in Europe • Structure of EU IPR system increases costs • Dominance of relatively small plant size in Europe leading to scale disadvantages • Public perception of chemicals industry is mixed and sometimes still negative, which leads to a lack of interest in chemical education (see also threats) • Transport infrastructure congestion / weak pipeline infrastructure, in the EU-15 and esp in the NMS (pipelines, ports, railways).
Opportunities	**Threats**
• Emerging markets – provision of export / new markets • Demand for basic chemicals when industrialising • Demand for pharmaceuticals as developing countries get richer and industrialised age • Solutions required for environmental challenges / technologies – chemicals as solution provider • Efficiency leader → technology exports / competitive advantage once stricter global regulation comes in force • New technologies such as biotech and nano-tech; substitutes for oil inputs and new materials with higher performance characteristics • Presence of user industries • Regulation also conducive to future development of sector.	• Competition from emerging economies – declining trade surplus in (basic) chemicals • Growth of markets outside Europe • Labour supply declining – particularly high skilled technical personnel • Lack of interest in chemical education • Weakening position of EU university education and research for the sector • IPR violations by competitors, particularly in pharmaceuticals (generic drugs) • Unilateral European regulation REACH and ETS structurally increase production costs • Relocation of user industries • High energy / resource costs • Safety and security issues (densely populated areas) • Small / creative start-ups are easily bought up for strategic reasons. IPR does not help to protect their IP.

10 Drivers

10.1 Identifying 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.[11] 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:

[11] Common ways to rank trends and drivers are the DESTEP (Demographic-Economic-Social-Technological-Ecological-Political) and STEEP (Social-Technological-Economic-Ecological-Political) categorisations. For our purpose, slightly altered DESTEP definitions are used to reflect the embracing dimension of analysis.

- 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.

10.2 Identification and discussion of sectoral drivers

In total 26 drivers falling in the six DESTEP (demographic, economic, social, technological, environmental and political) were assessed for the sector as a whole (see Table 9.1). Drivers with relevance of 7 and higher were identified as relevant for the sector and are presented in summarising Table 9.2.[12] The most important drivers by relevance (rated with a 9) are innovation and sustainability; regulation (both environmental and security and safety regulation); and emerging economies driving global growth. Innovation is of crucial importance to the sector frequently addressed as provider of sustainable solutions. While the innovative challenge is taken up, more needs to be done to warrant Europe's future competitiveness. Regulation affecting the future of the sector stems from several current legislative initiatives such as REACH, the Environmental Liability Directive (rethinking the concept of hazards) and legislative responses to climate change-related legislation such as the ETS Directive concerning the greenhouse gas emissions (GHG) allowance trading system. Implementation and enforcement of regulation is important and currently tends to differ between Member States.

It should be remarked that although the pharmaceuticals sector is not subject to environmental regulation, it is affected by health and safety regulations.

Outsourcing and offshoring, increasing demand for environmentally friendly products, the availability and price of oil, natural gas (methane) and energy and the quality of institutions were identified as the next important drivers (rated with an 8). The chemicals industry is mostly affected by the offshoring of user industries that lead to new investments primarily outside Europe. Outsourcing plays an increasingly important role in the pharmaceuticals industry, while offshoring and low wage production is important for the rubber and plastic products sector. The demand for environmentally friendly products is particularly important for the chemicals industry as supplier of materials and solutions for new technologies. With the importance of carbon for products in the chemicals, pharmaceuticals and rubber and plastic products sector, the availability and price of energy is important for all sectors,

[12] It should be noted that the DESTEP analysis and workshop was held in late Spring 2008, i.e. *before* the financial and economic crisis. Further validation took place in another workshop in August 2008 and during the final workshop in October 2008.

however, crucial for the energy intensive sub-sectors such as basic chemicals. Lastly, the sector being characterized by large capital investments (chemicals) and high research intensity (pharma) is served by quality institutions, which include reliability, quality and enforcement of rules and regulations and a stable political environmental.

Other important drivers (rated with a 7) identified were increasing global competition, increasing market segmentation, income per capita and ageing (retiring baby boomers, fewer younger workers) leading to a shrinking labour force. Global competition up to now has been fuelled by very low tariffs and an integrating world market. Until recently, at global scale firms could still exploit scale advantages leading to further M&A-led consolidation. Furthermore, with emerging economies breaking into upstream activities (basic chemicals), competition intensifies also based on resource advantages. Increasing market segmentation can be seen as a response to the global competitive pressures, with firms focusing their activities on market niches that provide higher value added activities. Income per capita is an important driver for the sector in two respects. Income increases generally drives the demand for products and services. As the chemicals sector is an input sector to most other industrial sectors, when the economy expands so does the demand for chemicals. With rising income per capita also a larger proportion is available for healthcare spending, driving the demand for pharmaceuticals.

Table 10.1 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?[13] 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	N										
	Ageing – declining labour force	Y	7	2	N	N	Y		x	x	Y	N
	Population growth (birth and migration)	N										
Economic	Income per capita and household	Y	7	6	N	N	N		x	x	Y	N
	Income distribution	N										
Globalisation	Outsourcing & offshoring (user industries)	Y	8	2	N	N	N	x	x	x	N	Y
	Increasing global competition	Y	7	2	-	-	Y	x	x	x	N	N
	Emerging economies driving global growth (new market demand, especially BRIC countries)	Y	9	3	-	-	N	x	x	x	N	Y
	Global / regional production networks (dispersed production locations, transport)	N										
	Counter-trend regionalism / protectionism	N										
Cultural values	Increasing market segmentation (tailor made production, mass customization)	Y	7	4	Y	Y	N	X	X	X	Y	Y
	Lifestyle changes	N										
	Increasing demand for environmentally friendly / products and inputs	Y	8	4	-	-	Y	x	x	X	Y	Y

[13] Short = 0-3 years; medium = 3-7 years; long = > 7 years. All three categories may apply. All three categories may apply. In the column short-medium-long term impact capital letters (e.g. X instead of x) indicate a larger expected impact in that particular category.

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?[13] S	M	L	Are substantial differences expected between (groups of) countries? Y / N	Are substantial differences expected between sub-sectors? Y / N
Technology, R&D and product and process innovation	Advances in IT impacting on organizational structures & new business models	N										
	Internet changing production and consumption patterns (e-business; etc.)	N										
	New types of work organisation (teams-based, sociotechnique, etc.)	N										
	New/additional value-added services	N										
	Sustainability and innovation	Y	9	4	N	Y	Y	x	X	X	Y	Y
Natural resources	Availability and price developments of oil, gas and energy	Y	8	6	Y	-	N	x	x	X	N	Y
	Availability and price of other natural resources	N										
Institutional / Political	Trade and market liberalisation (national level)	N										
	EU integration – deepening (single European market etc.)	N										
	EU integration – broadening (bigger domestic market)	N										
	Quality of institutions (judiciary, transparency, lack of corruption, viable business climate, structural rigidities)	Y	8	1	N	N	Y			x	Y	N
	Labour market regulation	N										
	Environmental regulation	Y	9	3	Y	Y	Y	x	x	X	N	Y
	Security , health and safety regulation	Y	9	3	Y	Y	Y	x	x	x	N	Y

Table 10.2 Summary of main drivers

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
Demographic	Ageing – declining labour force	Y	7	2	N	N	Y		x	x	Y	N
Economic	Income per capita and household	Y	7	6	N	N	N		x	x	Y	N
	Outsourcing & offshoring (user industries)	Y	8	2	N	N	N	x	x	x	N	Y
	Increasing global competition	Y	7	2	-	-	Y	x	x	x	N	N
	Emerging economies driving global growth (new market demand, especially BRIC countries)	Y	9	3	-	-	N	x	x	x	N	Y
Social	Increasing market segmentation (tailor made production, mass customization)	Y	7	4	Y	Y	N	X	X	X	Y	Y
	Increasing demand for environmentally friendly products and inputs	Y	8	4	-	-	Y	x	x	X	Y	Y
Technological	Sustainability and innovation	Y	9	4	N	Y	Y	x	X	X	Y	Y
Environmental	Availability and price developments of oil, gas and energy	Y	8	6	Y	-	N	x	x	X	N	Y
Political	Quality of institutions (judiciary, transparency, lack of corruption, viable business climate, structural rigidities)	Y	8	1	N	N	Y			x	Y	N
	Environmental regulation	Y	9	3	Y	Y	Y	x	x	X	N	Y
	Security, health and safety regulation	Y	9	3	Y	Y	Y	x	x	x	N	Y

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. This structure is based on the functions as they appear in Eurostat's Labour Force Survey and further elaborated. Chapter 10 discusses the main implications of the scenarios in terms of future employment volumes by job function (step 5). Chapter 11 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 chemicals industry broadly defined but excluding the pharmaceuticals industry (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 for the chemicals sector broadly defined

Endogenous, sector-specific drivers:
- Sustainability and innovation
- Integration / integrated chemical clusters
- Environmental regulation
- Security and safety regulation
- Quality of institutions

- EU lead markets in sustainability with strong policy support and strong innovation
- Active integrated cluster strategies
- Environmental regulation based on pro-active two-sided 'co-thinking' dialogue with industry
- Ditto safety & security regulation
- Sustained quality institutions, continuing EU integration (deepening)

Exogenous drivers:
- Outsourcing & offshoring of user industries
- International competition; emerging economies driving global growth
- Market segmentation and green demand (environmentally friendly safe products and feedstock)
- Availability/price of oil, gas and energy
- Income

Increasing modestly	**Green and Focus Europe** **(Scenario II)**	**Green and Global** **(Scenario I)**	Increasing strongly
Moderating, more inward-looking / protectionist			Strengthening
More segmentation, strong increase in autonomous green demand	**European Retreat** **(Scenario III)**	**Global Pressure** **(Scenario IV)**	Moderate increase in segmentation, and in autonomous green demand
Continuing price increases (scarcity & politically driven)			Moderate price increases
Slow growth			High growth

- Absence of lead markets and lagging innovation performance
- Cluster integration taken up by business only
- One-sided environmental regulation, no proactive 'co-thinking' dialogue with industry
- Ditto of security & safety regulation
- Sustained quality institutions but 'standstill' in European integration

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 chemicals sector broadly defined, and refer to the chemicals, rubber and plastic products sub-sectors, yet not to the pharmaceuticals sector. This is not to say that developments in each of these sub-sectors are taken to be one and the same. Compared to chemicals, rubber and plastic products tend to be produced further downstream, with chemicals being an important input, and developments in chemicals influencing the rubber and plastic products industry. The drivers influencing the rubber and plastic products sub-sectors are similar, however, and roughly coincide with the drivers for the basic chemicals segment. This being said, the mix of drivers (i.e. constituting relative magnitudes) as well as market structures in the rubber and plastic products sub-sectors differ substantially from the chemicals industry narrowly defined, making future developments most likely quite different. The way in which the scenarios have been constructed does not preclude such a differentiation. While the same underlying drivers apply, a different starting position and development can apply. This also holds for developments between each of the Member States. Thus the Green and Global scenario may be closer at hand in some Member States than in others, and different Member States might therefore be located in different scenario quadrants, now as well as in the future.

Pharmaceuticals have been excluded, because of important differences in underlying defining drivers and hence direction. These differences apply to, amongst others, sustainability (with 'greening' being far less of a driver than in the other sub-sectors), innovation (even though innovation is thought to play a bigger role in the chemicals industry the role of innovation and R&D in the pharmaceuticals industry is by nature far more dominant), the importance of oil, gas and energy (pharma being less dependent), as well as ageing (as a driver of consumption of pharmaceuticals, driven by a higher percentage of elderly people).

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. At the right

hand side we observe a world economy that is expanding, globalising and integrating further, with oil, gas and energy prices moderately but steadily increasing from current levels, on the left side opposed to a world economy that faces further shock-wise strong rises in oil, gas and energy prices over time that will affect global growth and trade flows in the medium and longer term, and hence income. Competition in all scenarios will be fierce, but in the right-hand part will even strengthen further and at global level, because globalisation and integration will develop more rapidly. The left-hand part is characterised by Green and Focus Europe, with country blocks such as the EU, North America, South Asia (India-led) and East Asia (Japan/China-led) having a stronger inward focus in terms of trade and development, and less focus on external 'global' linkages. Regionalisation, whether or not stimulated by lurking protectionist tendencies, creates a tendency towards more fragmented regional markets and more segmentation. The *endogenous drivers* on top of Figure 10.1 exemplify a situation of 'more' Europe. Europe is actively pursuing better, less bureaucratic and more flexible standards and harmonisation of EU environmental and safety and security regulations, and trust and an active dialogue with the chemicals industry lies at the basis of new policy directions. More generally, the quality of institutions will continue to improve, especially at EU level, by a further deepening of EU integration exemplified by further progress on the single European domestic market (energy, services, customs procedures). Innovation and green are thriving in the upper part, but lag and stay behind in the bottom part of the Figure. The bottom part reflects a Europe that does not make much progress in deepening EU integration, neither in further tailoring and improving environmental and safety and security regulation, leaving much of the discretionary regulatory powers to the individual Member States, but also with the current EU ETS proposals and REACH legislation kept unchanged. Differences can also be observed in the way how government and industry act together towards the future. 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 tends to continue across sectors (e.g. automotive; ICTs) in the right hand-side of figure 10.1; they do only moderately so in the left-hand side. 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.
- *Increasing global competition*: Pressures for global competition strengthen in a climate of continuing globalisation and global integration.
- *Emerging economies driving global growth*: The development and growth of key emerging economies depends on a further integration of the world economy and increasing specialisation between countries. Growth in emerging economies slows in a more protectionist environment feeding back into the sector through lower demand (right) vs continuing growth of emerging economies driven by investments in emerging economies in a favourable climate towards globalisation.
- *Increasing segmentation / focus on high value added activities*: Firms continuously adapt their competitive position depending on changing global market conditions. More segmentation on the left-hand part is especially related to

an increase in 'green' demand (products, feedstock and energy). More segmentation on the right-hand side is driven by further Green and Global .

- *Increasing demand for environmentally friendly products*: Demand is driven by resource scarcity and ditto prices, putting a premium on new bio products and on efficiency in production and consumption over the whole life-cycle of products and services. This driver is considered certain, while being relatively more important in the scenarios characterised by feedstock scarcity and higher prices.
- *Availability and price of oil, gas and energy*: Current prices develop upward but moderately so vs higher scarcity and global politics driving prices up to further extremes.
- *Income per capita*: Slower growth of income per capita due to less domestic growth and less global trade versus faster growth of income per capita driven by an expanding global economy. Differentiations may apply between the old EU-15 and the new Member States, with higher consumption (catch-up) rates in the latter. The income variable implicitly reflects a relatively high quality of life standard throughout the EU.

Demographics – ageing of young and old – and its effects on labour supply including the composition of the labour force have not explicitly been taken into consideration as a distinguishing driver. Rather they are assumed to play similar roles in each of the scenarios. Measures to soften these impacts, such as international migration and labour mobility are dealt with in chapter 14 on strategic choices. Economic growth is is supposed not to play any role whatsoever for demographic developments itself. The horizon of 2008-2020 is too short to play a distinctive role in terms of economics and demographics in the different scenarios.

Overview and description of endogenous drivers

- *Sustainability*: The chemicals sector in Europe is vitally important as a provider of chemical solutions and as a key player in our search for sustainable development. This includes improving eco-efficiency of products and processes by optimising the use of resources, clean air and minimising waste and environmental impacts, and solutions for coping with climate change. Both scenarios on top of Figure 10.1 reflect an active stance towards sustainability and innovation, both by European industry and by government (EU, national). This approach includes the promotion of energy and resource efficient technologies, creating a dynamic internal market for sustainable, better performing products and for the move to leaner and cleaner production. It aims furthermore at stimulating and enabling consumers to move to more sustainable consumption patterns. At the same time, European and national governments play an active role in establishing a European lead market for sustainable products. The scenarios shown at the bottom of Figure 10.1 reflect a situation where sustainability and innovation are lagging. There is no concerted European effort to establish sustainability further as a top priority. Initiatives are there, but remain fragmented. The industry uses sustainability as a label and marketing tool towards customers to the outside world but does not live up to expectations when it comes to 'real' sustainable solutions.
- *Clusters and integration*: Integrated clusters are vital to the competitiveness of the European chemicals industry (see e.g. conclusions of the 2007-09 High Level Group (HLG) on competitiveness of the European chemicals industry). Both governments (EU, national) and industry have a role to play in improving and

establishing clusters. The success of clusters largely depends on the infrastructure in place (on site and between sites), and its adequacy for the special needs of the chemicals industry. Companies have a main role to play when it comes to cluster leadership, recognizing also that public authorities can play an important supportive role as a facilitator. In the top part of Figure 10.1, integration is actively sought by the industry and supported by public authorities. In the two bottom scenarios, cluster strategies are there, but its main proponents are to be found in the industry only. Outsourcing of parts of the European chemicals industry (as opposed to user industries, see exogenous drivers) can be seen as part of a move towards optimal clustering. Offshoring on the other hand is a force that might undermine the integrated cluster capacity of European industry.

- *Environmental regulation*: Environmental regulation is crucial not only in addressing sustainability issues (see above) but more generally to climate change (CO2 reduction). ETS arrangements are part of the regulatory package in all scenarios. The difference between the top scenarios and those at the bottom of the figure is in how regulation will be taken up in the coming years – both in terms of 'new' rules and regulations and in implementation/enforcement. Reliable and harmonised implementation matters. The top scenarios reflect a situation where both government and industry are involved in a pro-active dialogue and a process of policy learning, with both parties co-operating and co-thinking on the best possible way to sustain and improve the environment and at the same time keeping the chemicals industry in Europe as a vital pillar of the European economy. The top scenarios include a further tailoring of the current environmental regulatory package, with renewal of the ETS arrangements and measures aimed at influencing consumer demand (eco-products). In the two bottom scenarios, however, a real pro-active dialogue does not materialise; government one-sidedly imposes further measures to curb environmental damage and current ETS measures are imposed strictly without much room for change. European industry reacts by further off-shoring vital parts of its production outside Europe.
- *Security and safety regulation*: security and safety regulation plays an important role wherever hazardous substances are involved, particularly in the densely populated areas of Europe. In response to security and safety threats government and industry are involved in an active dialogue to design even better regulation to bring safety and security levels up to the needed standards, while respecting competitiveness and the need of keeping a chemicals industry in Europe. The two bottom scenarios reflect a situation in which security and safety regulation is imposed one-sidedly without such dialogue and 'co-thinking', with will put an additional burden (and costs) to industry. REACH will form part and parcel of European policy in all scenarios; however, in the top scenarios governments are more inclined to seek active solutions where problems in REACH implementation might pop up.
- *Quality of institutions*: the chemicals sector is characterised by large capital investments with long life times, and similarly long lead times in research and product development before chemical innovations can be brought to the market. This requires stability in the orientation of the regulatory system. High quality and stable institutional settings are a prerequisite to attract long term investments and employment. Europe sustains its higher quality institutions compared to emerging competitors and expands its position by deepening European integration

(furthering of one domestic market for goods and services, with more adequate unified EU customs provisions, checks and balances) (the two top scenarios), versus a continuation of the current institutional Member State dominated institutional set-up with some but limited leeway for EU-wide interventions, i.e. business as usual (the two bottom 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 7 'the main strategic choices to meet skill needs' (see chapter 14). In step 7, 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.

10.3 The scenarios – detailed discussion

Based on the combination of endogenous and exogenous drivers the following four scenarios for the chemicals, rubber and plastic products sector are distinguished:

- Scenario I: *Green and global*
- Scenario II: *Green and focus Europe*
- Scenario III: *European retreat*
- Scenario IV: *Global pressure.*

Scenario I: *Green and global*

The combination of drivers for this scenario results in a world characterised by strengthening international competition and strong global and European economic growth, coupled with more flexible and targeted European environmental, security and safety regulation, including lead market initiatives for the sector, as well as innovation. As a result Europe is able to build up and specialise in global niches, focussing on energy efficient processes and bio-based chemistry and materials. This improves and further strengthens existing chemicals clusters. But low energy prices mean that this development is largely driven by regulation, and hence restricted to front-runners like Europe, with fossil feedstock based chemistry remaining the dominant force in international competition. Europe can sustain its advantage of its high quality institutions at the national level and combines this with a further deepening of EU integration, and the establishment of a true European single market, including an effective and efficient framework of checks and balances. Strong European growth also provides for a sufficiently broad and healthy tax base which enables to invest in the necessary future (infrastructure!).

Together this provides for a competitive edge that allows the chemicals sector to sustain its current position in the global economy and at the same time lead the transformation to sustainable production. Consequently, growth accents may differ with what we observe in the industry nowadays. Strengthening competitive pressures due to further globalisation and multilateral trade are expected to lead to a continued search by firms to further focus on core activities (restructuring).

Scenario II: ***Green and focus Europe***

The combination of drivers for this scenario reflects a situation in which competition continues but with a slowdown of global economic growth, which in combination with protectionist pressures will lead to regionalisation in which most trade takes place within rather than between regional trading blocks. Slowing growth is predominantly the result of continued upward shock-wise pressures in the oil, gas and energy markets which make international business and transport more expensive and lead to a downturn in international trade in the medium an longer term. As a result the trend of globalisation and integration of markets will halter, especially in the light of increased risk of disruptions in the supply chain. Europe will be able to sustain its advantage of its high quality institutions at the national level and combines this with a further deepening of EU integration, and the establishment of a true European single market, including an effective and efficient framework of checks and balances.

High energy prices and disruptions in supply markets on the other hand make substitutes competitive leading to a market-driven adoption of green technologies and innovation. Consumers opt for energy-conscious and efficient products in which the chemicals industry has a key role to play as enabling industry. This will lead to a greater variety of products and a further segmentation of the market. In addition existing dual oil and gas pricing exacerbate the differences in global feedstock prices between Europe and elsewhere in the world (e.g. Middle East, China) making European exports in these segments uncompetitive leading to a strong focus on energy efficient and bio-based chemistry. This is supported by a pro-active dialogue between government and industry and a process of collaborative 'co-thinking' that will enable a better and smarter tailoring of existing environmental and security and safety regulations. Environmental and safety standards provide incentives for the industry to sustain its global innovative edge making the European chemicals sector a leading solutions provider to various societal challenges, with a focus on sustainability/environmentally friendly solutions. This development goes hand in hand with environmental protection and a better quality of life for European citizens. Last but not least: the potential strength of Europe's chemical clusters is further enhanced by active investments by both industry (more efficient plants, further integration) and government (infrastructure).

Scenario III: ***European retreat***

This third scenario combines an overall slowdown in economic growth caused by high energy prices and supply disruptions with continuing pressures from external competitors even if global competition is not as fierce as in scenario I and IV. Whereas the strong rise in oil, gas and energy prices leads to an increased demand in environmentally friendly and foremost energy-saving products, the support of governments to facilitate this change is minimal – with a strong belief in market forces being the dominating doctrine. There is stable but less tailored regulation without any renewing and innovating initiatives as regards chemicals production and consumption from the side of the EU or of national governments. Despite high energy prices, low growth rates lead to rather low demand preventing a real strong take-off of the 'green' segment, with at the same time slowing demand for the more traditional chemicals products (blockbusters). Taken together these ingredients form a dangerous mix as regards the future competitiveness of the EU chemicals industry.

The strong rise in oil, gas and energy prices leads – like in scenario II - to a downturn in international trade. One of the results will be further regionalisation, in which most trade takes place within rather than between regional trading blocks. This is the key differentiator compared to scenario IV. As a result of the gradual build-up of global capacity in excess of global demand, predominantly originating in the Middle East and East Asia, low EU tariff barriers make that surpluses easily can make their way into European markets. This is further exacerbated by dual oil and gas pricing in these regions, making Europe lose competitiveness in certain market segments. This results in a further squeeze of EU market shares and profit rates, especially in energy intensive, basic chemicals production. It could well be that in this scenario protectionist tendencies will come stronger to the surface as a result in later phases of the period 2008-2020. Europe does not only face a loss of global leadership in chemicals production, but will possibly also witness a gradual retreat of production capacity throughout Europe, which in this scenario is not compensated with regulation stimulating a transformation to a green and innovative industry.

Scenario IV: *Global pressure*

Scenario IV *Global pressure* combines strong overall economic growth and high incomes, with an even stronger global competition that makes 'all hands on deck' for the EU chemicals industry a leading adage and warning. The strong economic growth is engendered by continuing and expanding global trade flows in combination with a stable development of the global oil and energy prices. Globalisation, however, also stimulates further international competition which is predominantly coming from emerging economies in the Middle East and East Asia, and to a lesser extent from Russia. Europe's competitors are able to produce high-quality chemical goods at structurally lower prices. Stable but less tailored regulation without any renewing and innovating initiatives as regards chemicals production and consumption from the side of the EU or of national governments will add to the increased competitive pressures internationally. As a result of the gradual build-up of global capacity in excess of global demand, low EU tariff barriers make that surpluses make their way into European markets, with low priced products from China and the Middle East directly competing with EU chemical products. This results in a further squeeze of EU market shares and profit rates. Furthermore, stagnating progress on the institutional part (i.e. no further deepening of the internal market), with emerging competitors managing to close the gap with European producers, not only in terms of production efficiency but also in terms of innovation and market penetration. This results in the loss of global leadership of the European chemicals industry, and requires all hands on deck as regards the future and survival of the industry in Europe.

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 chemicals 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.

Table 11.1 Job classification

Classification in Labour Force Survey (LFS)	Specific jobs of high relevance to sector in the LFS classification	Job function categories applied in chapters 12-14
Managers	Corporate and specialist managers covering all firm functions	Managers
Computing professionals	Computer systems designers, analysts, programmers and computer associate professionals	IT professionals
Engineers and related professionals	Chemical and mechanical engineers and technicians	Engineers - production - R&D
Business professionals	Accounting, finance and sales professionals	Accounting & finance Sales & marketing
Other professionals & technicians	Lawyers* and economists, other science professionals**, and associate professionals	Supply chain management
Office clerks and secretaries Service workers	Office clerks and secretaries, receptionists and information clerks, Transport conductors	Support staff - administrative - drivers
Metal, machinery & related workers Craft and related trade workers	Machinery mechanics and fitters, metal moulders, welders, tool makers	Plant and machinery maintenance and repair
Chemical products machine operators Rubber & plastic products machine operators Plant and machine operators & assemblers	Chemical, pharmaceutical , rubber and plastic products machine operators, chemical processing plant operators, machine assemblers	Production workers
Labourers	Manufacturing labourers; also maintenance and cleaning personnel; porters	Labourers

Note: * classified under support staff; ** classified under engineers

Table 11.1. shows the detailed job functions for the chemicals, pharmaceuticals and rubber and plastic 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 as well as different specialist managers in HRM, finance, production, sales, and R&D.
- *IT professionals:* ICT professionals such as system designers and programmes as well as lower computing professions and computer operators as well as industrial robot controllers.
- *Engineers*: chemical, but also mechanical engineers as well as related technicians. Engineers, chemists, life science technicians and pharmacologists working in *Research & Development (R&D)* form a special sub-group of this job function.
- *Accounting & finance*: accountants and bookkeepers.
- *Sales & marketing*: sales and marketing staff and product stewards.
- *Supply chain management (SCM)*: a relatively new emergent category of high-educated workers who enable and facilitate complex regional and global SCM processes, including contracting.
- *Support staff*: 1) office clerks / secretaries & support staff cover administrative functions, including order management and stock keeping, 2) legal professionals and HRM staff, and 3) drivers.
- *Plant and machinery maintenance and repair workers*: 1) machinery and precision workers such machinery mechanics and electrical and electronic equipment mechanics, 2) all craft related occupations not falling under metal, machinery and precision workers (needed to repair plants and machinery).
- *Production workers*: skilled production workers, most importantly plant and machine operators, currently making up a large share of employment in the sector.
- *Labourers*: low-educated/skilled workers such as manufacturing labourers, caretakers, porters and related workers.

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:

- Production workers and labourers. Production workers represent a sizeable occupation function (920 thousand workers). Labourers - low-educated - form an additional 340 thousand workers employed largely in production but declining quickest. As a result a relative shift in volume was observed from low educated labourers to skilled production workers. This trend is expected to continue.
- Support staff: secretaries and office clerks (405 thousand employees) represent one of the fastest declining job functions in relative shares. This 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.
- Engineers (474 thousand) and business professionals (685 thousand) are the job functions expanding most in terms of relative share. This is caused by the general up-skilling trend observed in many manufacturing sectors where lower skilled employment is replaced with higher skilled work. This trend is expected to continue.
- Management: the relative volume shares of managers (360 thousand in absolute terms) have been more or less constant, showing slight growth in the NMS and EU-9. While changes in work organisation require more day to day management, this is integrated in more and more job functions rather than executed by 'pure' managers. This trend is expected to continue.

12.1 Volume effects scenarios *Green and Global* and *Green and Focus Europe*

Tables 12.1 and 12.2 present the *relative* expected changes in employment volume by job function in the chemicals sector for each of the four scenarios.

The tables show the expected changes as from 2009 towards the year 2020. A distinction has been made between fine chemicals on the one hand and the bulk chemicals on the other. In the last row an assessment of the overall expected job development is given. Because of the qualitative expert judgement-based nature of the exercise, expected changes are ranked in three categories: an expected increase (I), decrease (D) or no relative change (M). Table 12.1 represents the *Green and Global* and *Green and Focus Europe* scenarios. Table 12.2 highlights the *European Retreat* and *Global Pressure* scenarios.

Although the direction of the *Green and Global* and the *Green and Focus Europe* scenarios are different, the implications of both scenarios in terms of overall employment volume in 2020 are judged to be rather similar (see Table 12.1). It is the development path towards 2020 and the type of niche specialisation and therefore skills composition – resulting for instance in more SMEs in the *Green and Focus Europe* scenario than in the *Green and Global* scenario - than the ultimate result in number of jobs that is expected to be different. Whereas the *Green and Global* scenario is the most open and global one, with most rapid change to be expected, the *Green and Focus Europe* scenario is more gradual and smooth.

Green and Focus Europe implies more diversification and segmentation of the market, with more (diversified) companies present in the market and more SMEs than in the

Green and Global scenario. The former scenario, because of its stronger focus on leading-edge sustainable and safe products, will create positive employment effects similar in size to the more specialised global portfolio and generally bigger sized companies in *Green and Global*.

The *Green and Global* scenario is the most challenging in terms of solutions that have to be implemented on relatively short notice basis to withstand global competition and to benefit from leading-edge new product concepts and production processes. WTO negotiations materializing in a new multilateral trade agreement, and world trade and economic growth continuing, are conducive. As a result the demand for chemical products increases substantially, with a positive effect on chemicals employment worldwide. Europe focuses on high-value products markets with sustainability in the core of its growth strategy. This has a direct impact for the product composition of the Europe-based industry. Fine chemicals niche products are Europe's growth markets. Yet a European production base for bulk chemicals is needed in order to guarantee the longer-term viability of the fine chemicals (and pharmaceuticals) manufacturing in Europe.

Table 12.1 Scenarios I and II: relative volume changes by job function 2008-2020

Scenario	Green and Global		Green and Focus Europe	
Sub-sector / Job function	Fine chemicals	Bulk chemicals	Fine chemicals	Bulk chemicals
Managers	M/D	D	M	D
IT professionals	M	M	M	M
Engineers	I	I/M	I	I/M
Production	I/M	I	I/M	I
R&D	I	I/M	I	I/M
Accounting & finance	M	M	M	M
Sales & marketing	I/M	M	I/M	M
Supply change management	I	I/M	I	I/M
Administrative support staff	M/D	D	M	M/D
Other support (drivers)	I/M	M	I/M	M
Plant and machinery maintenance & repair	M/D	D	M/D	D
Production workers	M/D	D	M/D	D
Labourers	D	D	D	D
Overall job change	***I/M***	***M/D***	***I/M***	***M/D***

Notes: D =decrease, I=increase, M=maintain. I/M indicates "slight increase to stabilization of work force expected." Similarly M/D indicates indicates "stabilization to slight decrease of work force expected", etc.

Most change in the job function structure is found in the fine chemicals part of the industry. The search for environmentally friendly, high-performance products, for new

catalysts and 'less complex, simpler' chemistry (clay!) requires not only additional R&D capacity, but also an up-skilling of the entire labour force.

Pre-competitive research will be more and more shift to universities (in close collaboration with industry). Engineers are in high demand, as are new specialist profiles such as nanotechnologists. Supply chain management (SCM) in world-wide operations and increased collaboration with suppliers is one of the booming job functions. SCM and engineering capacity (toxicologists!) is also needed to address and fulfil REACH needs. Computer professionals will remain in demand, although services related to this job function are expected to be increasingly outsourced. Low-educated labourers are gradually but significantly substituted by capital over time, as investment in more efficient all-purpose labour replacing production units – now already visible – further proceeds. Support and finance functions continue to exist, although with more pressure on the lower skilled end. Sales and marketing efforts are increased, because of increased global profiling.

The *Green and Focus Europe* scenario signifies a different and more moderate development in global competition, with production and trade concentrating within rather than between country blocks. Failure of the WTO agreement along with protectionist pressures lead to an increased use of still existing WTO safety clauses. Further surges in oil, gas en energy prices which come in shocks in the coming years will create strong pressures to move even more towards the high-end of the market, but will also drive the adoption of green and innovative processes and materials. Cluster integration is - because of the high feedstock prices - taken up with high speed. Important investments are made in order to renew existing production capacity, leading to more labour-extensive production and lay-offs of low-skilled employees. Because of a diversified product portfolio more engineers and more R&D staff are hired. The number of supply chain management staff increases, even though operations worldwide are less pervasive than in the *Green and Global* scenario. However, with user industries continuing – even if moderately - to offshore part of their production capacity to Asia and elsewhere, coordination and collaboration needs world-wide will further increase. The *Green and Focus Europe* scenario puts more emphasis on intra-EU exports than the *Green and Global* scenario. The demand for truck drivers is much dependent on business and policy efforts to invest in pipeline capacity and/or more railroad transport. Harmonisation across Europe of current mostly national regulation regarding heavy weight transport could increase the chemical load per truck and therefore lessen the pressure on the chemicals transport market, and the road transport infrastructure in general.

In both scenarios a stable demand for management, support and finance staff functions is observed, even though business operations get more complicated. More and smarter ICT will take over part of their tasks.

12.2 Volume effects scenarios *European Retreat* and *Global Pressure*

The net overall employment implications of both the Global Pressure and the European Retreat scenarios are almost similar, with employment in specialties showing similar volumes as in 2009, but with a considerable decrease in bulk chemicals. With no substantive concerted support or attention from government, neither at the European nor at the national level, and an increase in global competition, the EU chemicals industry is losing customer markets both inside and outside Europe. Little or no protection at the EU borders makes the European market a welcome destination for imports of chemicals, and rubber and plastic products. The recent boom in investment in new plants in Asia

(China!), the Middle East and Russia will lead to global overcapacity, with a flood of cheap-priced chemicals arriving at the European market as a result. This has a direct impact on European employment. The move towards the more sustainable high-end of the market falters, despite increased R&D efforts and more R&D personnel. Government support and customer awareness are needed to make Europe a lead global sustainability producer; both remain far below what is needed. The general trend of up-skilling is visible also in these scenarios, but the influx of more engineers and supply chain management staff is too little to make the big difference that is needed. Companies appear hesitant to hire more high-educated personnel because of down scaled market prospects in Europe. Although income developments are such that European customers are able to buy high-end quality products, only a fraction of them actually do.

Table 12.2 Scenarios III and IV: relative volume changes by job function 2008-2020

Scenario	European Retreat		Global Pressure	
Sub-sector / Job function	Fine chemicals	Bulk chemicals	Fine chemicals	Bulk chemicals
Managers	M	D	M	D
IT professionals	M	M	M	M
Engineers	I/M	M	I/M	M
Production	I/M	I/M	I/M	M
R&D	I/M	M	I/M	M/D
Accounting & finance	M	M	M	M/D
Sales & marketing	I	M	M	M
Supply change management	I/M	I/M	I/M	I/M
Admin. support staff	M	M/D	M	M/D
Other support (drivers)	M	D	M	D
Plant and machinery maintenance & repair workers	M/D	D	M/D	D
Production workers	M/D	D	M/D	D
Labourers	D	D	D	D
Overall job change	***M***	***D***	***M***	***D***

Notes: D =decrease, I=increase, M=maintain.

Producers of specialised chemicals turn to buy on the world market rather than in Europe, with internet sales surging further. European clusters not backed by any focused policy action find it harder to compete with companies outside Europe. Offshoring production is one of the few viable alternatives for European industry to survive, yet at the direct expense of cluster integration in Europe itself in the longer term. The increase of all purpose production units leads to lay-offs of production staff in both the fine and bulk chemicals industry. Managers in the bulk industry find themselves in a difficult situation, which in the global scenario leads to a sizeable cut in the existing layer of managers.

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.

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.[14] 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

[14] '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).

scenario is made. Skills and knowledge needs are operationalised as expected key changes in specific skills and knowledge categories by occupation.

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, 2008e; see also European Commission, 2008f):

- *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

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.

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 5) come very close to what is generally understood as 'soft skills'.

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

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 highly regulated and science-based sectors such as chemicals.

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. Key 'new' skills and knowledge needs were thus identified for various job functions taking the *Green and Global* scenario as the focal scenario. The skills and knowledge needs for the Green and Focus Europe, the other positive scenario is also discussed. The implications of the other two scenarios have also been analysed; the results are reported in the tables below. Both the *European Retreat* and the *Global Pressure* scenarios reflect 'gloomier' futures in which endogenous drivers are less well tuned to the interests of the chemicals sector in Europe, but with

identical exogenous factors as scenarios I and II. In other words, the exogenous driver context between the top and bottom scenarios (see Figure 10.1) does not differ. What differs are the endogenous ('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 scenarios are characterised by fast change and dynamic markets. While under the *Green and Global* scenario outsourcing and offshoring continue strongly, driven by increasing global competition, these pressures are slightly lower in the Green and Focus Europe scenario. Diversification and segmentation of markets is key in both scenarios, requiring strong management skills to develop new markets and niches. In the following the main future skills and knowledge needs are described. A summary 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 in both scenarios. 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.
- 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.

Specifically for the chemicals sector this also means to open up to other sectors for talent as new market niches are likely to develop in chemicals related sectors arising from interdisciplinary technology development.
Specific knowledge requirements:

- The chemicals sector is a highly regulated sector affected by several important legislations that pose challenges and opportunities for business. Managers need to learn about new legislations and their impact on their sector.

- A sound technical understanding of chemistry is also of key importance to managerial functions to be able to judge business developments. So far most of the managers are industry grown making it for outsiders difficult to switch.
- e-skills are crucial to operate in a modern business environment, also for managers; there is hence a need for continuously updating e-skills.

Differences between functions in management:

The technical knowledge required is generally related to the tasks of the specific function within the firm. High levels of chemistry knowledge are of crucial importance in production and R&D, whereas sales / marketing, finance or personnel management requires technical knowledge related to their function.

Differences between firm size:

The management requirements are similar across firm size, whereas managers in large firms are likely to be more globally oriented requiring a stronger emphasis of language and intercultural skills to function in a global environment.

Differences between scenarios:

The relative share of managers has been fairly stable since 2000. This is expected to continue across scenarios. Under the "Green and Global scenario" however high growth and fast change means that more managers are needed soon compared to the "Green and Focus Europe" scenario.

Table 13.2 Emerging skills and knowledge needs: Managers 2009-2020

		Green and Global	Green and Focus Europe	European Retreat	Global pressure
Knowledge	Legislative & regulatory knowledge				
	e-skills				
	Technical 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 knowledge needs		Count 20	Count 17	Count 11	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.

13.3 IT professionals

The skills required by IT professionals are to a large extent not scenario dependent. What is important is firm size (see below). There are two important lines of IT work within organisations:

- IT support (infrastructure / provision of functioning service)
- Specific IT solutions to sector – modelling / simulation of production processes / R&D which is increasingly important in product development and research.

IT support requires certain technical knowledge related 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.

Key soft skills are related to business-oriented service provision, as in-house IT support competes with outsourced services. This requires good communication and team work skills.

IT solutions for modelling and simulation in production and research comprise two components. Programme developers that likely to sit outside the chemical firm and require a hybrid knowledge set of chemical and software engineers. Secondly, the users of these programmes in production and research are also a hybrid job function with emphasis on chemical knowledge integrating specialised IT skills.

Differences between firm size:

Firm size has an important effect on required skill sets as large organisations have more complex IT systems with higher specialisations needed, whereas smaller firms require well functioning IT all-rounders. The Green and Global scenario has an intrinsic drive towards bigger firm size (specialisation world-wide) compared to the Green and Focus Europe scenario (niche specialisations per region).

Table 13.3 Emerging skills and knowledge needs: IT professionals 2009-2020

		Green and Global	Green and Focus Europe	European Retreat	Global pressure
Knowledge	Programming languages				
	Modelling & Simulation				
	B2B IT platforms				
	System integration				
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 knowledge needs		Count 12	Count 12	Count 12	Count 12

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

Production

Engineers represent a considerable share of total employment with every eighth job in the sector. Furthermore, it is the most important job category for growth and wealth creation as the sector is science-based, making research and especially development key functions in the chemicals 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. The fast changing environment in combination with flexible regulation aimed at stimulating sustainability requires innovation whose key source are engineers. Increasingly, engineers will move into services (health and other) which will imply strong competition in recruiting engineers.

Innovation requires certain technical but also organisational and social skills:

- Under both scenarios a change towards market niches in sustainable production (technologies) requires certain technical knowledge from engineers related to a move away from basic feedstock, products and processes to alternatives. While technical knowledge is a prerequisite for innovations to be successful, 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 strong project management skills from engineers.
- Additionally, team and project drive work requires increasingly social skills to engage in networking with necessary language and intercultural skills as well as strong communication skills.
- The use of hazardous materials in the sector with potentially high impacts on the environment and health make risk management a crucial skill also for engineers.

Specific knowledge requirements include:

- Interdisciplinary studies – future markets are chemicals related. Previous studies therefore envisage future chemists / chemical engineers as researchers in chemicals related multidisciplinary subject areas (e.g. KNCV, 2003).
- Potential for bio-based chemistry is not in replacement of fossil materials / processes but in new, better products and processes (HLG, 2008). This likely requires new technical knowledge to be built up by the scientific community.
- Toxicology is an increasingly important subject just as risk assessment driven by legislation.
- Focus on a good basic chemical education; industry partly notes that some universities focus on nanotech / biotech without laying a good foundation in basic chemicals.

Table 13.4a Emerging skills and knowledge needs: Engineers (production) 2009-2020

		Green and Global	Green and Focus Europe	European Retreat	Global pressure
Knowledge	Legislative / regulatory knowledge (environmental; safety; labour; contracting)				
	e-skills				
	Technical knowledge				
	Product knowledge				
	Product development				
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 knowledge needs		Count 21	Count 22	Count 16	Count 16

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.

Differences between subsectors:

There are clear differences between subsectors related to skill requirements of engineers. Pharmaceuticals and fine chemicals have much higher R&D spending and rely on the creativity of their engineers. However, in pharmaceuticals the focus is more on biotechnology. Furthermore, particularly in bulk chemicals, engineers' technical knowledge is required for process optimisation and development of substitutes.

Research and Development (R&D)

Next to production where most engineers work, research and development (R&D) is another key area for engineers to work requiring specific skills. While the emphasis in skill needs in production is on implementing and managing production (efficiency gains / product performance), in R&D the emphasis is on developing and updating scientific knowledge.

With the changing science landscape becoming more open and interdisciplinary with concepts such as open innovation, managing necessary relations with research partners such as universities and other research institutes becomes a key skill for scientific personnel. Furthermore, in research it is particularly important to keep scientific knowledge up-to-date as the research function also acts as absorptive capacity, bringing knowledge from academia into the firm.

As competitive pressures faced by the sector also require efficiency gains in R&D, identifying product needs and sufficient product knowledge become increasingly important in the early research phase requiring entrepreneurial skills from engineers and collaboration with sales and marketing.

Similar to all job functions e-skills are crucial for R&D with additional specific skill requirements. Modelling software replaces more and more tasks that previously had to be conducted in experiments. Operating and understanding modelling software is therefore a key emerging knowledge need.

Differences between scenarios:

While emergent skill requirements of individual engineers are similar across scenarios, volume effects differ between scenarios. High growth in "Green and Global " requires more engineers and production workers especially in light of very fast changes. This poses a challenge to recruit the right talent from the labour markets with the demographic factor hitting the industry in 2012. Demand for new engineers in the "Green and Focus Europe" scenario develops slower but due to the demographic factor and low numbers of graduates nevertheless poses a challenge as well.

Table 13.4b Emerging skills and knowledge needs: Engineers (R&D) 2009-2020

		Green and Global	Green and Focus Europe	European Retreat	Global pressure
Knowledge	Legislative / regulatory knowledge (environmental; safety; labour; contracting)				
	e-skills				
	Technical knowledge				
	Product knowledge				
	Product development				
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				
	Industry / University relations				
	Project management				
	Process optimizing				
	Quality management				
Total Emerging skills and knowledge needs		Count 22	Count 23	Count 16	Count 16

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 Management

Supply chain management is a relatively new function based on global reach of firms promising strategic advantages by sourcing globally, improving customer service and getting products to market faster. Especially for pharmaceuticals but also in other chemical business domains SCM has become very important. The function is a hybrid of previous job functions related to purchasing, sales and logistics. The skills required by SCM professionals are not very scenario dependent, although differences apply.

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 skills 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).

Differences between subsectors:

The subsectors differ in regulatory terms important to sourcing. Therefore, the technical knowledge required by SCM professionals in relation to regulations and legislation differs between sectors making it most effective to learn on the job.

Differences between firm sizes:

So far SCM is a relative specialism of larger firms with international reach. However, effective supply chain management is a considerable source of competitive advantage making it likely to spread to medium sized firms over time. The demand for this specialism is therefore likely to expand under all scenarios.

Differences between scenarios:

The relative share of employees is expected to be constant across scenarios. In the high growth scenario of “Green and Global ” more SCM professionals will be required.

Table 13.5 Emerging skills and knowledge needs: Supply Chain Management 2009-2020

		Green and Global	Green and Focus Europ	European Retreat	Global pressure
Knowledge	Legislative / regulatory knowledge (environmental, safety, IPR)				
	e-skills				
	Technical knowledge				
	Product knowledge				
	Product development				
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 suppliers & 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 knowledge needs		Count 13	Count 13	Count 13	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.

13.6 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 chemicals sector is a global sector making it necessary for accounting and finance professionals to have an international orientation.
- E-skills are of crucial importance, specifically programmes used for bookkeeping and accounting.

Differences between scenarios:

The relative share of accounting and finance professionals as in the past is expected to stay constant across scenarios.

Table 13.6 Emerging skills and knowledge needs: Accounting & Finance 2009-2020

		Green and Global	Green and Focus Europe	European Retreat	Global pressure
Knowledge	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 knowledge needs		Count 11	Count 10	Count 8	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.

13.7 Sales & Marketing

Sales & marketing staff is responsible for managing customer relations, marketing the products and managing sales activities. The global nature of the industry in some of the scenarios envisaged requires strong language and intercultural skills; but also for the more European-focused scenarios such skills are required. 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 and business development (as 'antenna' by bringing in new ideas) become increasingly important.

While sales and marketing is not a science but an art, it is mostly learned through learning on the job. Nevertheless certain knowledge is required for sales and marketing as the chemicals sectors broadly defined is a special industry that often grows its talent in the sector. Specific knowledge requirements relate to:

- Product knowledge, especially the technical understanding of products, in order to be able to serve clients. With chemical product services one of the highest growth markets in the sector (EC-JRC, 2006), this aspect has become already and will be even more important in the future.
- e-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. Additionally, sales are increasingly done via electronic portals (B2B).
- 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.

Differences between scenarios:

The relative share of sales and marketing is expected to be constant across scenarios. However, in absolute terms there are differences expected between sub-sectors and scenarios. The pharmaceuticals sector experienced large employment growth in marketing and sales over the last decade (see Part 1 for details) which is unlikely to continue; it may even reverse with increasing societal criticism of too high marketing expenditures in the sector.

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

		Green and Global	Green and Focus Europe	European Retreat	Global pressure
Knowledge	Legislative / regulatory knowledge (environmental; safety;)				
	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				
	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 knowledge needs		Count 17	Count 17	Count 9	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.

13.8 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 knowledge needs: Support staff 2009-2020

		Green and Global	Green and Focus Europe	European Retreat	Global pressure
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 knowledge needs		Count 9	Count 9	Count 6	Count 6

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 Production workers

Workers involved in the manufacturing of chemicals, pharmaceuticals, rubber and plastics can roughly be ranked into two groups:

- Workers operating chemicals and rubber and plastic products machinery and plants largely involved in operating processes
- Craft and related workers involved in the maintenance and repair of plants that consist of large pipe-systems and metal machinery.

The skills related to repair and maintenance are presented separately from the skill requirements of workers involved in production operations (see section 13.10), although in practice some of the tasks described might be carried out by the same person. This predominantly depends on the size of the company and the way in which production processes have been organised within the firm.

In contrast to job functions described earlier which required a large and diverse set of soft skills, the core skills of manufacturing workers relate first and foremost to the technical knowledge required to perform the tasks of their work. However, also for this job function the changes in work organisation require increasingly social skills related to team working and communication skills.

For the operation of plant and machinery in production specifically educated workers to operate chemicals and plastic and products machinery as well as general machine operators are needed. The technical nature of this job function makes it crucial to keep the technical knowledge of workers up-to-date. Specific emerging skills and knowledge needs relate to:

- Technical knowledge – operating new machinery production plants involving new technology and / or new products and production processes
- Environmental and health and safety regulations relate to the tasks performed on the job, with training needs particularly dependent on new regulation
- Production operations in the chemicals industry are increasingly influenced by ICT technology. This requires production workers to develop and train their e-skills.

One special area that deserves additional attention due to its large growth rates are chemical product services (CPS). The current market for CPS in Europe is estimated to be € 8 bn in 2006, with double digit growth rates expected (EC-JRC, 2006). CPS describe the tendency to not just sell a specific quantity of chemicals to a customer but instead provide the service of a chemical substance for a production process of a customer. This includes the timely delivery, waste management and product improvements. Most importantly services are not billed by substance quantity. Chemical product services therefore require additional service skills of employees going beyond the technical knowledge. CPS currently are largely provided for the automotive sector and to a lesser extent in metal products manufacturing and electrical equipment industry involving coatings, cleaning solvents and industrial gases (EC-JRC, 2006).

Table 13.9 Emerging skills and knowledge needs: Production workers 2009-2020

		Green and Global	Green and Focus Europe	European Retreat	Global pressure
Knowledge	Legislative / regulatory knowledge (environmental; safety; responsible care)				
	e-skills				
	Technical knowledge				
	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	Strategic & visionary				
	Coaching & team building				
	Collegial management style				
	Change management				
	Project management				
	Process optimizing				
	Quality management				
Total Emerging skills and knowledge needs		Count 13	Count 13	Count 7	Count 7

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 Plant and machinery repair and maintenance workers

Increasing automation means that repair and maintenance will become even more important in the future, with speed and safety being key issues. In contrast to high skilled jobs that require largely a diverse set of soft skills, the key needs of workers relate to technical knowledge they require to perform the tasks of their work. For repair and maintenance of production plants and machinery metal and related crafts knowledge is required. For this job function it is therefore of prime concern to keep technical knowledge up-to-date.

- Technical knowledge – new materials / production machinery requiring technical training
- Repair works increasingly comprise exchanging parts of highly technical systems which are repaired elsewhere. These are mostly electronics based requiring specific technical knowledge.
- Environmental, health and safety regulation relevant for work (training needs dependent on new regulation)
- E-skills.

Maintenance and repair works in the industry are often carried out by smaller chemical service firms. Works on large production plants are done in short periods of time as closing down and firing up of production is very costly. This requires works to be carried out quickly but at the same time ensuring high levels of safety. This type of work therefore also requires increasingly social skills related to team work and communication skills.

Differences between sectors

The bulk chemicals sub-sector has been most affected by job losses over the last decade which is likely to continue with leading economies turning to high-value added production of fine chemicals. While productivity increases in fine chemicals production will also demand relatively fewer workers in manufacturing operations, the increasing demand for fine chemicals is likely to compensate for productivity increases with stable or increasing demand for employment.

Differences between scenarios

The differences between scenarios relate to the shifts of employment between the sub-sectors. In scenario 1 the switch from bulk to fine chemicals is expected to happen much quicker than in scenario 2. This has implications for the skill demand and how quickly this demand can be met.

Table 13.10 Emerging skills and knowledge needs: Plant and machinery repair and maintenance 2009-2020

		Green and Global	Green and Focus Europe	European Retreat	Global pressure
Knowledge	Legislative / regulatory knowledge (environmental; safety)				
	e-skills				
	Technical knowledge				
	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	Strategic & visionary				
	Coaching & team building				
	Collegial management style				
	Change management				
	Project management				
	Process optimizing				
	Quality management				
Total Emerging skills and knowledge needs		Count 7	Count 7	Count 6	Count 6

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 Labourers

Low educated workers still make up a considerable part of the workforce in the sector; they have been, however, the biggest loser in terms of employment in the recent past. Part of this job function category is expected to disappear over time, with all purpose production units and automation taking over and replacing most labour. The category comprises low educated workers in production (manufacturing labourers) and other low educated work functions that are required throughout a firm such as cleaning and low-skilled maintenance work.

Manufacturing labourers: In the mid-term manufacturing labourers without technical qualifications need to be up-skilled to be able to participate in the workforce in the long run. The work that is done now by manufacturing labourers is likely to be replaced by machines.

However, availability of labourers varies between countries. In countries such as France initiatives between the social partners aim at retraining labourers from the sector to work in other sectors where they are needed.

Other low educated workers, including cleaning and maintenance personnel. These job functions are increasingly done by third party service providers and therefore shift to the service sector.

Table 13.11 Emerging skills and knowledge needs: Labourers 2009-2020

		Green and Global	Green and Focus Europe	European Retreat	Global pressure
Knowledge	Legislative / regulatory knowledge (environmental; safety)				
	e-skills				
	Technical knowledge				
	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	Strategic & visionary				
	Coaching & team building				
	Collegial management style				
	Change management				
	Project management				
	Process optimizing				
	Quality management				
Total Emerging skills and knowledge needs		Count 7	Count 7	Count 7	Count 7

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[15] 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 chemicals 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

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

appropriate levels with each actor having a different responsibility and a different role to play.

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 general and 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).

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 <u>at what level</u> and <u>to whom</u> 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 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 choices

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 and knowledge 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 skills and knowledge, there is probably no need to apply many strategic options. Please focus on the options that are most effective.
>
> If many skills and knowledge categories are changing, there is probably a need to apply many strategic options. Create a package of strategic options to meet skill needs. *[Note: see Table 13.2 and following for the number of competences changing per job function per scenario.]*

Question 3. Do SMEs 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 3.7 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 3.8 to 3.11, 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)? *[Note: see section 3.3, for age structure.]*

> 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 difficult 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 Green and Global scenario has 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 the viable strategic options for emergent skills and knowledge needs of managers. Both in the Green and Global and the Green and Focus Europe scenario recruitment of workers from other sectors, other Member or non-Member States are viable strategic options, albeit that from other sectors only generic skills can be recruited (social skills, self management, E-skills and general management skills such as vision and coaching). Sector specific skills (legislation, business development and understanding client and supplier) are much harder to recruit from other sectors. Recruiting these from other states (Member or non-Member) is a viable option though mostly for larger firms. Generally, more needs to be done to attract management potential to the sector.

In formulating a recruitment strategy that is aimed at pulling in workers from other sectors firms should broaden their recruitment horizon and also aim at for instance female management potential. The chemicals sector is still a 'white males' sector. This characterization does not appeal to the female workforce that offers management, sales and marketing potential. Recruitment of young people is a viable option, but well developed traineeships or apprenticeships are necessary and the sector could specifically target female candidates.

New recruits need to be trained or would need to build experience in order to gain sector specific skills, such as a more profound understanding of consumer and supplier needs as well as business developing skills in addition to managing and process optimizing skills. The latter is slightly more important in the Green and Global scenario than in the regionalization scenario, since more professionals are needed.

Table 14.1 Strategic options Managers

1. What is the maximum expected volume effect?	Maintain (bulk)/ Increase (fine)
2. What is the maximum expected change in skills?	20
3. Do SME's play a large role?	No
4. Is the sector national/EU/global?	Global
5. Is the workforce old?	Yes (in EU-15); younger in EU-12
6. Is the workforce low educated?	No

Option	Is this option viable?	Actors[1]
A. Recruiting workers from other sectors	Yes, mainly for generic management skills	C, S, I
B. Recruiting workers from other Member States	Yes, mainly in Green and Global, difficult for SME's and often language barrier	C, E, G, I
C. Recruiting workers from Non-Member States	Yes, mainly large companies, less viable for SME's	C, E, G, I
D. Recruiting unemployed with or without re-training	Only in rare cases	C, I
E. Recruiting young people from the education system	Yes, mainly through apprenticeships, sector ambassadors in schools, use "sustainability" image	C, S, E
F. Training and re-training employed workers	Yes, in-house promotion and further training in the firm	C, S, E
G. Changing work organisation	Yes, team work, flexible working time arrangements (mergers, acquisitions in Green and Global scenario).	C
H. Outsourcing and offshoring	Yes, but only for large companies and only in Green and Global scenario.	C
I. Changing vocational education	No	-
J. Designing and offering new courses	Yes, mainly aimed at planning, stress and time management, business development and E-skills	C, S, E
K. Providing information about emerging skills	Not necessary	
L. Improve the image of the sector	Yes, especially sustainability image in recruiting young workers and diverse target groups (female, ethnic minorities)	C, S
M. Stronger cooperation between stakeholders	Not necessary	

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

14.5 IT Professionals

Table 14.2 shows the strategic options for emergent skills and knowledge needs of IT professionals. Since some generic IT skills are needed, recruitment form other sectors is considered a viable option. This goes mainly for skills surrounding IT systems integration and IT support, maintenance and service. As a possible alternative these generic tasks can also be outsourced.

For the modelling and simulation of chemical processes and production processes and other more sector specific IT solutions, recruitment is a viable and necessary option, although in both the Green and Global and the Green and Focus Europe scenario, the number of IT professionals is expected not to increase. Recruitment from other sectors maybe less of an option for these specific skills. Recruitment in Member and non-Member States is, however, all the more viable since some of the emerging skills and knwoledge needs may be readily available in countries such as the US, Australia, China, Japan, Pakistan, Brazil or India.

Next to recruitment and outsourcing, training is another viable option. Training programmes should mainly be aimed at the users of modeling and simulation software as the largest benefits for firms are expected here. All strategic options appear more viable for large companies, especially the recruitment from abroad requiring considerable upfront investments.

Table 14.2 Strategic options IT professionals

1. What is the maximum volume effect?	Maintain (both Bulk and Fine)
2. What is the maximum change in skills?	12
3. Do SME's play a large role?	No
4. Is the sector national/EU/global?	Global
5. Is the workforce old?	Yes
6. Is the workforce low educated?	No

Option	**Is this option viable?**	**Actors**[1]
A. Recruiting workers from other sectors	Yes (banking sector, sales and marketing managers from other industry sectors)	C, S, I
B. Recruiting workers from other Member States	Yes, mainly in Green and Global and for large companies, difficult for SME's. Language barrier is less of a problem, but needs attention (safety)	C, S, E, G, I
C. Recruiting workers from Non-Member States	Yes, IT skills available in countries such as China, Japan, India etc. Mainly for large companies. Language barrier less of a problem, but needs attention (safety).	C, S, E, G, I
D. Recruiting unemployed with or without re-training	Yes, but only with retraining. Operating systems and programming languages change fast.	C, E, I
E. Recruiting young people from the education system	Yes, IT skills (knowledge) readily available. Competition is fierce, however.	C, E
F. Training and re-training employed workers	Yes, but maybe difficult for older workers (lacking IT based education/ affinity). Viable for project management skills, stress and time management skills)	C, S, E, U
G. Changing work organisation	Yes, team work, job enlargement and enrichment	C, I
H. Outsourcing and offshoring	Yes, in house IT support can be outsourced	C
I. Changing vocational education	Yes, integrating IT skills and chemical knowledge	C, S, E, U, G
J. Designing and offering new courses	Yes, mainly aimed at specific IT solutions to the sector (modelling/ simulation of processes). Integrating IT skills and chemical knowledge	C, S, E
K. Providing information about emerging skills	Not necessary	
L. Improve the image of the sector	Yes, especially sustainability image in recruiting young workers and diverse target groups (female, ethnic minorities)	C, S, U, E, G, I
M. Stronger cooperation between stakeholders	Not necessary	

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

14.6 Engineers – production and R&D

Table 14.3 presents the strategic options to address emergent skills and knowledge needs of engineers. Engineers are the most important job category for growth. That is one reason why all strategic options mentioned in the table are considered more or less viable. For this job function recruiting workers from other sectors is an option, albeit that recruitment options are limited to chemicals related sectors. Skills required from engineers are mainly sector specific. However, since innovation will be organized around interdisciplinary expert teams on a project basis, strong project management skills will also be required from future engineers. They would need technical as well as social, language, intercultural and communication skills. These soft skills can be recruited from other sectors although the preferred option. The first option would be to build on the technical skills that engineers already have, and train engineers to improve their communication, multilingual and intercultural skills. With the need for engineers being higher in the Green and Global scenario creative recruitment strategies need to be especially developed under this scenario.

Recruitment from other states, especially Member States, is an option, although recruiting from non-Member States is more costly and difficult with higher cultural and language barriers. Generally, engineers are recruited locally but often sent abroad when promoted during their career. These options are very much restricted to larger firms that have the capacities to manage and finance recruitment from abroad. Recruiting unemployed engineers is not considered a viable option, normally lacking the required mobility and social skills required.

Recruitment of young people through well developed technical traineeships (or courses) is the most preferred option in the sector as it allows training and forming graduates to the needs of the firm. However, at the same time this is a long term option that cannot cover short term demands for engineers. One special case combines recruiting young graduates from abroad that are attracted to Europe through high quality university education. This should be actively promoted and exploited by European firms. Interdisciplinary learning and understanding of clients and suppliers should receive attention. These training packages should also be made available (tailored) for older workers to retrain them.

While options G and H affect workers these are used by firms on a continuous basis to reduce costs and are not specifically carried out as a response to skill shortages or skill needs. However, the location decision of plants (offshoring) is also affected by the skills availability locally.

Table 14.3 Strategic options Engineers (production and R&D)

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SME's play a large role? 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Increase (Bulk and Fine) 20 No Global/EU Yes No	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, but limited to organisational, social and E-skills (modelling software). Not viable for most technical skills.	C, S
B. Recruiting workers from other Member States	Yes, but mainly in Green and Global, difficult for SME's and often language barrier	C, S, E, I
C. Recruiting workers from Non-Member States	Yes, but only for large companies, not for SME's, language barriers	C, S, E, I
D. Recruiting unemployed with or without re-training	Yes, but training always necessary, especially for technical skills needed.	C, I
E. Recruiting young people from the education system	Yes, aim at technical skills combined with language, intercultural and entrepreneurial skills.	C
F. Training and re-training employees	Yes, interdisciplinary courses, language/ intercultural skills and understanding customer supplier; health and safety skills	C, E, U
G. Changing work organisation	No	
H. Outsourcing and offshoring	No	
I. Changing vocational education	Yes, for technical specialist, focus on good basis chemical education, but also address future technologies (nanotech/ biotech). Including language, intercultural and entrepreneurial skills. Interdisciplinary studies.	C, S, E
J. Designing and offering new courses	Yes, especially for technical specialists, custom-fit courses (interdisciplinary courses). New technical knowledge bio based chemistry, risk assessment, modelling and simulation. Toxicology and risk assessment	C, S, E, U
K. Providing information about emerging skills	Yes	C, S, E, G, U
L. Improve the image of the sector	Yes, especially sustainability image in recruiting young workers and diverse target groups (female, ethnic minorities)	C, S, I
M. Stronger cooperation between stakeholders	Yes	C, S, E, S, U, G

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

14.7 Supply Chain Management

Supply chain management is a new function. Recruitment in other states is a viable option, although availability of people with the right degree is probably low, since university courses are relatively new.

Table 14.4 Strategic options Supply Chain Management

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SME's play a large role? 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Increase (both Bulk and Fine) 8 No Global Yes No	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, generic skills needed in SCM (finance), especially in Green and Global scenario.	C
B. Recruiting workers from other Member States	Yes, mainly in Green and Global, difficult for SME's.	C, S, E, I
C. Recruiting workers from Non-Member States	Yes, but difficult for SME's due to costs and organizational capacity as well as language barrier.	C, S, E, I
D. Recruiting unemployed with or without re-training	In rare cases.	C
E. Recruiting young people from the education system	Yes, but graduates with SCM degrees and skills scarce with further training needed.	C, E
F. Training and re-training employed workers	Yes, management, accounting and finance or IT professionals (volume effect for these is not increasing). Difficult for SMEs.	C, E, U
G. Changing work organisation	No	
H. Outsourcing and offshoring	Yes, but only partly (legal issues/ financial and tax issues)	C
I. Changing vocational education	Yes, internationally recognised degrees in Supply Chain Management.	S, E, U, G
J. Designing and offering new courses	Yes, develop SCM or business management courses on the job	C, S, E
K. Providing information about emerging skills	Yes	C, S, U, E, G
L. Improve the image of the sector	Yes, use sustainability image in recruiting young workers and diverse target groups (female, ethnic minorities)	C, S, I
M. Stronger cooperation between stakeholders	Yes	C, S, U, E, G,

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

For that reason recruiting unemployed workers is also not really an option. For the legal, tax and financial knowledge needed, companies can opt for recruiting in other sectors, with additional sector related training. It is suggested developing a business management course for people on the job. In order to attract the scarce people with SCM-degrees, improving the sector image among students is a good option to pursue.

14.8 Accounting & Finance

For accounting & finance emergent skills, such as legislative and regulatory knowledge of an international nature, and e-skills are of generic nature and can be recruited from other sectors, in other countries and among young people. Although the need for accounting and finance professionals is expected to be stable in both the Green and Global and the Green and Focus Europe scenario, replacing employees that leave the labour market is necessary and recruiting these skills from other sectors is a viable option. Recruiting accounting and finance skills from other states within or outside the EU can pose difficulties, since regulatory and legislative knowledge are often country-specific. Recruiting these skills from other Member States is a viable option for operations in the home state of recruits. Recruiting skills for other countries or markets than the home market of the recruit would be a less viable option. To make recruitment activities in other states more viable training programmes can be developed that provide recruits with an international set of skills and knowledge of international laws and rules. The EU could help in standardizing international rules and laws, potentially improving labour mobility.

14.9 Sales & Marketing

In Table 14.6 feasible strategic options for the sales & marketing functions are presented.

Both in the Green and Global and the Green and Focus Europe scenario recruitment of workers from other sectors is a viable strategic option. The focus is on generic skills, such as the ability to spot trends and market opportunities arising, but also on language and intercultural skills. They do need to be developed on the job however, since these entrepreneurial skills are not easily taught. New recruits will need to be trained on the job in order to gain a more profound understanding of consumer and supplier needs. The latter is slightly more important in the Green and Global scenario than in the regionalization scenario, since more professionals are needed in the first scenario.

In formulating a recruitment strategy that is aimed at pulling in workers from other sectors or countries, as well as for pulling in young people, firms should broaden their recruitment horizon and also aim at for instance female workers. The chemicals sector is still a ‘white males’ sector. A characterization that does not appeal to the female workforce that offers sales and marketing potential. Positive action is required also in recruiting workers from other sectors. Training courses need to be developed for sales & marketing functions in order to provide workers with up to date product knowledge. A focus in these courses would be on technical product specifications and translating these for clients in different markets and countries.

Recruiting young people is a further viable option especially related to up-to-date E-skills. Young people are used to work with IT and will be able to learn these skills more quickly than older workers. Also, young people often possess more intercultural and language skills as they grew up in a more mixed society/ school environment.

Finally, with marketing potentially declining in the pharmaceuticals sector after several year's of expansion these specialists could be hired by other chemical sub-sectors.

Table 14.5 Strategic options Accounting & Finance

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SME's play a large role? 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Maintain (Bulk and Fine) 11 No Global Yes Some	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, mainly generic skills involved (business, finance, law)	C
B. Recruiting workers from other Member States	Yes, but absolutely necessary if expanding business in specific Member States (knowledge of local laws)	C, S, E, I
C. Recruiting workers from Non-Member States	Not necessary, but a viable option	C
D. Recruiting unemployed with or without re-training	Yes, little training may be necessary	C, S, E
E. Recruiting young people from the education system	Yes, E-skills and up to date legislative and regulatory knowledge needed.	C, S
F. Training and re-training employed workers	Yes, when expanding local regulations. May be difficult for older workers	C, E, U
G. Changing work organisation	Yes (job rotation	C
H. Outsourcing and offshoring	Yes, bookkeeping can be outsourced	C
I. Changing vocational education	No	C, S, U, E
J. Designing and offering new courses	Yes, mainly in Green and Global scenario aim at international legislative knowledge/ E-skills in using new programmes	C, E, S
K. Providing information about emerging skills	Yes	C, S, U, I
L. Improve the image of the sector	Yes, especially sustainability image in recruiting young workers and diverse target groups (female, ethnic monirities)	C, I, G
M. Stronger cooperation between stakeholders	Yes	C, S, U, E, I, G

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

Table 14.6 Strategic options Sales & Marketing

1. What is the maximum volume effect?	Maintain in Bulk Chemicals, Decrease in Pharmaceuticals, Increase in Fine Chemicals	
2. What is the maximum change in skills?	20	
3. Do SME's play a large role?	No	
4. Is the sector national/EU/global?	Global	
5. Is the workforce old?	Yes	
6. Is the workforce low educated?	No	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, but limited, since product knowledge is very important for this job function.	C
B. Recruiting workers from other Member States	Yes, but limited since country specific knowledge is necessary in marketing. Absolutely necessary strategy however if expanding business in specific Member States	C, S, E, I
C. Recruiting workers from Non-Member States	Yes, see above	C, S, E, I
D. Recruiting unemployed with or without re-training	Yes, but limited availability	C
E. Recruiting young people from the education system	Yes	C, E
F. Training and re-training employed workers	Yes, E skills need updating (electronic sales portals) as well as international differences in market rules and regulations.	C, E, S, U
G. Changing work organisation	Yes, but mainly on order to stimulate learning on the job and knowledge transfer	C, I
H. Outsourcing and offshoring	Yes, outsourcing market research/ B2B via electronic portals	C
I. Changing vocational education	No	
J. Designing and offering new courses	Yes, mainly sector specific modules in product knowledge (technical understanding), E-skills and laws and regulations in emerging markets	C, E, S
K. Providing information about emerging skills	Yes	C, S, U, I
L. Improve the image of the sector	Yes, especially sustainability image in recruiting young workers and diverse target groups (female, ethnic minorities)	
M. Stronger cooperation between stakeholders	Yes	C, S, U, E, G, I

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

14.10 Support staff

Table 14.7 presents the strategic options to address emergent skills and knowledge needs related to support staff. With a generic skills set needed for this function (administrative, basic internet, spreadsheet, word processing) these are readily available in other sectors. Recruiting here is therefore a preferred option. Recruiting in other states within or outside the EU is a potential option but higher hiring costs pose a barrier just like language and cultural barriers.

In the Green and Global scenario skills related to supporting internationally operating teams will become increasingly important. Support staff ready to perform these tasks can be recruited in other internationally operating sectors. Next to language and intercultural skills, some basic technical understanding might be required depending on the specific job profile. The sector could work with educational institutions and sector organisations to develop a basic technical training for support staff. Finally recruiting unemployed people is a viable option for the sector, since generic skills are needed, and at least some of the current unemployed will have an administrative background. This will have to be combined with additional training.

14.11 Production workers

For production workers technical knowledge is key next to social skills that become increasingly important. Table 14.8 presents the related strategic options. Recruiting technical knowledge in other sectors is difficult making hiring from other sectors a low priority. Similarly, recruiting from other states is also a less viable option due to hiring costs and differences in HSE regulation. The EU could facilitate inter-sector and international labour mobility, however, by standardising safety standards together with the industry, the UK 'gold standard' as developed by the UK sector skills councils being one example.

Furthermore, with the sector being a process industry, training is best done on the job or very close to job requirements for best effects (dual system). The importance of firms in the design of training courses and training of the workforce also in regards to continuous training is crucial and requires more efforts from industry.

Table 14.7 Strategic options Support staff

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SME's play a large role? 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Maintain 9 No Global Yes Mainly	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, e-skills to function effectively. Aim at technical sectors, since a basic technical understanding is useful	C
B. Recruiting workers from other Member States	Limited, but option if expanding business in specific Member States Aim also at e-skills and communication skills	C, S, E, I
C. Recruiting workers from Non-Member States	Yes, especially for low skilled labour, difficult for SME's	C, S, E, I
D. Recruiting unemployed with or without re-training	Yes, if necessary train in basic technical and e-skills	C
E. Recruiting young people from the education system	Yes, E-skills, language and intercultural skills readily available	C, E
F. Training and re-training employed workers	Yes, train planning, team working and communication skills, as well as e-skills (basic internet/ spreadsheet and word processing)	C, E, U
G. Changing work organisation	Yes (team work, job enlargement and enrichment)	C, I
H. Outsourcing and offshoring	Yes, mainly outsourcing	C
I. Changing vocational education	Not necessary	
J. Designing and offering new courses	Not necessary	
K. Providing information about emerging skills	Not necessary	
L. Improve the image of the sector	Not necessary	
M. Stronger cooperation between stakeholders	Shared Services	C, S, U, I
Notes: 1. C (company), S (sector organisations and chambers of commerce), U (trade unions), E (education & training), G (governments), I (intermediary organisation, public or private).		

Table 14.8 Strategic options Production workers

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SME's play a large role? 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Maintain/ Decrease in Fine, Decrease in Bulk 11 No Global Yes Yes	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Less, only for generic skills, e.g. teamwork/ communication.	C
B. Recruiting workers from other Member States	Less, due to high hiring costs and language barriers	C, S, E, I
C. Recruiting workers from Non-Member States	Less, due to high hiring costs and language barriers, especially difficult for SME's	C, S, E, I
D. Recruiting unemployed with or without re-training	Yes, with relevant vocational training prerequisite , sector specific knowledge as well as HSE regulations and ICT need to be trained.	C
E. Recruiting young people from the education system	Yes	C, E
F. Training and re-training employed workers	Yes, most preferred option. Focus on new machinery, production processes and new HSE regulations	C, E, U
G. Changing work organisation	Yes, intertwined with new technologies in production processes	C, I
H. Outsourcing and offshoring	Yes, offshoring (processes and production) as well as outsourcing (maintenance and repair)	C
I. Changing vocational education	Yes; related to production (processes) based on new technologies (renewables).	C, S, U, G
J. Designing and offering new courses	Yes; related to production (processes) based on new technologies (renewables).	C, S
K. Providing information about emerging skills	Yes	C, S, U, I
L. Improve the image of the sector	Yes, especially to young people to improve quality of recruitment pool.	C, S
M. Stronger cooperation between stakeholders	Yes	C, S, U, E, G, I

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

14.12 Plant and machinery repair and maintenance workers

Table 14.9 presents strategic options for emergent skills and knowledge needs related to plant and machinery repair and maintenance. While the technical skills required for plant and machinery repair and maintenance differs compared to production workers, the strategic options are more or less identical. Repair and maintenance is mostly related to metal working skills for production plants and repairing machines requiring a combination of mechanic- and electro-technical knowledge.

Consequently, recruiting technical knowledge in other sectors is more viable than for production workers with metal and repair skills available in other sectors. But, recruiting from other states is also a less viable option due to hiring costs and differences in HSE regulation. The EU could facilitate intersectoral and international labour mobility, however, by standardising safety standards together with the industry.

With technical knowledge of key importance on the job, training courses preparing workers for repairing new machinery and using new materials and techniques are needed to keep technical skills up-to-date. With differences in learning these should be adapted for younger and older workers. Recruiting young people through vocational training systems is an important strategic option. However, the sector needs to stimulate the interest in schools in technical and science related subjects for people to bring with them the necessary technical understanding for working in the chemicals sector.

14.13 Labourers

Lastly, Table 14.10 presents the strategic options for labourers. With this job function in strong decline and expected to further decline in the future, no emergent skills and knowledge needs were assessed. Instead current labourers need to be up-skilled/ (re)trained to the level of production and repair and maintenance workers, or maybe even engineers.

Labourers outside production are likely to be replaced by technology (security / receptionists) or outsourced to the service sector (cleaning / maintenance).

Table 14.9 Strategic options Plant and machinery repair and maintenance workers

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SME's play a large role? 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Maintain in Fine, Decrease in Bulk 9 No Global Yes Yes	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	Yes, other metal and machinery repair sectors.	C
B. Recruiting workers from other Member States	Less, due to high hiring costs and language barriers	C, S, E, I
C. Recruiting workers from Non-Member States	Less, due to high hiring costs and language barriers, especially difficult for SME's	C, S, E, I
D. Recruiting unemployed with or without re-training	Yes, with relevant vocational training prerequisite, sector specific knowledge as well as HSE regulations need to be trained.	C
E. Recruiting young people from the education system	Yes	C, E
F. Training and re-training employed workers	Yes, main focus on technical knowledge of new materials and products and safety regulations.	C, E, U
G. Changing work organisation	Yes, (team work, job enlargement and enrichment)	C, I
H. Outsourcing and offshoring	Yes, outsourcing of repair and maintenance to specialist firms.	C
I. Changing vocational education	Yes, renew technical knowledge in training (new materials)	C, S, u, E
J. Designing and offering new courses	Yes, on new materials, new regulations	C, S, E
K. Providing information about emerging skills	Yes	C, S, I
L. Improve the image of the sector	Yes, especially to attract young people.	C, S
M. Stronger cooperation between stakeholders	Yes	C, S, U, E, G, I

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

Table 14.10 Strategic options Labourers

1. What is the maximum volume effect? 2. What is the maximum change in skills? 3. Do SME's play a large role? 4. Is the sector national/EU/global? 5. Is the workforce old? 6. Is the workforce low educated?	Decreasing in Bulk and Fine 5 No Global Yes Yes	
Option	**Is this option viable?**	**Actors[1]**
A. Recruiting workers from other sectors	-	
B. Recruiting workers from other Member States	-	
C. Recruiting workers from Non-Member States	-	
D. Recruiting unemployed with or without re-training	-	
E. Recruiting young people from the education system	-	
F. Training and re-training employed workers	Yes, manufacturing labourers need up-skilling in technical qualifications, other labourers less; in some countries labourers are retrained to work in other sectors.	C, E, U
G. Changing work organisation	Yes, automation of production processes	C, I
H. Outsourcing and offshoring	Yes, outsourcing for cleaning etc., offshoring for manufacturing	C
I. Changing vocational education	Yes, need up-skilling to production worker level.	C, S, U
J. Designing and offering new courses	Yes, need up-skilling to production worker level.	S
K. Providing information about emerging skills	-	
L. Improve the image of the sector	-	
M. Stronger cooperation between stakeholders	-	

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

14.14 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 at the individual job function level. This section serves to summarise the main implications and solutions for each of the job functions presented in chapters 12, 13 and 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.

Table 14.11 Summary of job volumes, skills changes, strategic choices and main players in anticipatory action by scenario					
		Green and Global	**Green and Focus Europe**	**European Retreat**	**Global Pressure**
Managers	1. Employment volume change	M/D	M/D	M/D	M/D
	2. Skills changes counted	Count 20	Count 17	Count 11	Count 11
	3. Emerging skills needs	Management, Entrepreneurship, Self-management, Social skills, Knowledge	Management, Entrepreneurship, Self-management, Social skills, Knowledge	Management, Social skills, Self-management	Management, Social skills, Self-management
	4. Most important solutions	In-house development; recruiting from other sectors	In-house development; recruiting from other sectors	In-house development; recruiting from other sectors	In-house development; recruiting from other sectors
	5. Most important actors	C	C	C	C
IT professionals	1. Employment volume change	M	M	M	M
	2. Skills changes counted	Count 12	Count 12	Count 12	Count 12
	3. Emerging skills needs	Knowledge, Self-management	Knowledge, Self-management	Knowledge, Self-management	Knowledge, Self-management
	4. Most important solutions	Recruit, (Re-)train,	Recruit, (Re-)train,	Recruit, (Re-)train,	Recruit, (Re-)train,
	5. Most important actors	C, E	C, E	C, E	C, E
Engineers (Production & R&D)	1. Employment volume change	I	I	I/M	I/M
	2. Skills changes counted	Count 21 (22)	Count 22 (23)	Count 16 (16)	Count 16 (16)
	3. Emerging skills needs	Knowledge, Problem Solving, Social Skills, Entrepreneurship	Knowledge, Problem Solving, Social Skills, Entrepreneurship	Self-management, Management, Social Skills	Self-management, Management, Social Skills
	4. Most important solutions	Recruit, (Re-)train,	Recruit, (Re-)train,	Recruit, (Re-)train,	Recruit, (Re-)train,
	5. Most important actors	E, C	E, C	C, E	C, E

		Green and Global	Green and Focus Europe	European Retreat	Global Pressure
Accounting & Finance	1. Employment volume change	M	M	M	M/D
	2. Skills changes counted	Count 11	Count 10	Count 8	Count 9
	3. Emerging skills needs	Knowledge, Self-management, Social	Knowledge, Self-management, Social	Knowledge, Self-management	Knowledge, Self-management
	4. Most important solutions	Recruiting, Training	Recruiting, Training	Recruiting	Recruiting
	5. Most important actors	S, E, C	S, E, C	S, E, C	S, E, C
Sales & marketing	1. Employment volume change	I/M	I/M	I/M	M
	2. Skills changes counted	Count 17	Count 17	Count 9	Count 9
	3. Emerging skills needs	Entrepreneurship, Knowledge, Self-management	Entrepreneurship, Knowledge, Self-management	Social skills, Self-management	Social skills, Self-management
	4. Most important solutions	(Re-)training	(Re-)training	(Re-)training	(Re-)training
	5. Most important actors	C	C	C	C
Supply chain management	1. Employment volume change	I	I	I/M	I/M
	2. Skills changes counted	Count 13	Count 13	Count 13	Count 13
	3. Emerging skills needs	Knowledge, Social Skills, Problem-Solving Skills	Knowledge, Social Skills, Problem-Solving Skills	Knowledge, Social Skills, Problem-Solving Skills	Knowledge, Social Skills, Problem-Solving Skills
	4. Most important solutions	Recruiting, Training, Information, Image	Recruiting, Training, Information, Image	Recruiting, Training, Information, Image	Recruiting, Training, Information, Image
	5. Most important actors	C, S, E	C, S, E	C, S, E	C, S, E

		Green and Global	Green and Focus Europe	European Retreat	Global Pressure
Support staff	1. Employment volume change	M	M	M/D	M/D
	2. Skills changes counted	Count 9	Count 9	Count 6	Count 6
	3. Emerging skills needs	Knowledge, Social, Self-management	Knowledge, Social, Self-management	Knowledge, Self-management	Knowledge, Self-management
	4. Most important solutions	(Re)train, Recruit	(Re)train, Recruit	(Re)train, Recruit	(Re)train, Recruit
	5. Most important actors	E, C	E, C	E, C	E, C
Production workers	1. Employment volume change	M/D	M/D	D	D
	2. Skills changes counted	Count 13	Count 13	Count 7	Count 7
	3. Emerging skills needs	Knowledge, Social skills, Problem-solving, Management	Knowledge, Social skills, Problem-solving, Management	Social Skills, Management	Social Skills, Management
	4. Most important solutions	(Re)training	(Re)training	Retrain (to make fit for other sectors)	Retrain (to make fit for other sectors)
	5. Most important actors	S, E, C	S, E, C	S, C	S, C
Plant &machinery maintenance / repair	1. Employment volume change	M/D	M/D	D	D
	2. Skills changes counted	Count 7	Count 7	Count 6	Count 6
	3. Emerging skills needs	Knowledge, Social skills, Self-management	Knowledge, Social skills, Self-management	Social skills, Self-management	Social skills, Self-management
	4. Most important solutions	Recruiting workers from other sectors	Recruiting workers from other sectors	Retrain (to make fit for other sectors)	Retrain (to make fit for other sectors)
	5. Most important actors	S, E, C	S, E, C	S, C	S, C

		Green and Global	Green and Focus Europe	European Retreat	Global Pressure
Labourers	1. Employment volume change	D	D	D	D
	2. Skills changes counted	Count 7	Count 7	Count 7	Count 7
	3. Emerging skills needs	Knowledge, social skills, Self-management	Knowledge, social skills, Self-management	Social skills, Self-management	Social skills, Self-management
	4. Most important solutions	Up-skill, Retrain	Up-skill, Retrain	Up-skill, Retrain (to make fit for other sectors)	Up-skill, Retrain (to make fit for other sectors)
	5. Most important actors	E, C	E, C	E	E

C=Companies; S=Sectoral organisations, U=trade Unions; E=Education and training institutes; G=Government (EU, Member State, regional, local)

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.

Both vocational education and training (VET) systems and the general education systems (primary, secondary and tertiary education) differ considerably between Member States, in terms general set-up, organisation and implementation (see Box 6). While a discussion about which are the most adequate models and/or best practices is useful, the current variety in VET and general education systems in Europe makes it very difficult to come up with specific conclusions or recommendations about education needs and requirements for the chemicals sector from an EU-wide perspective. Most conclusions and recommendations should be based on the particularities of the existing education systems in the Member States, or even regions. This obviously is beyond the scope of this study. Some general observations can, however, be made. As a general trend most Member States at all levels of education tend to focus more than in the past on 'teaching' soft skills, by integrating soft-skills related lessons in existing curricula. One also observes a counterdevelopment in that in some Member States there is again a call for conventional knowledge and the teaching of 'harder' skills, as the attention for soft skills would go at their expense. This holds both for secondary education (relating to essential knowledge of foreign languages, mathematics, physics and chemistry) as well as university education (too broad curricula).

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

The different VET systems in Europe all have their own merits. It would make no sense to try to standardise VET throughout Europe. Especially in the new Member States, more focus and assistance is required to further fine-tune the existing VET systems to new and emerging needs (see further below).

Social mobility in many European countries is low. The VET system plays a key role for people to move up the social ladder. It is especially important to exploit the potential of 'late developers' that in the first instance did not reach tertiary education. VET systems should be enhanced to facilitate the option for people to continuously up-skill – also in light of life-long learning (LLL).

2) In-company training and lifelong learning are vital and require more attention and funding

In addition to initial and continuing vocational education and training, for many job functions (including the highest qualifications), additional in-company training and lifelong learning are essential. Both appear to be more difficult for SMEs because of problems of within-company staff continuity and financing.

3) Collaborate with all relevant stakeholders and intensify co-operation in education and training

Collaboration is needed on various aspects concerning the matching of future skills demand and supply and the development of sectoral learning strategies.

Close collaboration between all relevant stakeholders, including companies, education and training institutes, social partners, research institutes and public authorities, is needed to adapt to new realities and collaboration is an effective instrument to stimulate that changes are taken up and implemented. A stronger linkage between industry and education and training is recommended in state driven full-time school-based VET-systems (Koch and Reuling, 1998). In all countries, and in the new Member States in particular, co-operations are essential to improve the practical orientation in VET (Skjølstrup and Mayen, 2007).

The 'Sector skills councils'[16] in the United Kingdom and the 'FreQueNz' research network[17] are best practice examples. The 'Sector skill councils' in the 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, and further translated into sector skills agreements, Cogent's Gold Standard in the chemicals sector being a prime example. 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.

A specific issue of relevance to the chemicals sector applies to improving collaboration on VET issues in the new Member States. With certain chemicals firms having been taken over by foreign investors in the new Member States, the traditional cooperation between

[16] www.sscalliance.org
[17] www.frequenz.net

the social partners to work on VET issues is negatively affected. While the skilled labour pool in the past used to be large enough, the growth of the sector in the new Member States requires foreign firms together with domestic counterparts and other social partners to take a more active role in VET.

4) Support upgrading of education and training by providing benchmarks and best practice solutions

Further upgrading of existing education and training programmes and systems throughout Europe can supported by providing appropriate benchmarks and best practice solutions. These could include, by way of example, the following:

- Reform of the teaching programmes in chemistry, physics and biology, esp. at primary and secondary levels , e.g. the Netherlands
- Vocational training, e.g. German or British dual systems
- Tertiary level education and training, e.g. German Fachhochschule.

5) Improve information provision on skill needs and job requirements: essential for training and education as well as for finding employment

The information gap between existing and future education and training needs as well as education and training supply is still obvious. A similar information mismatch is true for current and emergent skills and knowledge needs. 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. Training providers are often not meeting the training needs and do not respond on emergent training needs in a sufficient way (especially in vocational training). Consequently, a major implication for education and training is to establish and further improve information systems on current and emergent skills needs and job opportunities. Facilitating students by entering the labour market and finding a suitable occupation is just as much important as assisting employees to find new job opportunities based on their existing skills or guiding them in finding the fitting vocational training course. Information systems on the sectoral level as well as on the regional, the national and the European level assist in minimising information asymmetries in order to overcome skill gaps resulting from information deficits.

6) Provide better career guidance for those in search of a job

Regularly, persons equipped with required skills and qualifications are available, but do not apply for vacancies due to the lack of information of labour market possibilities. Systems for the recognition of prior learning (RPL) support the determination to what extent people possess necessary competences for a new job. The integration of RPL in career guidance and targeted training bridges the gap of hidden competences especially for mature workers. Some Member States included this 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). Career guidance can be supported by user friendly online-tools, also for self guidance. An extraordinary example in this respect is the Polish multi-dimensional career information system called ‘Counsellor 2000’ (ibidem, p. 44) in which information about educational and training pathways, and the relevant occupations they lead to, is linked to the personal profile of the client using an online system.

7) Increase transsectoral and transnational mobility and promote international and intersectoral acknowledgement of certificates

For some job functions between-sector and international mobility is an option to meet future skill needs. To increase international and sector mobility, improving the acknowledgement of certificates between countries is important. There is indeed a strong need for co-ordination to increase intra-European mobility. One idea could be to complement the existing European and National Qualification Frameworks with sectoral qualification frameworks validated and comparable across countries, leading to more transparency. Another ideas is to use Experience Certificates.

One of the issues in international acknowledgement of certificates is obviously the content of diplomas and degrees. As has been described in Box 6, VET systems differ greatly between European Member States. One of the more specific recommendations addressed in final workshop is that the European social dialogue should define commonly accepted standards recognized across countries regarding operators and lab assistants to increase intra-EU mobility of workers.

One possibility might be to further bring Vocational Qualifications into line in the EU, for instance by using Experience Certificates, so as to further enhance mobility and flexibility (see also the next point on modularisation). The chemicals industry is in need of various soft skills, such as communication skills, project management skills and e-skills. These are practically never in diplomas or regular education programmes but learned on the job. When recruiting workers from other countries or from other sectors it is practically impossible to find out whether one is skilled in these areas or not. A common certification system would simplify recruiting outside the national labour pool. Certificates would reduce related barriers to recruiting.

Improving the acknowledgement of certificates as well as improving certification itself also applies to in-company training, as several of existing training provisions are not certified or not acknowledged across sectors. This obviously prevents a greater mobility of the workforce and hinders the matching of skill demand and supply (lack of skills transparency). Educational and training institutes that are able to provide broadly accepted certificates could herewith increase their value added for students. Support from government is needed here to build effective international and intersectoral acknowledgement systems.

8) Enhance flexibility through modularisation of education and training

Strengthening the information basis on skill demands and supply of training as well as career possibilities are the basis for enhanced flexibility and adaptability of continuing vocational education and training. Flexibility is meant as the capability of the prevailing VET system to adapt effectively to new training needs in terms of quality and 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. Flexible forms of blended learning contribute to enhanced participation of, in particular, SME employees in continuing vocational training. Not only do SMEs often have difficulties in financing continuing VET, but they also often face difficulties in

finding suitable solutions to training leaves of their staff. More flexible blended forms of training open up important possibilities in this respect.

In principle, blended learning combines 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. This is not only a possibility to reduce costs of further training and enhance flexibility to combine work with training, but it also has positive effects on skills which will be needed in the future. Because large parts of this training are self-directed and informal, the learner has to build up several skills, like self reflection, self motivation, strength of purposes and an effective information processing.

9) Supply special courses dedicated to sector characteristics

For some job functions special courses are needed. It is necessary to have a balance between what is offered in the educational system and what is needed in the sector. For example one issue raised by the chemicals industry is that academia focuses on synthetic chemistry resulting in graduates very well prepared on synthesis but not on formulation chemistry. But in fact about 40% of EU chemical production involves formulation chemistry. In the chemicals sector there is a growing need for well educated supply chain managers (SCM), especially in the more positive scenarios and in both bulk and fine chemicals. While SCM-oriented university degrees internationally accepted already appear to exist, this may give room to modularised SCM-courses to satisfy demand.

Firms able to improve the skills of the workforce fast have a competitive advantage. Education and training institutions can exploit this situation to provide dedicated courses. With respect to this implication it is very important to have professional teachers. They have knowledge on the current state-of-the-art and developments in the Chemical sector and are able to transfer their enthusiasm to students. In the Netherlands there are plans to develop a 'Centre for skills and competence development in the chemical sector". This centre can also bridge the gap between theory and practice for the sector (Regiegroep Chemie, 2007).

Another instrument to bridge the gap between theory and practice is to incorporate researchers more in the primary process at firm level. This is done by stimulating mobility and introducing exchange programmes (Casimir regulation in the Netherlands, see Regiegroep Chemie [2007]).

10) Supply special courses for older workers

The workforce in several occupational functions is ageing. Education and training institutions should take this development into account for the design of training measures to develop specific courses. Older workers learn differently compared with younger workers. Older learners have in some cases more problems with theory-based, upfront teaching only focused on examinations. For older learners this kind of training is less effective, as it is not exploiting practical experience in the learning process.

11) Pay more attention to interdisciplinary and multidisciplinary skills / knowledge

Innovation is key for future competitiveness of the chemicals sector; innovation often call for interdisciplinary work involving chemistry, physics, biology, environmental studies as well as business and economics. Giving more attention to inter- and multidisciplinary aspects, and sensibly combine different technical and non-technical skills skills and knowledge matters. While sound chemical education forms a good basis, attention should also be given to other skills, such as project management, languages and business

development skills. Interdisciplinarity and multidisciplinarity can be taken on board in formal education, but can also be a part an apprenticeship or traineeship programme. Interdisciplinarity also applies to team work. For instance, with the chemicals sector being a highly regulated sector it is important to involve more scientists in the legislative / regulatory process. Similarly, integrating social scientists early on in the innovation process could enhance innovative performance. Last but not least: better understanding and ditto communication between natural scientists and society will be served by stronger interdisciplinary knowledge and skills.

12) Stimulate multi-skilling and strengthen intercultural and language skills

Multi-skilling – training employees to master different skills in order to fulfil a range of tasks – is becoming increasingly important. Multi-skilling 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 chemical 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) Improve the image of the sector – to the young and to society at large

The chemicals sector is still perceived by some as a dirty and declining industry in terms of employment instead as a modern sector which is key in searching for and providing sustainable solutions. There is need to better communicate and bring the message across

of being a motor ("enabler") for innovation with a great future that can help solve challenges such as climate change. Stakeholders should work together to convey this positive message, particularly to the young. Showing innovativeness is very important in bringing a better image across.

2) Bring 'chemicals' to school as early as possible

Research shows that interests and affinity for science is sparked at very early age. To interest future generations for the chemical sector they need to be fascinated early on in school. This can be achieved through integrating important and interesting subjects such as climate change, pollution by bringing together the different fields of physics, chemistry and biology. But not only primary schools should be involved but also vocational education and universities (workshops, apprenticeships etc.) including social sciences.

A practical example to interest the young for science is the project "Future Detectives" financed under the Sixth Framework Programme currently under execution. Similar projects are supported un the Seventh Framework Programme 'Science and Society'.

3) Invest strongly in human capital and lifelong learning

In order to meet the skills needs, enhanced investment in human capital is required. Cost sharing mechanisms between actors, such as public authorities, companies and individuals, need to be developed and lifelong learning throughout the lifecycle promoted: 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 need to be initiated, and a lifecycle approach to work implemented. In addition, the training and education systems in the Member States need to be improved, as stated in implications for education and training.

4) Attract top international talent through universities

European universities still enjoy an excellent reputation globally in chemicals attracting considerable international talent. This opportunity should be used to keep top talent in Europe in research and industry. Strict immigration regulation currently makes it difficult for the sector to keep the wanted talent. This requires more flexibility from national governments and cooperation between universities and the sector (firms).

5) Diversify personnel and take positive action

The EU chemicals industry of 2009 is very much a white male and ageing sector. It shows compared to other sectors a striking lack of diversity of its workforce. Female workers as well as ethnic minorities are still greatly underrepresented. A main recommendation therefore is to implement an active strategy of diversification of personnel in all job functions. This goal is to be met through a broadening of the chemical sectors' recruitment scope, in order to achieve that female workers as well as ethnic minorities and other groups of potential workers are better reached. Personnel diversification not only would make the sector more appealing to groups the sector now lacks. Personnel diversification would also enable companies to better develop business in new markets. Diversification can be stimulated by positive action towards underrepresented groups, such as female workers. This should go hand in hand with other Human Resource measures, such as more flexible working time arrangements.

6) Standardize basic health, environment and safety regulations

Environmental regulations differ in many European countries lowering the possibilities for job mobility (migration) and posing additional training costs for workers moving between countries. The EU could help cut costs and stimulate mobility by standardizing regulations.

7) Collaborate with all relevant stakeholders and intensify co-operation

A main general recommendation to better meet emergent skills needs is to intensify co-operation between all relevant stakeholders in the sector, and especially between industry, social partners, education and training institutes and policy-makers. The challenge to overcome sectoral skill gaps and shortages will only be met sufficiently if stakeholders act in close concert, with sufficient interaction also between the regional, national and the European level. Collaboration is needed not only on various aspects concerning the matching of future skills demand and supply and support in developing sectoral learning strategies but also in establishing partnerships for innovation, skills and jobs. Social dialogue at the sectoral level is one of the ways to make collaboration happen.

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 qualification levels in qualifications 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 also 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).