

Universitat Rovira i Virgili

INNOVATION POLICY OF EUROPEAN CHEMICAL COMPANIES

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CHAPTER 1. THE EUROPEAN CHEMICAL INDUSTRY

1.1 Introduction

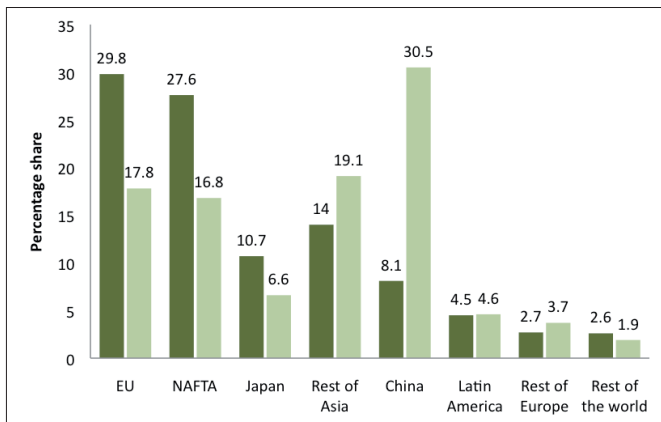
The European chemical industry is key to economic development and wealth. It creates modern products and materials, and provides virtually all sectors of the economy with technical solutions (Arora et al., 1998). The European chemical industry supplies virtually all sectors of the economy and accounts for 17.8% of the total sales of chemicals in the world (Cefic, 2014). It is one of the largest and most R&D-intensive manufacturing sectors in all the advanced economies, and its innovative patterns and productivity growth processes can have profound impacts on economic growth as a whole. In a recent study, Tullo (2013) shows that 19 of the top 50 global chemical companies are headquartered in Europe (Table 1) and they make 14.5% of all sales of chemicals in the world. The purpose of this book is to provide an overview of the status of the European chemical industry and the problems it currently faces. According to specialists, innovation and research are key to securing the future of the European chemical industry. Research and development is one way in which companies can ensure future growth by developing new products or processes to improve and expand their operations. The book discusses investment in research and development in the European chemical industry in general and also in the top fifteen European chemical companies in particular. In order to understand research strategy and trends in innovation, we analyze R&D investment, the patent landscape, university-industry collaboration and the regional distribution of chemical companies.

1.2 Background

Over the years, the European chemical industry has shown considerable resilience, strength and adaptability. In 2007, 12 of the 30 leading chemical

companies in the world were headquartered in Europe, representing 10 percent of the world's sales of chemicals while in 2012, 11 of the top 30 global chemical companies were from Europe (Cefic, 2013). Like virtually every other industry worldwide, the European chemical industry has felt the full force of the recent global recession. At its lowest point in March 2009, the industry saw a monthly year-on-year decline of 13.2 percent, a figure that if annualized would represent an output decline of approximately EUR 56 billion (Cefic, 2013). In Europe, the chemical industry saw massive reductions in demand for plastics, paint and man-made fibres, especially in key markets such as automotive and construction. This fall in demand led to severe destocking by many companies, some of which saw their own output decline by 30 to 60 percent. Many large companies are finding difficult and expensive to obtain credit. The European chemical industry is currently facing the unprecedented challenges of strong competition from emerging countries, notably Asia, the Middle East and Russia; and the decline in their share of world chemical sales from 29.8% in 2001 to 17.8% in 2012, which means a 34% decline over a period of 10 years (figure 1).

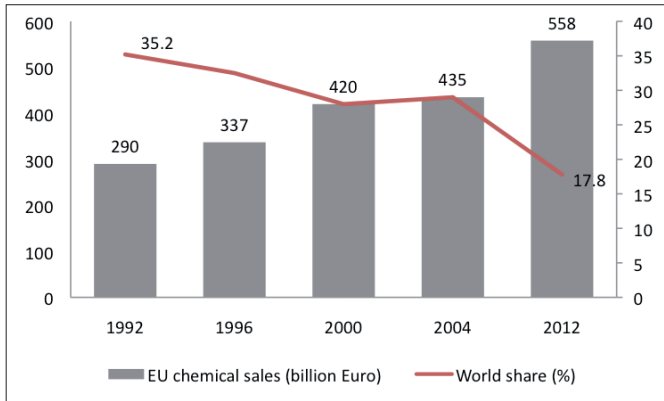
Figure 1. Contribution of each region to global chemical sales for the year 2001 and 2012



Source: Cefic (2014)

The graph below (figure 2) shows that even though EU sales of chemicals have increased over time, the world market share has decreased so the sales of other areas have increased at a much faster rate.

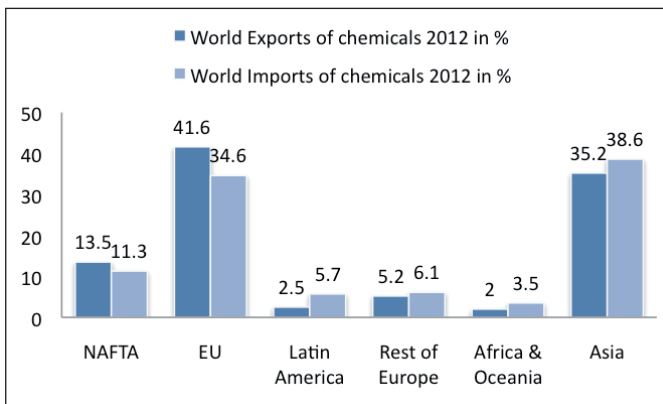
Figure 2. EU chemical sales over time and the declining percentage of total world shares



Data source: Cefic (2014)

Although Europe is losing its position in terms of global sales of chemicals, in terms of trade balance it is doing well: exports are 7% higher than imports. Although Asia is reducing the gap between exports and imports, it is still importing more than it is exporting (figure 3).

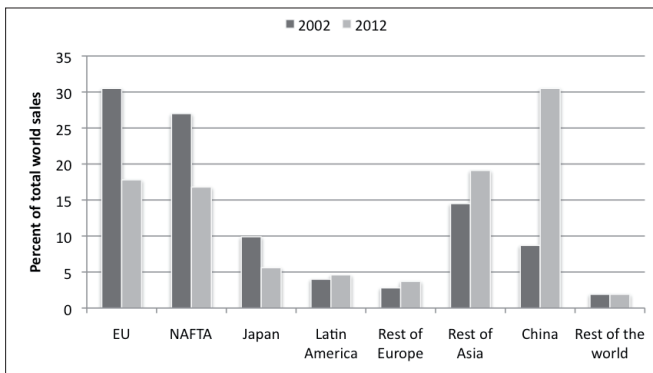
Figure 3. The export and import of chemical products for different regions



Source: Cefic (2013)

Figure 4 shows how the global market share of the chemical industry changed from region to region between 2002 and 2012. Neither the EU nor NAFTA have the largest percentage share any longer. They have been surpassed by China and the rest of Asia.

Figure 4. Distribution of sales of chemical products over different regions



Data source: Cefic (2013). Author's calculation and graph

In 20 years, the EU's share of the chemical market nearly halved. In 1991 the European Union was in a much stronger position than in 2011 with sales of €295 billion, 36 per cent of world sales in terms of value. Sales constantly grew throughout this period, the total increase being 83%. However, the level of world chemical sales increased threefold in the same period (€819 billion in 1991 and €2744 billion in 2011). As a consequence, the EU chemicals market share nearly halved in 20 years, from 36 per cent in 1991 to 20 per cent in 2011 (based on raw data in Cefic, 2013).

1.3 Motivation for current work

Major asset of European chemical industry is knowledge, and a strong research base is, therefore, essential for building a knowledge-based competitive economy. Due to the multinational character of the large European chemicals industry and the tendency to relocate development activities closer to customers along the value chain, at least the 'D' component of R&D has gradually moved nearer to the large emerging markets. One reason for the relatively low overall R&D intensity is the fact that even today base chemicals – which require rather low investment in research – represent almost 60% of European industry's sales. This obscures much higher R&D investments in specialties and fine chemicals, advanced materials and other higher tech subsectors.

Corporate R&D in Europe is increasingly concentrated in large companies where revenues from base chemicals and commodities can be reinvested in research and innovation for new products and technologies. Large companies have generally maintained high R&D levels. In comparison, R&D expenditure in smaller companies is lagging far behind. Public funding varies greatly from region to region. Nevertheless, more private investment, in particular, is needed in R&D.

As far as chemical research in universities and research centres is concerned, the EU leads in terms of number of scientific publications. But it is performing less well compared to US in terms of citations of publications in chemistry, while being almost equal to the US in chemical engineering. However, an analysis of world scientific literature shows that the research output of China and India is growing much faster, with a higher degree of specialisation in chemistry and chemical engineering applied research.

It is the time for the big European players to prepare to defend their home markets, develop growth platforms based on innovation and better value capture and build the skill and scale required to compete. The key to survival for European chemical companies is based on innovation at three different levels-moving from bulk chemical production to the specialty end of the value chain, leveraging their traditional advantage in technology and establishing closer customer and competitor relationships through joint development agreements, acquisitions, value add services and other strategies initiatives (Schulz et al., 2012).

The efficient and fair sharing of knowledge and technologies among enterprises, research institutions and the public sector, coupled with rules for technology transfer are important for ensuring the EU chemicals industry remains competitive. Compared with many other industries, the chemicals sector is characterized by long development and lengthy pay back times. Certain product groups (e.g. plant protection items) require relatively long intellectual property rights protection in order to achieve a sufficient rate of return. One way is by improving the dialogue to establish closer cooperation and collaboration with downstream users and other stakeholders. Closer cooperation calls for appropriate and flexible structures for dialogue that go beyond traditional boundaries applied so far by university faculties, government departments and trade associations.

During 2009, the chemical companies were badly hit by the global economic crisis. The sell plunged and share price hit the rock bottom. It was being observed that the European chemical industry is losing its ground both in market and also in total sales. Due to higher labor cost, stringent environmental regulation, and higher cost of production, the chemical production has been moving to Asia and Far East.

So, in perspective of the chemical industry scenario in Europe, the study is even more relevant. Moreover innovation is key for a sustainable and healthy European chemicals industry. There is also an intent to understand the trend and the factors that influence such innovation in nineteen large chemical companies headquartered in Europe (Table 1).

Table 1. The top 19 chemical companies in Europe for the year 2012 based on total sales in chemical products

	Company	Headquarter		Company	Headquarter
1	BASF	Germany	11	Yara	Norway
2	Shell	Netherlands	12	DSM	Netherlands
3	LyondellBasell	Netherlands	13	Lanxess	Germany
4	Bayer	Germany	14	Syngenta	Switzerland
5	Ineos Group	Switzerland	15	Borealis	Austria
6	AkzoNobel	Netherlands	16	Arkema	France
7	Air Liquide	France	17	Eni	Italy
8	Evonik	Germany	18	Styrolution	Germany
9	Solvay	Belgium	19	Total	France
10	Linde	Germany			

Data source: Tullo (2013). Table: Author

1.4 Innovation in an industrial environment

Innovation is the process of translating an idea or invention into goods or service that creates value or for which customers will pay. It can be a new idea, device or process and is seen as the application of better solutions that meet new requirements or satisfy the existing market needs. This is achieved through more effective products, processes, services, technologies, or ideas that are readily acceptable by markets, governments and society thus bringing economic benefit.

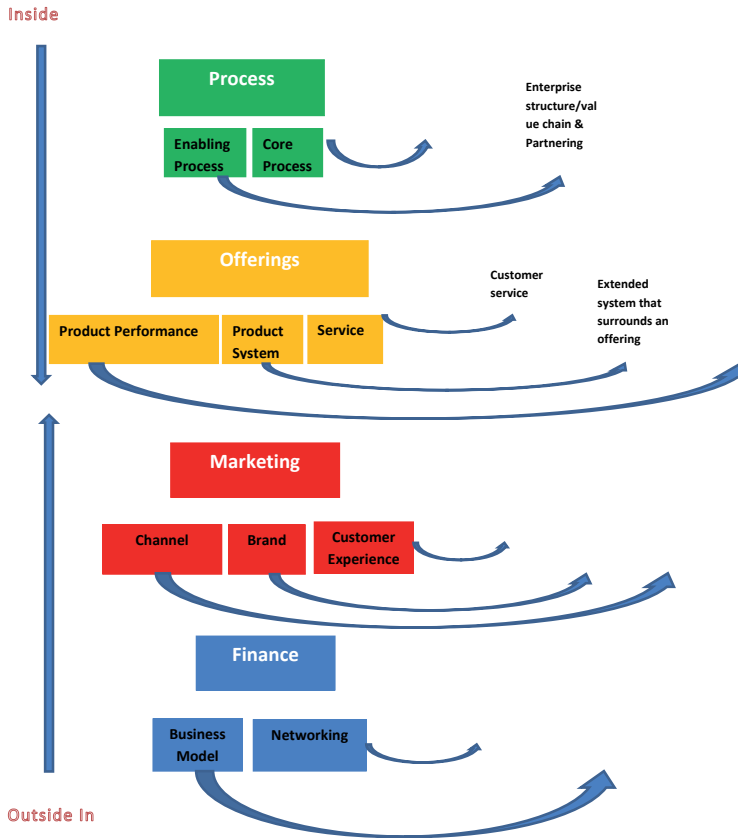
Schumpeter (1934) comments that “radical” innovations shape big changes in the world, whereas “incremental” innovations fill in the process of change continuously.

Various types of innovations can be introduction of a new product or a significant change in an existing product, process improvement, the opening of a new market, new sources of supply for raw materials or changes in industrial organisation.

According to UNESCO (2012), the innovation in a company can be broadly divided into four types: Product innovation, Process Innovation, Marketing innovation, Innovation in Finance. This can be sub-divided

into ten group of innovation as shown in the figure 5. The innovation in a company can be inside-out or outside-in.

Figure 5. Ten different types of innovation in any business



Source: Author

There are basically three kinds of activities that lead to innovation: strategic, R&D and non-R&D (European Commission, 2010):

Strategic: To make decisions about the types of markets to serve and the types of innovations they will attempt there.

R&D: Some of the options relate to R&D are:

- undertake basic research to extend its knowledge of fundamental processes related to what it produces;
- develop product concepts to judge whether they are feasible and viable followed by prototype design, development and testing; and further research to modify designs or technical functions
- engaging in strategic research to broaden the range of applied projects and applied research involving specific inventions or modifications of existing techniques;

Non-R&D: The firm may engage in many other activities that bring innovation to a firm via its marketing side and relations with users, via the identification of opportunities for commercialization resulting from its own or others' basic or strategic research, via its design and engineering capabilities, by monitoring competitors; and by using consultants;

1.5 Purpose and Sources of innovation

It is believed that a firm's reasons for engaging in innovation activity should be mainly due to its economic benefit in terms of products and markets, and also of process innovation it can bring within the reach. The focus should be on all of the firm's innovation activities.

The main objectives for innovation are (European Commission, 2010):

- Replace products being phased out through extending product range or develop a better products;
- Retain market share or increase market share or enter into a new markets
- Improve production flexibility or lower production costs
- Improve product quality or working conditions

There are various sources for innovation as laid down below:

- Internal sources within the firm or business group such as marketing, in-house R&D, production, and other internal sources
- External market/commercial sources such as clients or customers, competitors, consultancy firms, suppliers of equipment, materials, components and software

- Educational/research institutions such as higher education institutions, government research institutes, private research institutes
- Other sources such as patent disclosures, professional conferences, meetings, journals, fairs and exhibitions

1.6 The impact of innovations on the performance of the enterprise

Selecting and defining the right metrics for innovation for any business can be both tricky and difficult. Metrics can be important levers of innovation – for driving behavior, as well as evaluating the results of specific initiatives. There's generally no one right answer and agreeing on what to measure can feel more like art than science. Many companies have had innovation metrics for years – the most noteworthy that 10% of employees' time is dedicated for experimentation with new opportunities. Most metrics programs begin with benchmarks of established companies that have been successful with new products, metrics tend to revert back to traditional measures of R&D or technology investment and effectiveness.

Various indicators that can be used to measure the impact of innovations on the performance of the firm are:

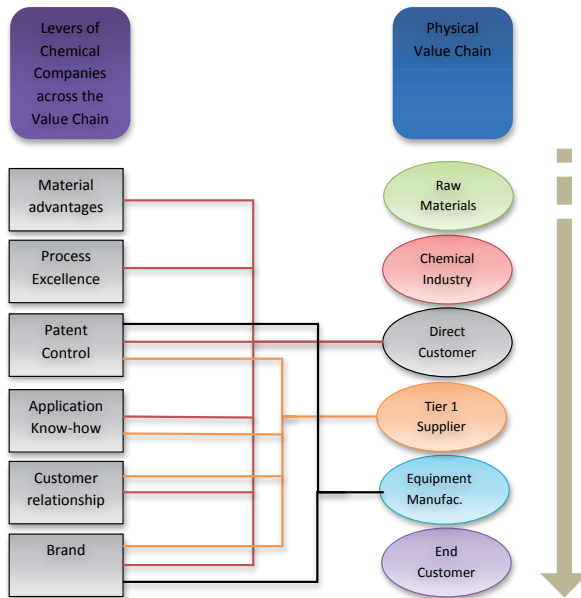
- Number of patents filed and granted in the past year
- Number of active projects
- Annual R&D budget as a percentage of annual sales
- The proportion of sales due to technologically new or improved products;
- Total R&D headcount or budget as a percentage of sales
- Number of ideas submitted by employees
- Percentage of sales from products introduced in the past X year(s)

1.7 Impact of Innovation on Chemical Industry

The chemical industry throughout its entire history has been driven by innovation. This has helped it transition from a traditional supplier role of being paid by the ton of material to play a more important and indispensable role in the industry value chain. In accordance to this trend, it is seen that many established chemical companies over the last

ten years has driven an increased focus on research and development, moving ever further towards the speciality end of the value chain. There has been several ways to meet this goal. As shown in figure 6 below, the chemical industry value chain has sweet spots that companies can use, to a certain degree, to control the development of the industry and earn above average, sustainable returns. These include raw materials advantage, process optimization and excellence, patent protection and control, and application know-how which reach far beyond the chemical industry to have, ultimately, an impact on end users.

Figure 6. Impact of innovation on chemical industry value chain



Source: Author

In 2012, DuPont had a record number of new product introductions while DSM's sales from new products and applications introduced in the last five years was of Euro 1,644 million which accounted for 18 percent of total sales. By 2015, DSM wants innovative products and solutions to account for 20 percent of its total sales. Many forward thinking chemical companies already have local-market specific R&D center.

CHAPTER 2. EUROPEAN CHEMICAL INDUSTRY

2.1 Introduction

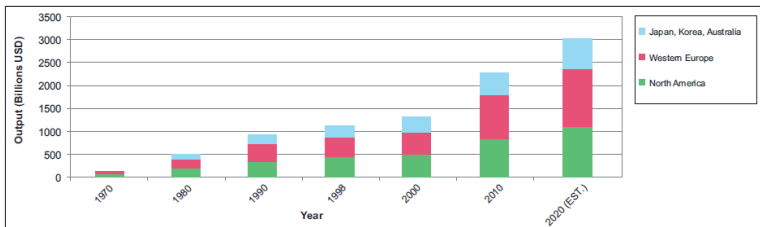
The global chemicals industry has grown rapidly over the past several decades. Within the last decade in particular, this growth has been driven primarily by dramatic growth in developing countries and countries with economies in transition. The industry is undergoing dynamic change, with a range of external factors presenting industry executives with vastly divergent challenges in different regions of the world. Fundamentally, the industry continues to be driven by two main factors: Global GDP dependence, which necessitates vastly different behaviors in emerging markets which continue to expand; Europe, where embedded structural issues point to long-term stagnation; and the US where a sustained economic recovery seems to be taking hold; and Global issues including population growth and middle class expansion; food and water shortage; energy and climate change, all of which drive demand for chemical products under the mantra of making life better and our planet healthier – continuing to drive the march downstream and the search for higher value, science-based chemical products. This chapter gives an overview of the global and European chemical industry and explains how the industry was affected by global economic crisis. In the later part of the chapter, we talk in details each of the nineteen chemical companies under current study.

2.2 Global chemical industry

The global chemicals industry has grown steadily over the past several decades. Chemical industry data cited by OECD indicate that global chemical industry output was valued at US\$ 171 billion in 1970. In 2010, industry sources valued.

Global output at US\$ 4.12 trillion. The figure 1 shows as how the output of the chemical companies is increasing steadily for last 40 years in the developed economy. It is seen in the graph that the largest growth has happened in the last decade with Western Europe playing a significant role.

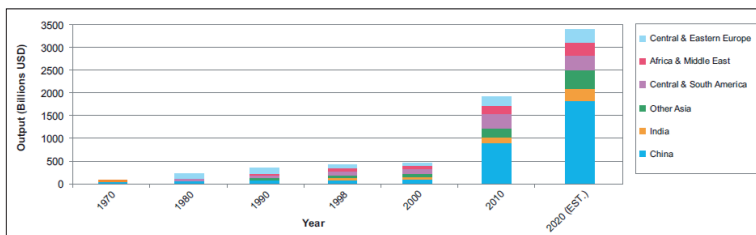
Figure 1. Chemical output in the developed region



Source: Chemical Outlook (2012)

In the figure 2, we see that the chemical output from the developing economy is expected to be higher than developed economy for the year 2010. For last fifteen years; Asia has played a very significant role in boosting chemical output.

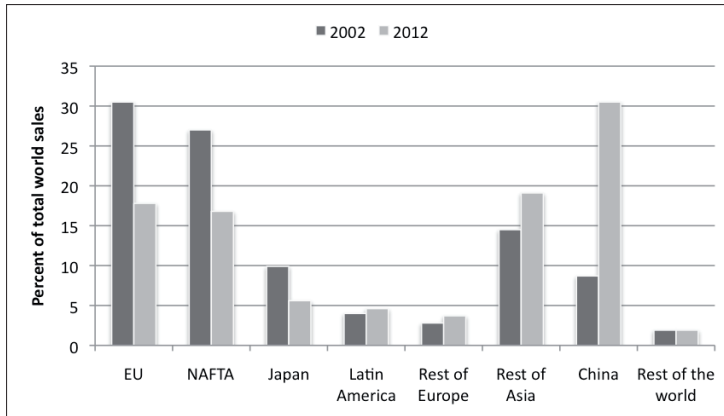
Figure 2. Chemical output in the developing region



Source: Chemical Outlook (2012)

Figure 3 is the comparison as how global market share of chemical industry is changing from region to region for the last ten years. EU has been losing largest share in terms of percentage followed by NAFTA region and as commented earlier, China and rest of Asia is gaining ground.

Figure 3. Chemical product over different region

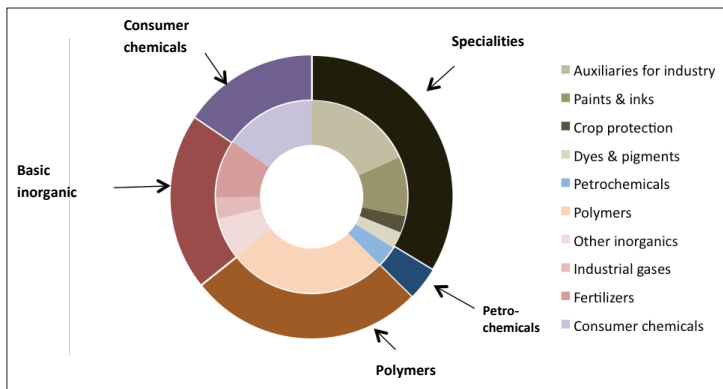


Data source: Cefic (2013). Author's calculation and graph

2.3 The European Chemical Industry: An Overview

The European chemical industry is a robust, world-leading sector in terms of productivity and employment. But it is also at the root of all other industries. The European chemical industry is based on the following six categories of products: basic chemicals, specialty chemicals, petrochemicals, polymers, pharmaceuticals and consumer chemicals. The industry has an extremely broad range of customers. Only 30% of the combined output of the chemical and pharmaceutical industries is sold to private households and other end users.

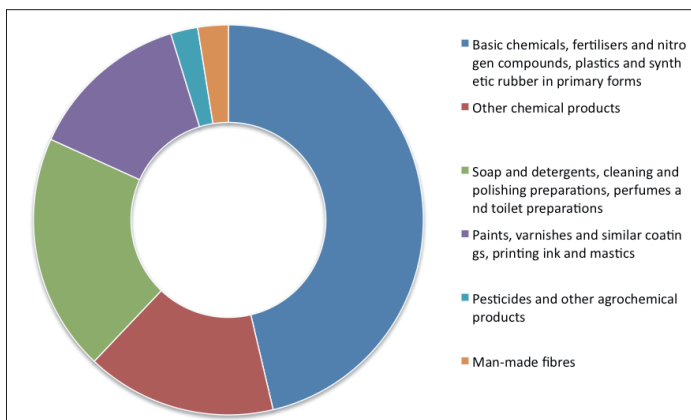
Figure 4: The product mix of the European chemical industry



Data source: Cefic (2014). Graph: Author

With a workforce of 1.2 million and sales of €642 billion, it is one of the biggest industrial sectors and an important source of direct and indirect employment in many regions of the European Union (Cefic, 2013). Figure 5 below shows how the direct work force is distributed among the various products. It can be seen that the bulk of the work force is employed in producing basic chemicals and related products.

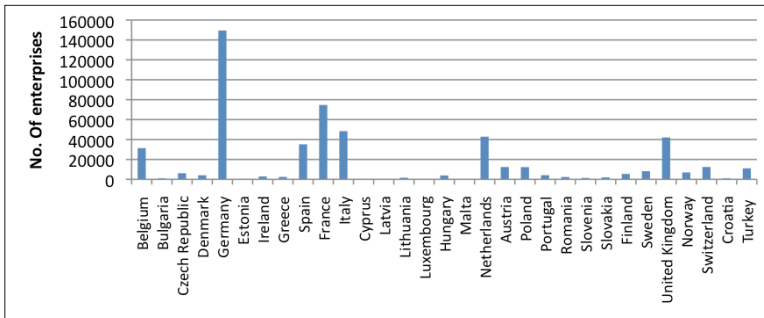
Figure 5: Percentage of employees in each sector of the European chemical industry



Data source: EUROSTAT (2013). Graph: Author

Most European chemical companies are located in seven EU countries: Germany, France, Italy, UK, Netherlands, Spain and Belgium. Of these, Germany has most with more than 140,000 companies followed by France and Italy.

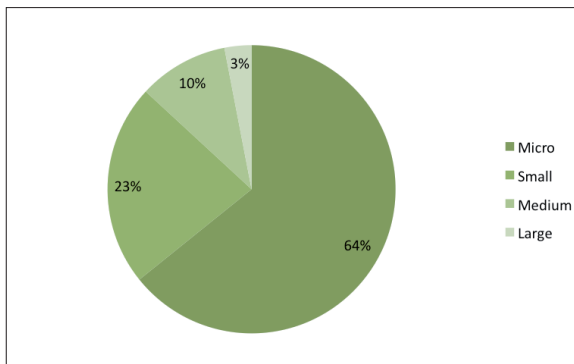
Figure 6. The number of chemical companies in EU countries



Data source: EUROSTAT (2013). Graph: Author

In the EU, there are around 29,000 semi-medium, medium and large chemical companies which employ a total staff of about 1.2 million. This is equivalent to 4% of the manufacturing industry's overall workforce. Employment in the industry has decreased by 2% annually over the past ten years. A total of 4% of all chemical companies have more than 250 employees and these are responsible for 72% of all sales and 65% of total employment (EUROSTAT, 2013). They make a major contribution to the transfer of innovation generated upstream in the chemicals value chain to downstream manufacturing industry. As producers of basic and specialty chemicals, large chemical companies often supply SMEs and are sources of innovation.

Figure 7: The percentage of different-sized companies in Europe



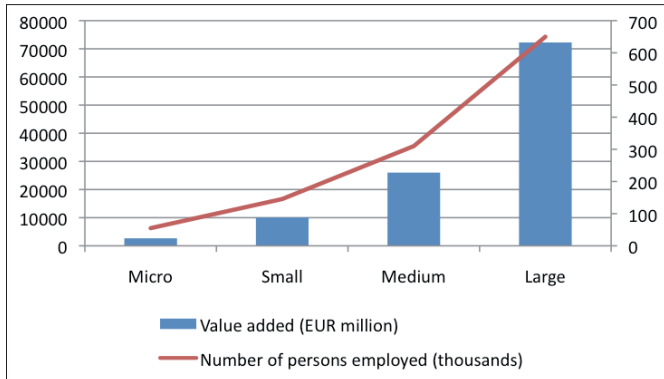
Data Source: EUROSTAT (2013). Graph: Author

Even though large chemical companies are only 3% of the total number of chemical companies, they make a significant contribution because they are the largest supplier of products and also the biggest employers. The companies are classified as one size or another on the basis of the following criteria:

- small enterprises: 10-49 employees
- medium-sized enterprises: 50-249 employees;
- large enterprises: 250 or more employees.

Figure 8 shows that large chemical companies in Europe bring most value to the chemical industry and justify the focus of the current research.

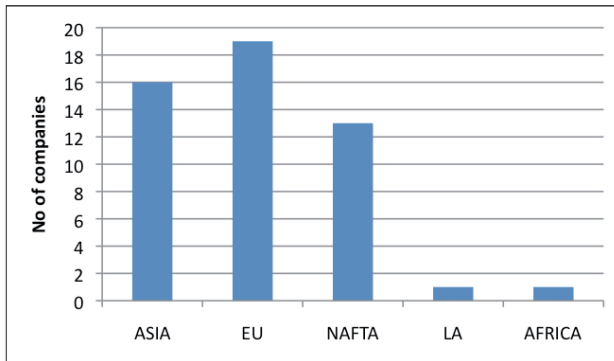
Figure 8. The value addition of different sizes of EU companies and the number of employees in each size



Data Source: EUROSTAT (2013). Graph: Author

The chart below (figure 9) shows the distribution of the world’s top 50 chemical companies according to geographical regions. It is interesting to see that the EU is still home to most of them, with 19 headquartered in this region followed by Asia with 16.

Figure 9. Distribution of world’s top 50 chemical companies according to geographical regions



Data source: Tullo (2013). Author’s calculation and graph

During those years of 2008-09, the commodity side of the business has been investing in large-scale advantaged capacity in developing markets and thus struggling with overcapacity. Among the fragmented specialty producers in developed markets, competition was growing fiercer, end markets are in chaos, and rationalization continues. Integrated players, wary of declining profits on the commodities side, are searching for ways to shift their portfolios to include more specialized products (Deloitte, 2010). The analysis shows that profitability has suffered in both the commodity and specialty sectors. The chemicals industry has an extremely broad range of customers. Only 30% of the combined output of the chemicals and pharmaceuticals industries is sold to private households and other end users (KPMG International, 2009). The rest goes to other industries, services and agriculture. The table 1 gives an overview of the European chemical industry, indicating that there are 28600 chemical enterprises in Europe. It is also a big employer, employing 1160000 persons.

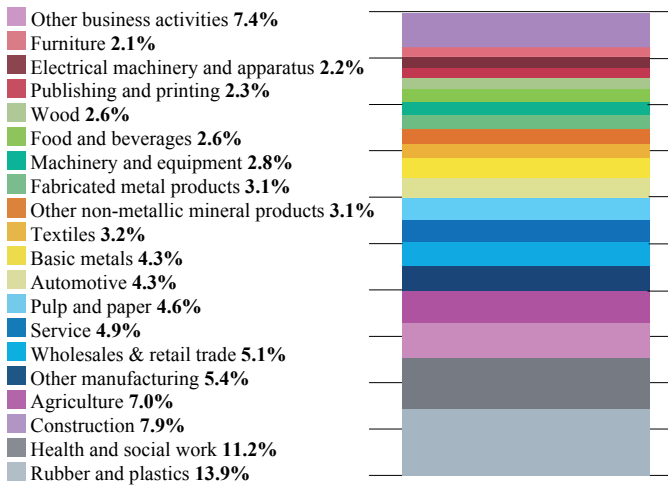
Table 1. Important data of European chemical industry

	Value
Main indicators	
Number of enterprises (thousands)	28,6
Number of persons employed (thousands)	1.160
Turnover (EUR million)	490.000
Purchases of goods and services (EUR million)	389.000
Personnel costs (EUR million)	60.000
Value added (EUR million)	111.000
Gross operating surplus (EUR million)	51.000
Share in non-financial business economy total (%)	
Number of enterprises	0,1
Number of persons employed	0,9
Value added	1,9
Derived indicators	
Apparent labour productivity (EUR thousand per head)	95,3
Average personnel costs (EUR thousand per head)	52,3
Wage-adjusted labour productivity (%)	182,0
Gross operating rate (%)	10,3

Source: EUROSTAT (2013)

The EU chemicals industry supplies virtually to all sectors of the economy. It has a pivotal position in the industrial value chain: raw materials and feedstock are transformed into tailor-made solutions for customers in the chemicals industry itself, as well as all other industries further down the value chain. The chart (figure 10) below shows that the chemical industry underpins virtually all sectors of the economy and its strategies impact directly on downstream chemicals users. The big industrial customers of chemicals are rubber and plastics, construction, pulp and paper, and the automotive industry. Nearly two-thirds of chemicals are supplied to EU industrial sectors, including construction. More than one-third of chemicals are supplied to the other branches of the EU economy such as agriculture, health and social work, services, and other business activities.

Figure 10. The chart showing the percentage of output of EU chemical industry consumed by customer sector



Data source: Cefic (2013)

2.4 Recent Economic crisis and its effect on global chemical industry

The financial crisis of 2007–2008, also known as the Global Financial Crisis and 2008 financial crisis, is considered by many economists to have been the worst financial crisis since the Great Depression of the 1930s. It threatened the total collapse of large financial institutions, which was prevented by the bailout of banks by national governments, but stock markets still dropped worldwide. In many areas, the housing market also suffered, resulting in evictions, foreclosures and prolonged unemployment. According to the U.S. National Bureau of Economic Research (the official arbiter of U.S. recessions) the U.S. recession began in December 2007 and ended in June 2009, and thus extended over 18 months. The figure 11 shows the Dow Jones Industrial Index for the last ten years. It is evident that the economic crisis started in 2007 and showed its extreme effect in early of 2009. Since then, it has steadily improved for last five years. The crisis rapidly developed and spread into a global economic shock, resulting in a number of European bank failures, declines in various stock indexes, and large reductions in the market value of equities and commodities.

Figure 11. Dow Jones Industrial Index for last ten years



Source: Google Finance I (2014)

As the global economy emerges from the Great Recession of 2007-2009, the chemical industry finds itself passing through a period of profound transformation. Profit margins have been shrinking; return on capital has been in steady decline. The recent recession has only exacerbated the problems. The figure 12 shows the trend of Dow Jones Chemical Index and it is plunge to rock bottom in the 2008 and early

2009 depict how intensely the chemical industry was affected by the great recession was mentioned earlier.

Figure 12. Trend of the DOW Jones Chemical Index



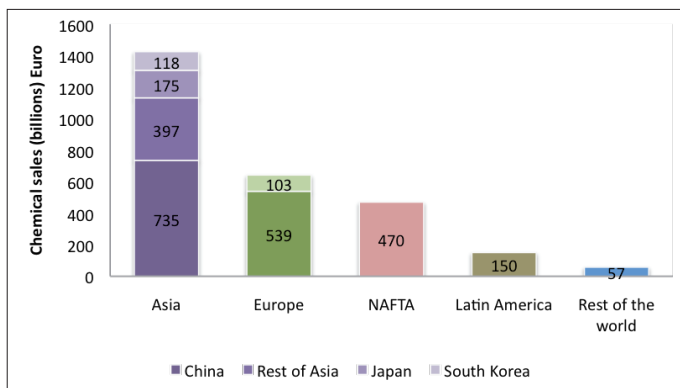
Source: Google Finance 1 (2014)

2.4.1 CHEMICAL SALES

The European chemical industry is facing major challenges as value chains increasingly move eastward, drawn by economic growth and market opportunities in Asia. A new, more competitive environment is taking shape, giving rise to state-controlled players and emerging chemical giants. Fragile economic conditions require managing volatility on a playing field where trade flows gradually change direction. Understanding what these challenges mean, and more importantly, identifying the right strategic options to thrive in this new competitive environment are at the top of every chemical executive's agenda. Since the mid-1980s, the global chemical industry has grown by 7 percent annually, reaching € 2.4 trillion in 2010. Most of the growth in the past 25 years has been driven by Asia, which now owns almost half of global chemical sales (Cefic, 2013). As seen in the graph in figure 13, Asian chemical production in 2011 surpassed that of the rest of the world chemicals turnover and was valued at €2744 billion. Data for 2011 also confirms that a significant recovery of the European chemicals industry occurred during the year. The global sales in value terms were up in 2011 by 11.6 per cent compared with 2010. Emerging economies contributed largely to the worldwide recovery of the sector during the past two years 2010 and 2011. The European chemicals industry, including the European Union and the Rest of Europe, is still in

a strong position, posting sales of €642 billion in 2011 which is 23.4 per cent of world chemicals sales in value terms. Worldwide competition is getting fiercer, however, witnessed by the European Union losing its top ranking in terms of sales to China for the third consecutive year (figure 13). Chemicals sales in Asia are more than double that of the European Union. When taken together, Europe, Asia and the North American Free Trade Area account for 92.5 per cent of world chemicals turnover (Americanchemistry, 2013).

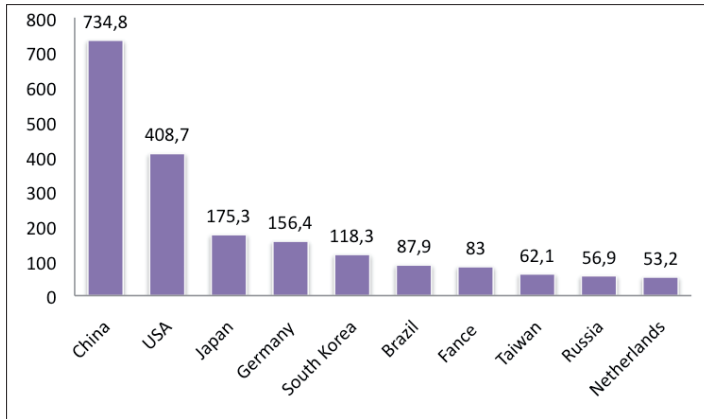
Figure 13. World chemical production



Data source: Cefic (2013)

If we compare country by country production, China - by far is the biggest chemicals producer in 2011. In 2011, the 30 largest chemical-producing countries had a combined turnover of €2447 billion. Twelve of the top 30 major countries are Asian, generating chemicals sales of €1278 billion, which represents nearly 52.2 per cent of the 30 top producing markets and 46.6 per cent of the share of world chemicals sales. Eight of the top 30 major chemicals-producing countries are European, generating chemicals sales of €480 billion (figure 14). This figure represents 19.6 per cent of the top 30 and 17.5 per cent of the share of world chemicals sales (Cefic, 2013).

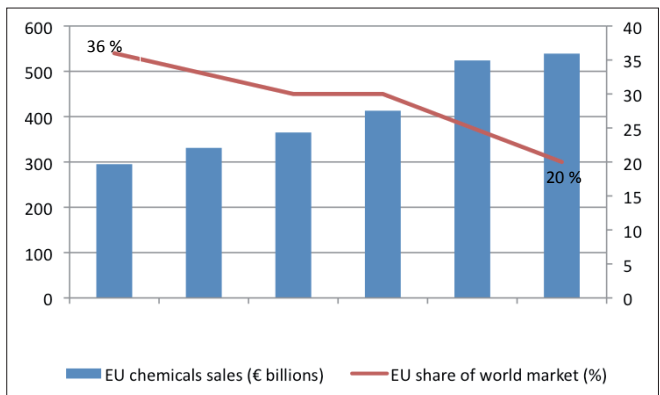
Figure 14. Top ten chemical producers for the year 2011



Source: Cefic (2013); Graph: Author

EU's share of the market of chemicals nearly halved in 20 years. Developments during the previous 20 years from 1991 to 2011 indicate that the European Union was in a much stronger position in 1991 than today, posting sales of €295 billion in 1991, 36 per cent of world chemicals sales in value terms. Chemicals sales have been growing continuously during this 20 years period, increasing in value terms by 83 per cent. The level of world chemicals sales increased, however, threefold in 2011 compared to 10 years ago, posting sales of €819 billion in 1991 to €2744 billion in 2011 (figure 15). As a consequence, the EU chemicals market share nearly halved in 20 years, from 36 per cent in 1991 to 20 per cent in 2011 (Based on Cefic, 2013 raw data).

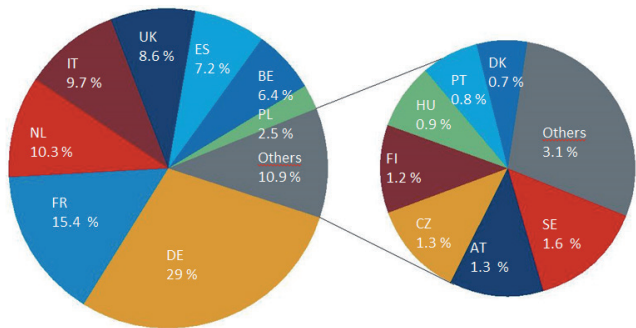
Figure 15. EU Chemical sales and EU share of world market in percentage



Data source: Cefic (2013). Graph: Author

Eight countries accounted for 90 per cent of European chemicals production. Germany remains the largest chemicals producer in Europe, followed by France, Netherlands and Italy (figure 16). Together, these four countries generated in 2011, 64.4 per cent of EU chemicals sales, valued at €347.2 billion. The share rises to nearly 90 per cent, or €480.3 billion, when the United Kingdom, Spain, Belgium and Poland are included. The other 19 EU countries in 2011 generated 10 per cent of EU chemicals sales, valued at €58.8 billion, mainly attributed to four EU countries – Sweden, Austria, Czech Republic and Finland.

Figure 16. Sales of each country in Europe and percentage sales

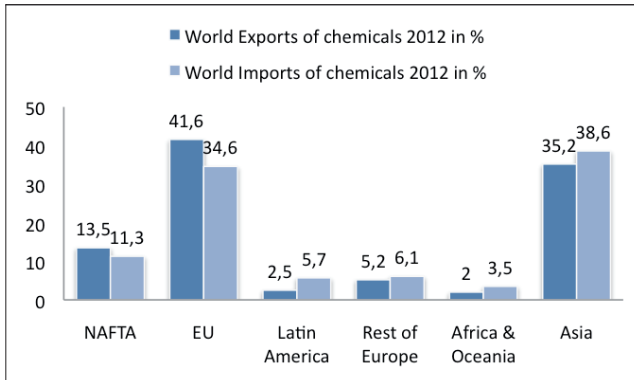


Source: Cefic (2013)

2.4.2 INTERCONTINENTAL CHEMICAL TRADE

Although Europe is losing its position in terms of global chemical sell, in terms of trade balance is doing well with export being 7 % higher than import. In case of Asia, although the gap is reducing between the export and import, but it is importing more than exporting (figure 17).

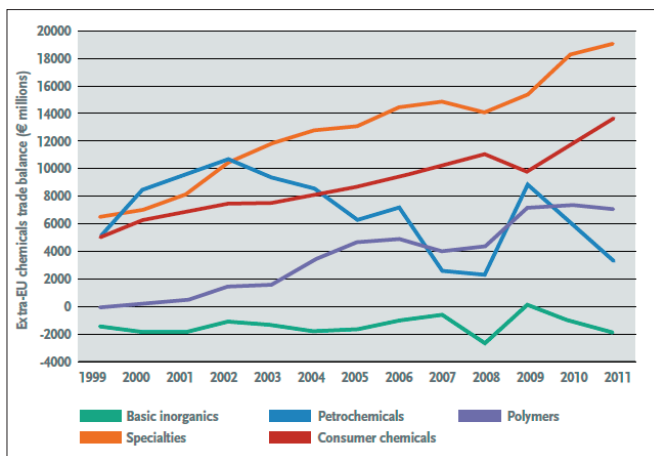
Figure 17. The export and import of chemical products over different regions



Source: Cefic (2013)

Specialty and consumer chemicals in 2011 accounted for 77 per cent of extra-EU chemicals trade surplus. The EU chemicals trade surplus in 2011 reached nearly €41.7 billion. Specialty chemicals accounted for 36 per cent of the EU chemicals trade surplus, with a value of €16.8 billion. The consumer chemicals subsector had the second strongest external trade performance, contributing €16.1 billion to the EU trade surplus, followed by polymers at €8.4 billion and petrochemicals at €7.5 billion. Basic inorganics experienced a trade deficit of €1.9 billion – the only sector with a trade deficit since 1994 (figure 18). Sectorial analysis shows that specialty chemicals and consumer chemicals performed well in 2010. The trade surplus in these sectors increased by 23 per cent and 18 per cent respectively in 2010 compared with 2009. Polymers registered a comparably low 10 per cent increase in terms of trade surplus in 2010 compared with 2009. Petrochemicals in 2010 registered a decline in overall trade surplus, however, of 20 per cent (Cefic, 2013).

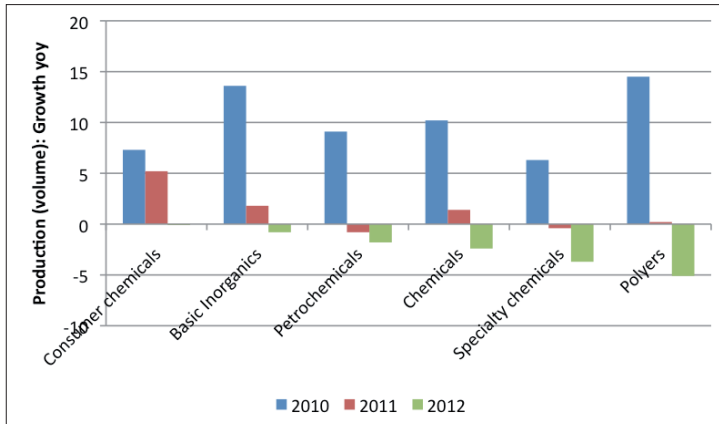
Figure 18. Extra EU-trade balances for various product families



Source: Cefic (2013)

Polymers and specialty chemicals are registering the fastest decline in 2012. As shown in figure 19, growth in EU chemicals production in 2010 was spectacular and stronger than expected. However, the overall economic recovery in Europe was fragile. Production in 2011 was anemic with 1.4 per cent growth of production in volume terms. Furthermore, a lot of uncertainty surrounds the prospects for full-year 2012. Latest data show that EU chemicals production fell by 2.4 per cent in the first nine months of 2012 compared with the same period in 2011. Data for the first nine months of the year point to EU chemicals production remaining 6.2 per cent below the 2007 peak levels. The 2.4 per cent year-on-year output decline during the first nine months of 2012 was mainly led by two sectors: polymers and especially specialty chemicals, which registered the fastest decline in 2012 compared to the other chemicals subsectors (Cefic, 2013). Looking ahead, the European chemicals industry continues to face relentless global competition. Access to raw materials and energy at globally competitive prices remains a prerequisite for a successful recovery for the EU chemicals sector.

Figure 19. Production volume growth or decline year over year



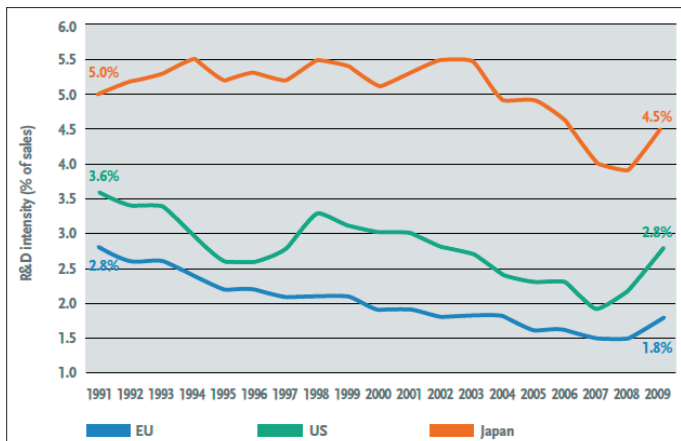
Source: Cefic (2013). Graph: Author

2.5 R&D in chemical industry

The high value-added products of the chemicals industry continuously open up new fields of application, paving the way to progress and innovation in other industries. Typical examples are health, food, consumer goods, aerospace and car manufacturing, telecommunications, electrical engineering and electronics. Wide variations in research and development (R&D) efforts are observed across the chemicals industry. Turning

R&D into innovation is becoming increasingly important in relation to the competitiveness of the region. Analysing the ratio of R&D spending to sales of the chemicals industry (R&D intensity), it can be observed that during the 19-year time period from 1991 to 2009, the R&D intensity level in the European Union was far below that of Japan and slightly lower than in the United States. The EU R&D intensity is equal to two per cent on average during the years 1991 to 2009, while the same ratio is equal to 2.8 per cent in the United States and to 5.1 per cent in Japan (figure 20).

Figure 20. R&D intensity of EU, USA and Japan over a period of 19 years



Source: Cefic (2013)

2.6 Structure of European chemical industry

Table 2 shows the distribution of the chemical enterprises in Europe according to its size. The European Union breaks the size into two broad categories: SME (Small and medium enterprise) and large enterprise. Large enterprise are those that employ more than 500 people, while the enterprises that have less than 500 employee fall under SME. The SME is further divided into micro, small and medium enterprise. Even though large enterprises consist of 3 % of the total chemical enterprise, they employ 56 % of the chemical industry work force. So their role in European chemical industry growth and employment is significant.

Table 2. Number of European chemical enterprises according to their size and number of persons employed

	Number of enterprises	Number of persons employed
	(thousands)	
All enterprises	28,6	1.160,0
All SMEs	27,3	510,5
Micro	18,1	55,0
Small	6,4	145,5
Medium-sized	2,8	310,0
Large	0,9	650,0

Source: EUROSTAT (2013)

2.7 European top chemical companies

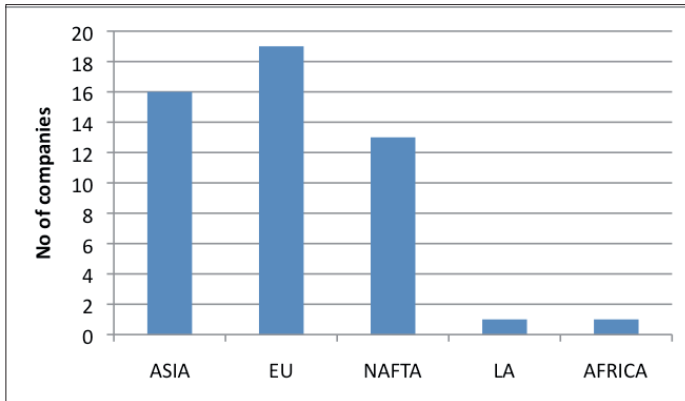
Table 3: The top 19 chemical companies in Europe for the year 2012

	Company	Headquarter		Company	Headquarter
1	BASF	Germany	11	Yara	Norway
2	Shell	Netherlands	12	DSM	Netherlands
3	LyondellBasell	Netherlands	13	Lanxess	Germany
4	Bayer	Germany	14	Syngenta	Switzerland
5	Ineos Group	Switzerland	15	Borealis	Austria
6	AkzoNobel	Netherlands	16	Arkema	France
7	Air Liquide	France	17	Eni	Italy
8	Evonik	Germany	18	Styrolution	Germany
9	Solvay	Belgium	19	Total	France
10	Linde	Germany			

Source: Tullo (2013). Author's calculation

Based on the data published by Tullo (2013), the table 4 shows the top 19 chemical companies head quartered in Europe from the list of 50 top selling global chemical companies. The current research is to lay down the innovation policy of these 19 companies and study its impact on profitability.

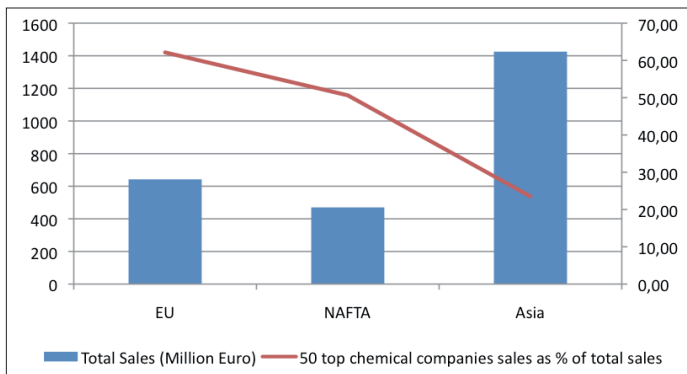
Figure 21. Distribution of world’s top 50 chemical companies according to geographical regions



Data Source: Tullo (2013); Author’s calculation and graph

The chart (figure 21) above shows the distribution of world’s top 50 chemical companies according to geographical regions. It is interesting to see that EU still leads the race with 19 out of top 50 companies followed by Asia with 16.

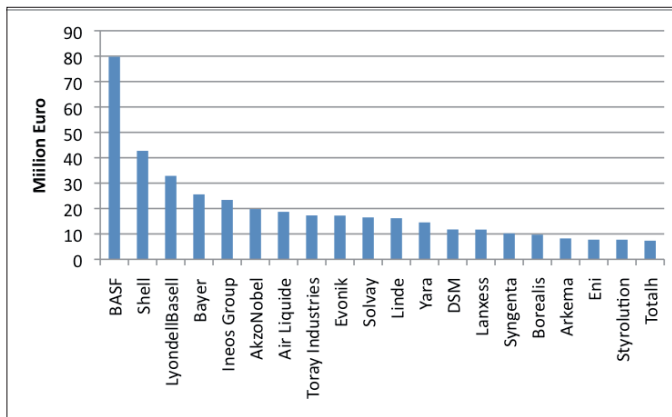
Figure 22. The percentage of sales of the top 50 chemical companies to total sales in particular region



Data source: Cefic (2013) and Tullo (2013). Author’s calculation and Graph

The figure 22 shows the total sales of the top three regions and the percentage of sales of the top 50 companies to the total sales of that region. We have seen that in the list of 50 top chemical companies, 19 are from Europe. These 19 companies contribute to 63 % of European chemical sales which further emphasizes the importance of analyzing the innovation strategies of these companies.

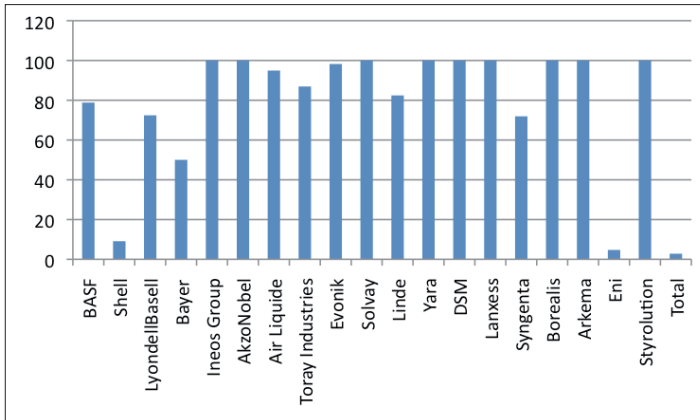
Figure 23. The chemical sales for the top 19 chemical companies in Europe



Data source: Tullo (2013). Graph: Author

The figure 23 above shows the chemicals of the top 19 companies. It is interesting to see that BASF has almost double of chemical sales to that of its following competitor. Another aspect, which is coming up is that the traditional oil companies are now investing in chemical business and thus playing a significant role in European chemical sales.

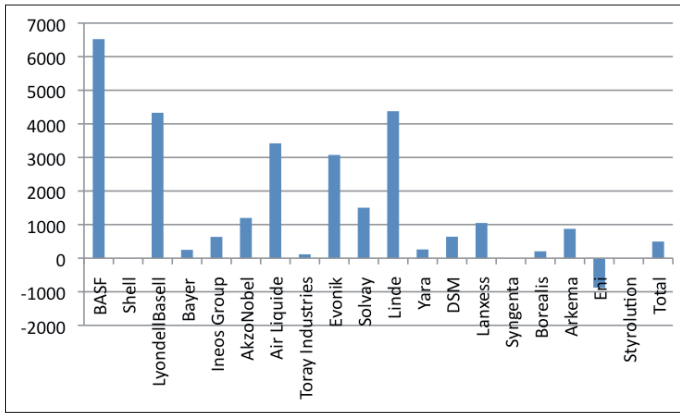
Figure 24. Chemical sell as a percentage of total sales of top European chemical companies



Data source: Tullio (2013). Graph: Author

The figure 24 above shows how much percentage of their revenue is from chemical product sales. Apart from the three companies (Shell, Eni, Total), most of the other companies have a very high percentage of chemical sales as a percent of total sales. It is interesting to note, even though BASF is the largest chemical company in terms of sales, it's chemical sales is slightly lower than 80 % of the total sales. Many large chemical companies have diversified into the pharmaceutical and bioscience industry, which brings to them significant profitability as seen in Bayer (figure 24).

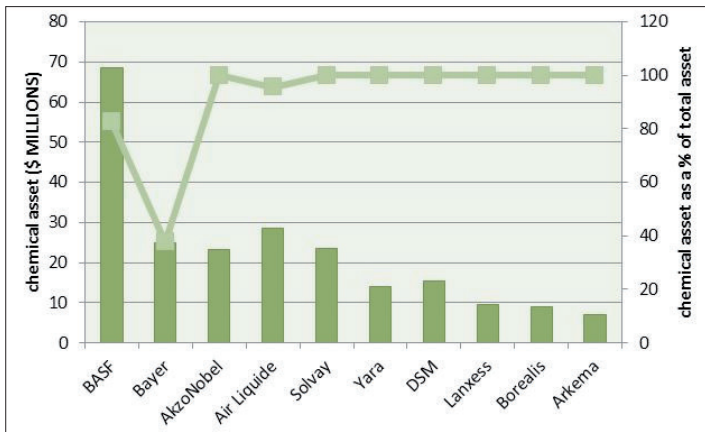
Figure 25. Operating profit as obtained from chemical sales



Data source: Tullo (2013). Graph: Author

The top five companies in chemical sales profitability are BASF, Lyondell Basell, Air Liquide, Evonik, and Linde. Most other companies, even though has a high volume of sales, the profitability percentage is significantly low.

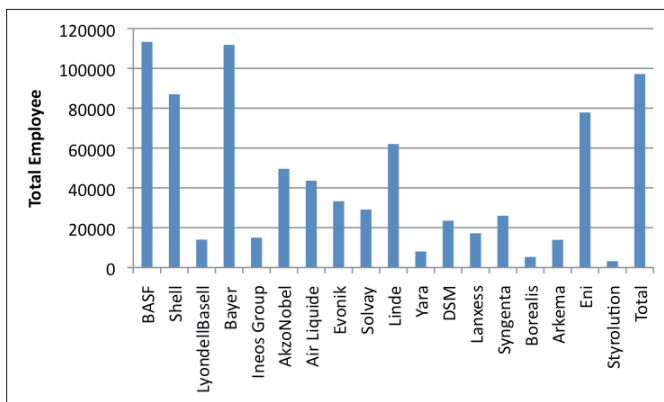
Figure 26. Chemical Assets and chemical assets as a percentage of total asset



Data source: Tullo (2013). Graph: Author

The bar in figure 26 shows the chemical assets. BASF is way ahead compared to others in terms of capital asset. It is interesting to see that Bayer’s chemical asset is only around 40 % of the total asset, which can be attributed to a diversified company. Most other companies in this analysis are pure chemical companies with their chemical asset being almost 100 % of their total asset (figure 26).

Figure 27. Total employees of the top 19 chemical companies (included in this chart are employees assigned to different business sector apart from chemical industry)



Data source: Wikipedia (2014). Graph: Author

From the figure 26, we can see in case of companies who are almost wholly dedicated to chemical industry, BASF and Linde are the top employers. Although the three oil companies Shell, ENI and TOTAL are large employers, but a significant portion of their work force is engaged in their oil and gas business.

CHAPTER 3. INNOVATION TREND OF LARGE EUROPEAN CHEMICAL COMPANIES

3.1 Introduction

Patent is defined as a government authority or license conferring a right or title for a set period, especially the sole right to exclude others from making, using, or selling an invention. It may be granted to a firm, individual or public body by a national patent office. Patent propensity rate is a potentially valuable indicator for innovative activities.

3.2 Measuring innovation through patent

Patents are undoubtedly one of the instruments that firms use to capture values from innovation and R&D activities. Among the few available indicators of technology output, patent-based indicators are probably the most frequently used. Most of the researchers support the idea of using patent data as the metrics of measuring innovation.

Although both industrial and academic researchers have tried to measure significance or impact of innovations using several methods, there is no commonly accepted way to measure innovation. Some authors have used qualitative data such as expert opinion to determine the most radical innovations in the industry. This approach is seen from the works of Achilladelis et al. (1990), Green et al. (1995) and Henderson (1993). Anderson and Tushman (1990) even combined qualitative methods with quantitative data while Christensen and Rosenbloom (1994) used performance improvement data to draw technological trajectories and to operationalize radical innovation. These earlier measure of innovation have two main weaknesses. First, in many studies evaluation is based on subjective assessments by managers, industry experts, or customers and as a result reliability of these measures is context-dependent. Moreover, collecting this qualitative data is time-consuming, resource-consuming

and always the right person was not approached. In such study, there was no distinction made between radical and incremental innovations.

The three drawbacks of innovation measures discussed above can be, however, addressed by patent-based measures as described in this study. Patents provide a relatively objective measure of new knowledge and are required to describe something novel and not obvious. Patents thus provide a good measure of technologically new knowledge as defined above. As a result, several studies have recently used patents as a measure of innovation performance (Dutta and Weiss, 1997; Henderson and Cockburn, 1994). In addition to the methodological strengths of patent-based measures, also the availability of patent data motivates the use and research on patent-based measures of innovation. Due to the electronic access to patent data through for example EPO and US Patent and Trademark Office databases, researchers have increased the use of patents in industrial and academic research (Pavitt, 1988; Walker, 1995). Arora and Gambardella (1994) further states that the importance of patents as innovation appropriability mechanisms will be increasing. Thus, patents are even more likely to be used as measures of innovation in future research.

According to Arundel and Kabla (1998), for chemical and pharmaceutical industry, there is a good relationship between innovations and patenting which is not be the same for other industry. The evidence from empirical study from Acs et al. (2001) suggests that patents provide a fairly reliable measure of innovative activity. Similar view is represented by the study by Thomson Reuter (2013), where they used patents as the indicator to rank top 100 innovative companies in the world. For our current research, we will consider number of patents applied and granted as the indicator of innovation. The study by Breitzman (2013) shows that large firms have a higher percentage of both granted patents and patent applications than small companies and this is especially noticeable during the recession of 2008-09. Based on these previous researches, patent data was selected as the metric for current research for measuring the innovation trend of the large chemical companies headquartered in Europe. In the first hypothesis we want to test if there is a proper trend in innovation of the European chemical industry and large companies in particular.

3.3 Patent process

The most commonly used indicators are counts of patent family that share a number of common elements. This section focuses on patent landscape of the top chemical companies in Europe. The list of the top nineteen chemical companies includes three oil companies. So as not to mix up chemical patents with other patents, these three companies are ignored in this study.

The patent process as according to the US Patent office consist the following broad steps (figure 1):

- Step 1, Applicant - Has the invention already been patented?
 - If already patented, end of process

If not already patented, continue to Step 2

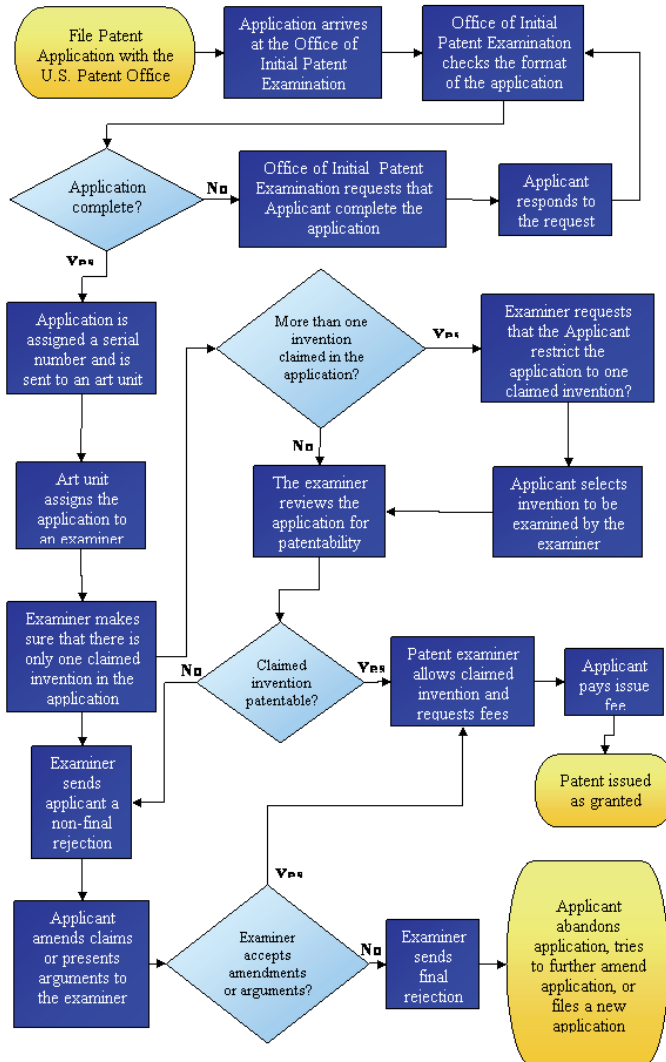
- Step 2, Applicant - What type of Application is being filed?
 - Design Patent or Plant Patent or Utility Patent
- Step 3, Applicant - Determine Filing Strategy
- Step 4, Applicant - Which type of Utility Patent Application to file?

Provisional or Non provisional

- Step 5, Applicant - Consider expedited examination
 - Prioritized or Accelerated or First Action Interview program
- Step 6, Applicant - Who Should File?
 - File yourself (Pro Se) or Use a Registered Attorney or Agent
- Step 7, Applicant - Prepare for electronic filing
 - Application processing fees and Apply for a Customer Number and Digital Certificate
- Step 8, Applicant - Apply for Patent using Electronic Filing System as a Registered e-Filer
- Step 9, USPTO - USPTO examines application
 - Check Application Status
 - Allowed?
 - Yes, go to Step 12
 - No, continue to Step 10

- Step 10, Applicant - Applicant files replies requests for reconsideration, and appeals as necessary
- Step 11, USPTO - If objections and rejection of the examiner are overcome, USPTO sends Notice of Allowance and Fee(s) due
- Step 12, Applicant - Applicant pays the issue fee and the publication fee
 - USPTO Grants Patent

Figure 1. US patenting process flow chart

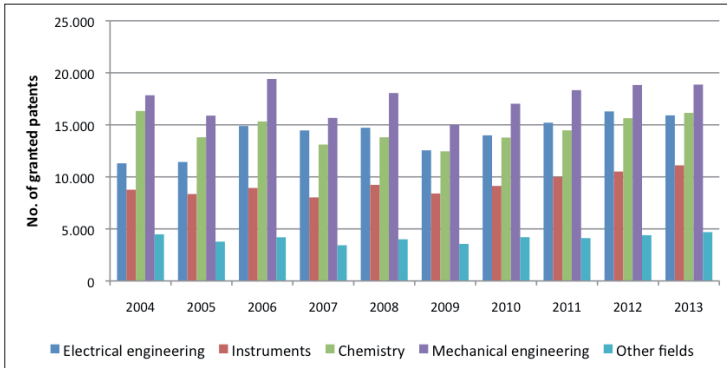


Source: Inventor basics (2013)

3.4 Patent Data Analysis

Patents having effect in most European states may be obtained either nationally, via national patent offices, or via a centralized patent prosecution process at the European Patent Office (EPO). The EPO is a public international organization established by the European Patent Convention. Since this study is focused on large European companies headquartered in Europe, we focus first on the patent activities at the European Patent Office. Figure 2 compares the patents granted to the chemical and chemical-related industry with other leading industries in Europe (electrical engineering, instrumentation and mechanical engineering). The bar graph shows that mechanical engineering has the highest number of patents granted while chemical engineering and electrical engineering are a little behind in second and third place. It also shows that the number of patents granted to the chemical industry was lowest in 2009, which is when the global economic crisis hit and the chemical industry was badly affected.

Figure 2. Number of patent granted at European Patent Office in various sectors

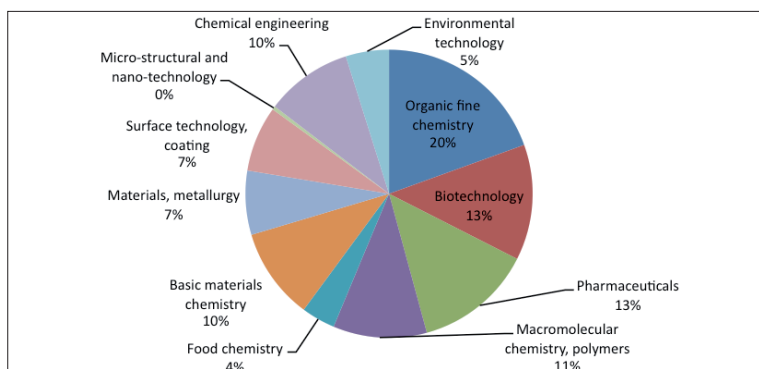


Data source: European Patent Office (2014). Graph: Author

According to the European Patent office, the chemical or chemical engineering sector consists of eleven subsectors. Figure 3 shows how the total number of patents granted for 2013 was distributed among various

sub-sectors. Fine organic chemistry has the highest share of chemistry patents followed by pharmaceuticals and bio-chemistry. We will discuss patenting in this sector further below. Patents in the basic materials sector also make a significant contribution to the total number of patents. On the other hand, research into food chemistry, environmental technology and nanotechnology was insignificant.

Figure 3. Patent granted at European Patent Office for various subsector for chemistry for the year 2013



Data source: European Patent Office (2014). Graph: Author

We look now deep into the fine organics chemistry patenting. The table 1 shows the application for 2013 in the sector of organic fine chemistry. The companies marked yellow are the companies which are under our study. Seven out of the top twenty five companies belong to the list of the top chemical companies in terms of sales which are headquartered in Europe. Based on the following data, where it was seen that BASF is the largest applicant of patents, BAYER surpasses BASF in terms of organic fine chemistry application of European Patent.

Table 1. Top applicants for organics fine chemistry patent application at European Patent Office

Rank	Organic fine chemistry	Applications
1	BAYER	337
2	BASF	310
3	UNILEVER	175
4	HOFFMANN-LA ROCHE	123
5	NOVARTIS	121
6	L'OREAL	112
7	MERCK KGAA	108
8	BOEHRINGER INGELHEIM	105
9	JOHNSON & JOHNSON	99
10	DSM	95
11	SYNGENTA	86
12	SANOFI	78
13	KAO	76
14	PROCTER & GAMBLE	72
15	DOW CHEMICAL	68
16	SOLVAY	65
17	EVONIK	59
18	HENKEL	58
19	EXXON MOBIL	56
20	MERCK & CO	53
21	SHELL	51
22	BRISTOL-MYERS SQUIBB	47
23	LONZA	45
24	COLGATE-PALMOLIVE	43
25	DUPONT	41

Source: European Patent Office (2014)

The table 2 below is an extract of a table of the top 100 companies in terms of patent application to European Patent Office for the year 2013. The first column shows the ranking in the original list of top 100 companies. We see only six chemical companies from our top twenty chemical companies appear in this list. As always BASF is leading the table with over 1500 patent applications.

Table 2. Extract of the table showing the ranking of the top European chemical companies in the total ranking of top 100 companies in terms of highest patent application at the European Patent Office for 2013

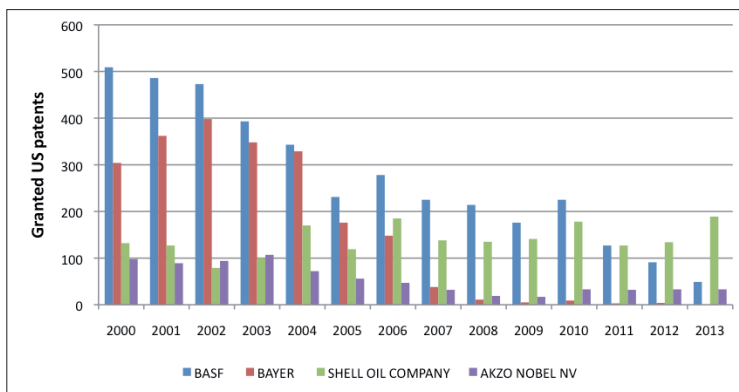
Rank	Company	Applications
5.	BASF	1577
16.	BAYER	850
23.	DSM N.V.	659
52.	EVONIK AG	360
61.	SOLVAY	313
68.	SHELL	272

Source: European Patent Office (2014).

Now let us focus on US patent. The United States Patent and Trademark Office (USPTO or Office) is an agency of the U.S. Department of Commerce. The role of the USPTO is to grant patents for the protection of inventions and to register trademarks.

It serves the interests of inventors and businesses with respect to their inventions and corporate products, and service identifications. Through the preservation, classification, and dissemination of patent information, the Office promotes the industrial and technological progress of the economy. The graph in figure 4 below shows the granted US patent for the top European companies. We could see BASF, Bayer, Shell and Akzo Nobel as the only companies that made it to the top of this list. It is interesting to see that apart from Shell, all other companies having a falling tendency over the years in terms of granted patents.

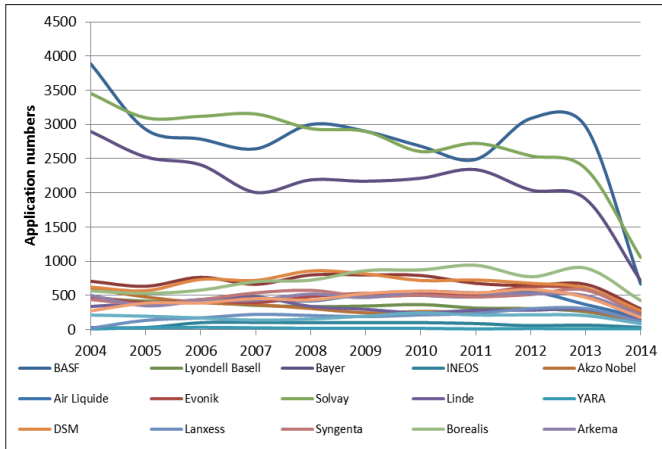
Figure 4. Granted US patent for the top European chemical companies for the last 14 years



Source: US Patent Database (2014). Graph: Author

Figure 5 shows the patent applications made by these companies over the last ten years to the leading patent authorities throughout the world. In order to avoid counting of the same patent applied for in two countries more than once, we counted patent families instead of the number of actual patents. A patent family is a set of patents taken out in various countries to protect a single invention (when the initial application in one country – the priority – is then extended to other countries). In other words, a patent family is the same invention disclosed by a common inventor(s) and patented in more than one country. BASF, Bayer and Lyondell Basel are the leading applicants. All other companies made considerably fewer applications, while Solvay showed an upward trend. So these three companies are at the forefront of research and development.

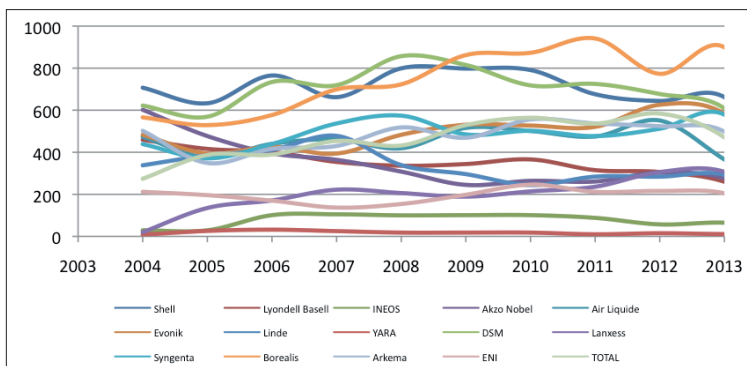
Figure 5. Global patent application and patent related document publication



Data source: Thomson Innovation (2014). Author's analysis

We now focus in more details on the companies which applies less than 1000 patents per year (figure 6). In this sub-group of companies Borealis, Shell and DSM are the leaders. These are followed by a group of companies whose application ranges between 350 and 400 patents per year. It was also surprising to see that there were few companies whose patent application was less than 100 per year. This also confirms that all companies do not have the same level on focus on innovation or patenting.

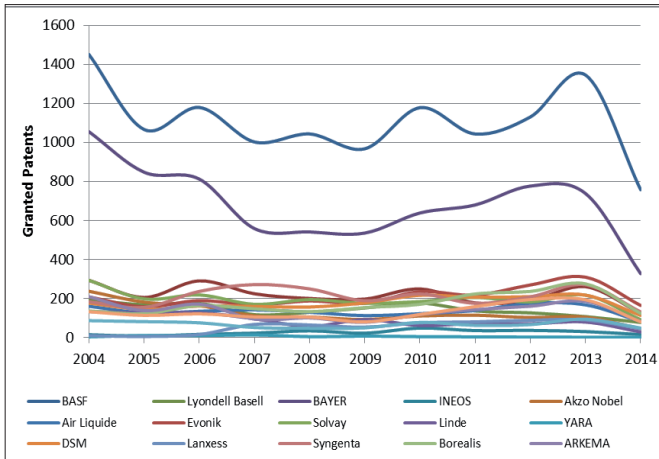
Figure 6: Global patent application and patent related document publication



Data source: Thomson Innovation (2014). Author's analysis

The graph below (figure 7) shows the number of patent families granted to the top fifteen chemical companies in Europe. The patents granted were searched for in the database of the most important patent authorities: US, Europe, Australia, Canada, Germany, China, India, Japan, Korea, Singapore and Vietnam. On the basis of the patents granted, the companies can be divided into highly patenting companies, medium patenting companies and low patenting companies. BASF has highest number of patents granted followed by Bayer. Likewise, in both cases, there was a fall in the number of patents granted between 2004 and 2009. Then they seem to have recovered. For the year 2014, we have considered data until the middle of the year. Many of the companies fall in the range of 150 to 250 patents granted, which we can consider as medium innovative companies. In this study we also found a few of the companies whose focus on patent has been very low, thus have very few patent granted.

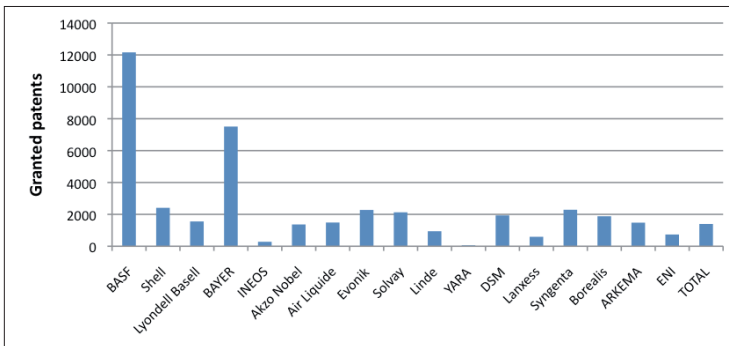
Figure 7. Granted patent of the top chemical companies at the important patent offices



Data source: Thomson Innovation 2014. Author's analysis

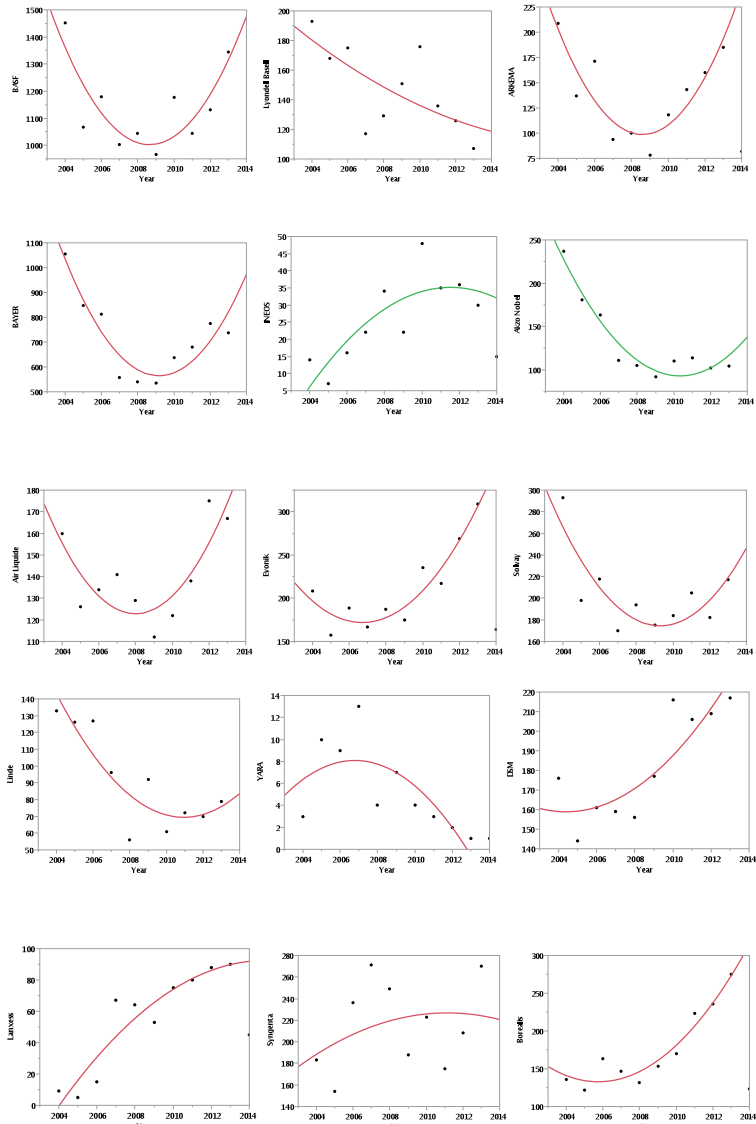
The bar chart below shows the total number of patents in terms of families granted for last ten years at all major patent offices. Like the previous trends, BASF is leader in terms of granted patents followed by Bayer. Shell, Evonik, Solvay, Syngenta all have in total slightly above 2000 patents families granted.

Figure 8. Total granted patent for the top chemical companies for the last 10 years



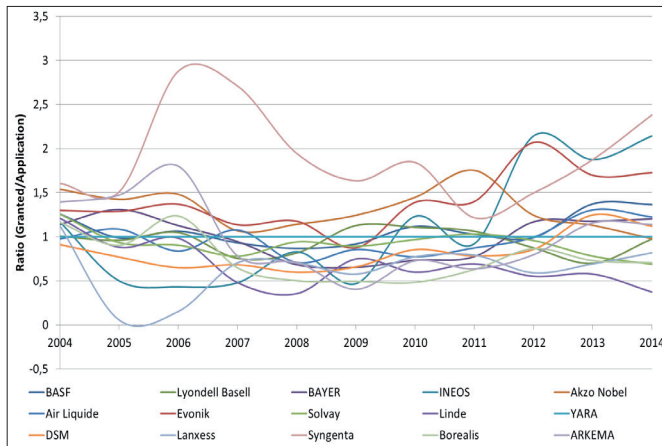
Data source: Thomson Innovation 2014. Author's analysis

Figure 9. The trend of patent granted of the specific companies



It is generally believed that the more research companies do the more patent applications they will make. It is also believed that the quality of research can be judged by the number of patents granted. Graph 10 below shows the ratio of patents granted to patents applied for in one particular year. It can be seen that in most cases the ratio is between 0.5 and 1.5 which suggests that both the research and the patent applications are of high quality. In many cases the ratio is above one. This is because a patent application can take a few years before it is granted. So in some cases the number of patents granted is higher than the number applied for in one particular year.

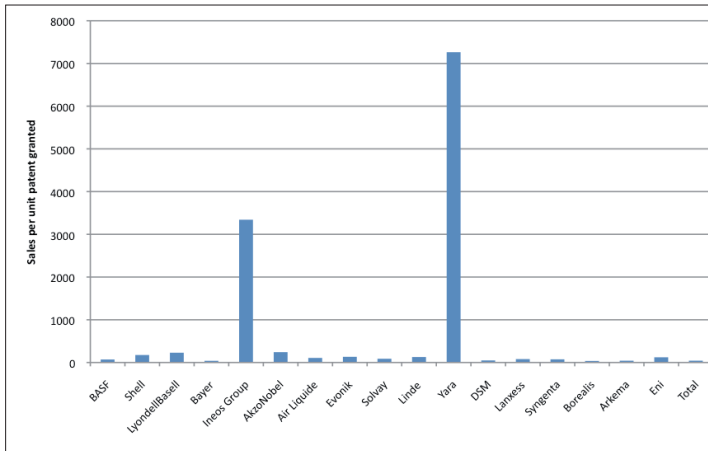
Figure 10. Ratio of application to granted patent for the top chemicals of Europe



Data source: Thomson Innovation (2014). Authors' analysis

Figure 11 is an interesting analysis as the amount of sales per patent applied. It is evident that Ineos and Yara have a very high value which is definitely due to less focus on patenting.

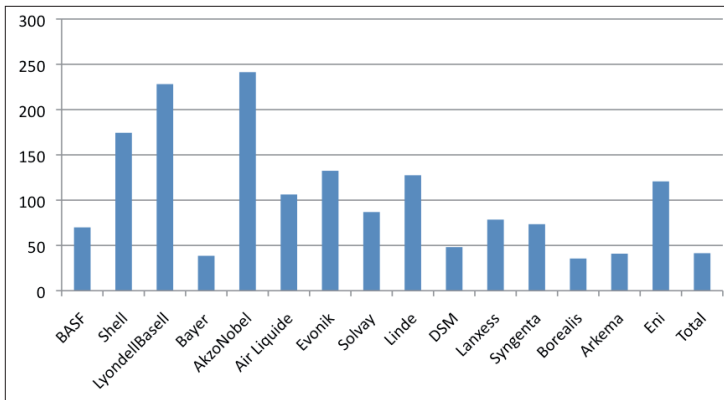
Figure 11. Sales per unit of granted patent



Data source: Thomson Innovation (2014). Author's analysis

Since the data from Yara and Ineos makes us difficult to see and compare other companies, the figure 12 shows better how are rest of the companies doing in term so sales per unit patent application. Bayer and Basf due to very large number of patent application have a lower ratio.

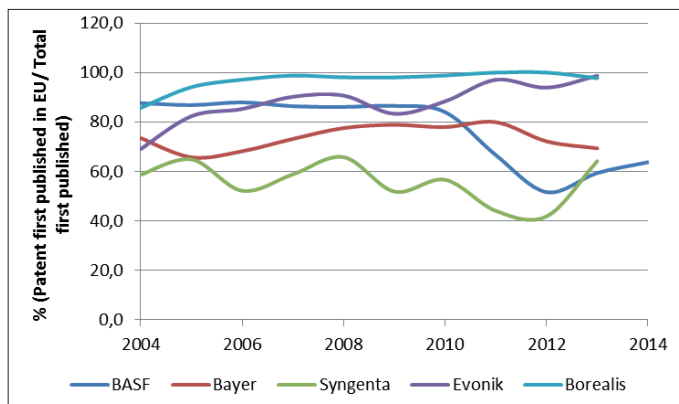
Figure 12. Sales per unit of granted patent for the companies whose ratio value is small



Data source: Thomson Innovation (2014). Author's analysis

The figure 13 shows the percentage of the patents of a particular family that were first applied in EU compared to total global application of the first patent of that family for the companies having highest granted patents. It is seen in most cases, 50 % of the first patent is applied in EU which can be due to the fact that the research is coming out of the laboratories in EU or the companies see higher urge to protect their technology in the EU market. It also interesting to see that in case of BASF, there is a steady fall of the EU share of the total first patent, which can be due to the effect of growth of the emerging economies.

Figure 13. Percentage of patent first published in EU compared to total patent published first time



Data source: Thomson Innovation (2014). Authors' analysis

3.5 Conclusion

Patent application until a patent is granted is a complex process consisting of several steps. Chemistry is a leading sector in which high volume of patents are granted at the European Patent Office of which organic fine chemistry, bio-chemistry and pharmaceutical are the key business sector. Only five of the large selling European chemical companies feature in the top 25 fine organic chemistry patent applicants for 2013 which is concerning in terms of their innovation policy. BASF, Bayer and Akzo

Nobel have a falling in number of US granted patents over last 14 years as they focus more on the emerging economies. BASF and Bayer have over the years had largest number of granted patents. For most of the companies that were studied, the first patent of a patent family is applied and granted at the European Patent Office. From the trend analysis for the first hypothesis test, it is seen that most companies did not have an upward trend for the last 10 years. It was seen for BASF and Bayer that they had a downward trend until 2009 and then there was sharp rise in the number of granted patent. This trend was also seen in case of many other companies analyzed. It can be concluded that the global crisis that hit the economy in 2008 – 09 had a negative effect on patenting and innovation.

CHAPTER 4. RESEARCH AND DEVELOPMENT SPENDING

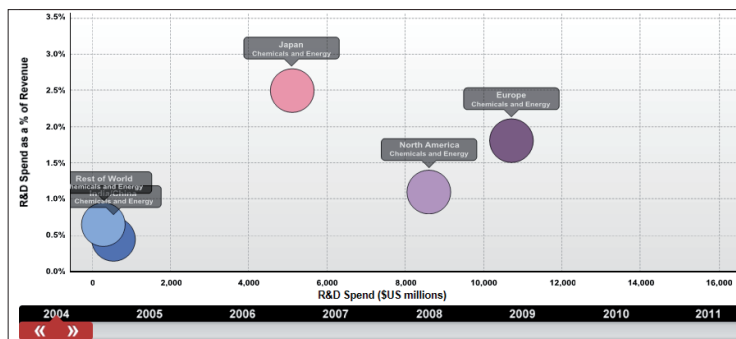
4.1 Introduction

European leadership in science, research and technology is the pillar to becoming a key player in the field of innovation. While innovation is more than research and development, the link between research in chemistry (and related sciences) and innovation is particularly strong in the chemicals industry. Overall, it is necessary to increase the quantity of research. Excellence in science and research must get more opportunities to unfold its inherent impact on open innovation along technology driven paths. In general, companies are urged to review their R&D plans and to extend corporate research programmes to medium and long term objectives. In this chapter we will test the second hypothesis of this research, i.e. if the large chemical companies which are headquartered in Europe are increasing their R&D activities by spending more in R&D. The R&D spending is studied both globally over different regions in the chemical sector. Then a deep drill is made to understand the R&D spending and R&D intensity of the companies under study. A bivariate analysis is made to see if there is any relationship between patent application and R&D spending.

4.2 R&D Spending

Product innovation, competitiveness, sustainability and resource efficiency provide important opportunities for differentiation and, potentially, growth. Innovation will have high positive impacts in economic terms such as improving the performance and competitiveness of existing industries, the development of new industries and solutions as in products and services; in social terms, such as keeping and creating new high value-added jobs and leading to healthier and more comfortable lives; and in environmental terms such as reducing the pressure on our resources by increased efficiency through optimised production processes and products.

Figure 1. Comparative study of R&D spending and R&D intensity of chemical industry in different regions of the world



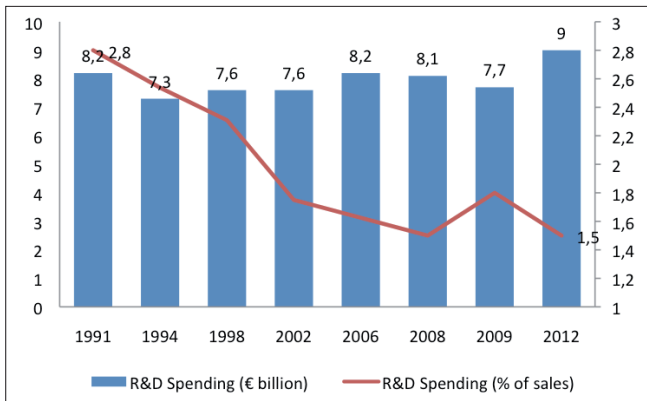
Source: Booz (2014)

Figure 1 compares the R&D activity of the chemical industry in different regions of the world for the year 2011 with 2004 taken as base year. The data is divided into seven regions: Europe, North America, Japan, India / China and Rest of the World. In terms of absolute value, European chemical industry is the biggest spender with almost \$10,500 million followed by North America of around \$ 8,500 million while Japan is distant third with around \$ 5,000 million. R&D spending for India / china in chemical industry is very low. In terms of R&D intensity which is the ratio of R&D spending to revenue expressed as percentage, Japan is the leader followed by Europe.

The European chemical industry is therefore uniquely placed to grow in the internal market as well as develop as a global leader for development –driven product and breakthrough. Many of the challenges faced by the chemicals industry affect economic activity and society as a whole and concern manufacturing industry across the board. Innovation is indispensable to overcome these challenges, avail of related opportunities and ensure the industry’s further success. The chemicals industry has a key role through its enabling function for the entire economy. It shapes economic activities in other sectors. It is an irreplaceable provider of innovation to ‘downstream’ industries and an essential component of value chains that end with the great majority of consumer products. This means that the industry will always have a strategic, economic and

social importance. Europe must retain a strong base in this sector, not only because of its economic weight, but also because of its ability to continually generate innovation critical to meeting the major challenges of modern societies. In European Union, there has been a decline in R&D spending in terms of absolute value as well as percentage of sales as shown in the figure 2.

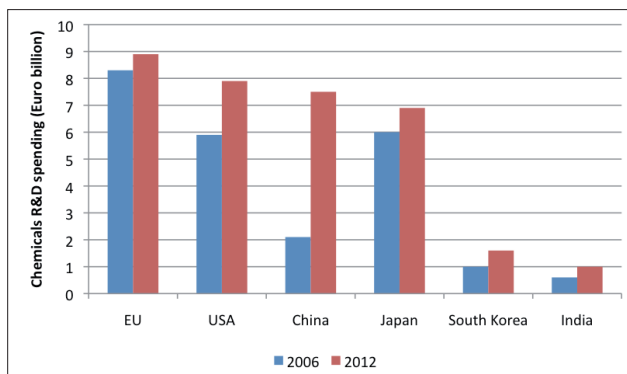
Figure 2. R&D spending and R&D spending as a percentage of total sales



Source: Cefic (2013). Graph: Author

Even though the R&D spending in absolute term has remained almost the same over the years, it is way ahead compared to other geographical regions. In China there has been threefold increase of R&D investment in 2012 compared to that of 2006. For Other regions, the R&D spending has slightly increased (figure 3).

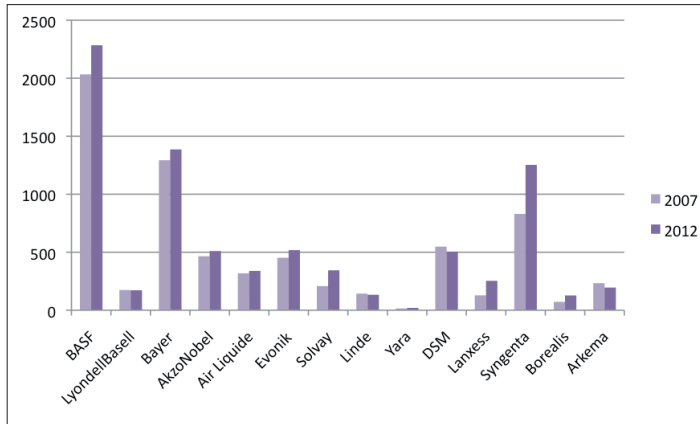
Figure 3. R&D spending of different geographical region in 2012 compared to 2006



Source: Cefic (2013). Graph: Author

Now we will like to understand the strategy large chemical companies are adopting in terms of R&D spending and investment. BASF has largest R&D spending followed by Bayer as distant second. BASF is the largest chemical company and this high spending on R&D justifies its enormous R&D infrastructure. Bayer invests heavily in research specially its pharmaceutical and crop science division. Syngenta showed highest possible increase in 2012 of R&D expense compared to it in 2007. On the other side of spectrum, we see Arkema and Linde have fallen in 2012 of R&D expenses compared to 2007. Yara had very small R&D spending for both the years (figure 4).

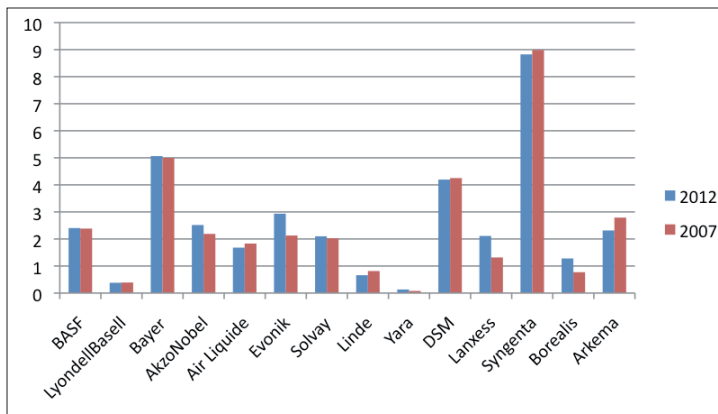
Figure 4. Investment in R&D for the top European chemical companies



Source: Cefic (2013). Author's calculation

R&D intensity is the ratio of the R&D investment to total sales and expressed as percentage. This is an index to show how efficient is R&D in bringing up the sales of a company. Syngenta has the highest R&D intensity followed by Bayer and DSM (figure 5).

Figure 5. R&D intensity of top chemical companies of Europe

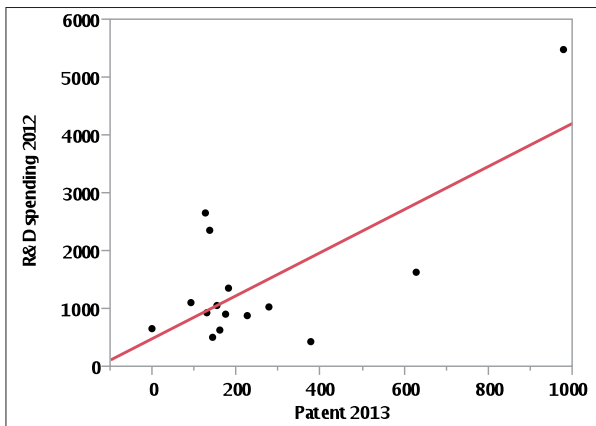


Source: Cefic 2013. Author's calculation

High R&D intensity means although there is high investment in R&D, this is not translated into Sales. Companies invest in R&D in order to develop new products which will increase its sales. But if the investment on R&D is not bringing new sales that means the money on R&D is not well spent. This results in a very high R&D intensity which is not good for any company. It can be noticed that many of the chemical companies is around 2 % in terms of R&D intensity such as BASF, Akzo Nobel, Air Liquide, Evonik, Solvay, and Arkema. Bayer also shows a high R&D intensity of 5 % which can be attributed to their high investment in crop science and pharmaceutical products. LyondellBasell and Yara have very low R&D intensity which can be due to very low level investment in R&D.

Figure 6 shows the relation between R&D spending for 2012 and patent application for 2013. There are two sets of population that can be seen on the chart. One set consisting of high amount of both R&D spending and patents which is seen on the upper right points on the chart. These are from BASF and Bayer. Then there is a scatter of points in the lower left part of the graph where most of the other chemical companies appear. They generally have a lower R&D budget and also as a result of it there is less number of patents applied.

Figure 6. Bivariate Fit of R&D spending 2012 By Patent 2013



Source: Tullo (2013) and Thomson Innovation (2014). Author's Calculation

Linear Fit

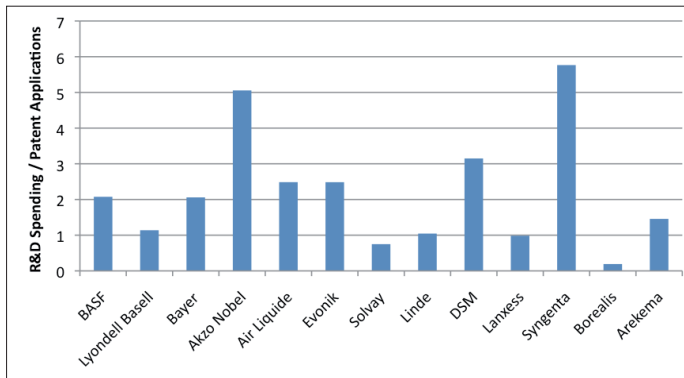
$$\text{R\&D spending 2012} = 494,49936 + 3,7204511 * \text{Patent 2013}$$

Summary of Fit

RSquare	0,51637
RSquare Adj	0,479167
Root Mean Square Error	926,7978
Mean of Response	1434,533
Observations (or Sum Wgts)	15

The red line shows the line fit of the data point. The RSquare of the fit is above 0.5 which makes it more interesting and shows that there is some degree of relationship between the amount of patent applied and the R&D spending a year earlier.

Figure 7. Patent intensity ratio



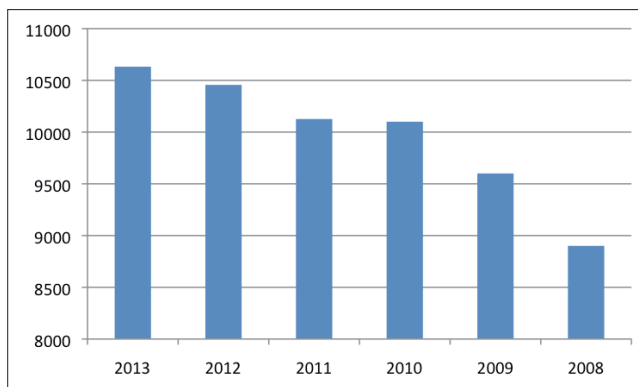
Source: Thomson Innovation (2014). Authors' calculation

Another way of measuring how efficiently is the R&D spending is how many patent applications has this resulted. Figure 7 shows the ratio of the R&D spending to patent applications. It is assumed in this data analysis that the patent is applied after one year of research, that means the R&D spending is taken for 2012 while patent application data is taken for 2013. Bayer and BASF, who have the largest patent granted, are both around 2 while few are also below one. The companies whose ratio is low tend to show that their R&D is more efficient in generating patent applications or ideas (figure 7).

4.3 Further R&D spending studies for specific companies

From the previous analysis, we have seen BASF and BAYER have the largest number of granted patent in the list of nineteen chemical companies that we are studying. So we will like to understand this on their R&D spending strategy. Figure 6 below shows that BASF has been investing in R&D by increasing in the number of people in that group. It is interesting to see that just after the financial crisis that hit in 2008, BASF has been increasing its work force in R&D, thus showing their strategy of R&D expansion (figure 8).

Figure 8: Number of people working in R&D in BASF



Source: BASF Annual Report (2008-2012). Author's analysis

The table 1 below shows how the R&D budget is spent in BASF. Until 2012, there was an expenditure head plastics, but from 2013 this does not exist. This is an interesting way of re-organizing the portfolio based on business need. Functional materials are given a much higher research focus. Chemicals and oil & Gas budget in terms of percentage is also increased over the years.

Table 1. R&D spending of BASF in several segments

Segment	2013	2012	2011	2010	2009
Chemicals	10	8	8	9	9
Plastics		9	9	10	9
Performance Product	20	20	21	19	20
Functional Materials & Solutions	20	14	12	12	12
Agricultural Solutions	26	25	26	26	25
Oil & Gas	3	2	1	1	1
Corporate Research & Others	21	22	23	23	24

All the numbers in this table are in percentage of the total R&D spending
 Source: BASF Annual Report (2009-2013). Author's analysis

Bayer's expenditure on R&D is divided into three broad segments: materials, agricultural and health. Pharmaceutical is the largest sector of R&D spending and this also results in largest number of patents for the company. Over the years, Bayer is slightly increasing its research focuses on crop science (table 2).

Table 2: R&D Spending of Bayer in different segments

Segments	2013	2012	2011	2010	2009
Material Science	7	8	8,1	7,6	7,5
Crop Science	27	26	24,7	23,6	23,8
Health Care					
Pharmaceutical	52	52	53	57,4	67,3
Consumer	12	13	13,4	10,3	

Source: Bayer Annual Report (2010-2014). Author's calculation

4.4 CONCLUSION

Europe makes the largest spending in research and development in chemistry and chemical engineering. BASF, Bayer and Syngenta are the largest spender in R&D while Syngenta, Bayer and DSM are highest in terms of R&D intensity. Most companies have a patent intensity ratio of around two or below. BASF has been increasing its R&D work force significantly over the last five years. It is focusing more on research on functional materials. Bayer is increasing its research in crop science. So the second hypothesis is proved true for most of the chemical companies that they have been increasing their R&D spending over the years, especially in last 5 years.

CHAPTER 5. INNOVATION THROUGH MERGER AND ACQUISITION

5.1 Introduction

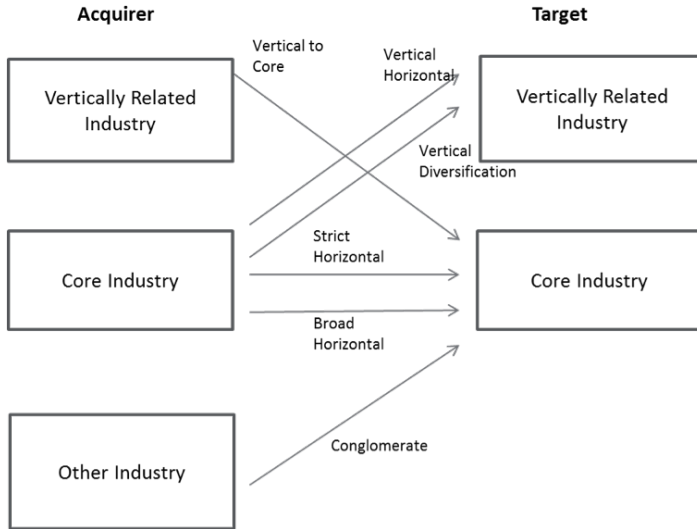
Research establishes that firms spend considerable amount of resources to acquire other firms in order to promote growth, improve efficiency, achieve risk reduction, and secure competitive advantage with respect to competitors in the product market. Both Merger and Acquisition (M&A) and innovation are instruments for growth and competitive advantage and therefore are fundamental to each firm's competitive strategy. Usually, both instruments have been studied separately, but much less together. Although we have a detailed understanding of these traditional motives of M&A, there has been relatively little research on the effect of M&A activity on the innovation output of a firm specially for chemical industry. This is unfortunate as both processes – the process of innovation and the process of mergers and acquisitions - are intimately connected. The impact of mergers on innovation can only be rigorously assessed, if the converse direction of influence - mergers caused by innovation - is accounted for. Therefore this chapter tries to take a balanced view on both processes and to point out links between them for the chemical industry. Nevertheless, the focus is on the impact of mergers on innovation.

5.2 Merger, Acquisition and innovation matrix

Chemical firms have played a prominent role in the wave of international M&As, accounting for some of the biggest international mergers of the decades. There are various reasons why a company acquires another. The figure 1 divides the acquirer's specialty as vertically related industry, core industry or other industry. So an acquirer with vertical related industry will try to acquire a core industry in its sector or other sector. An acquirer with core industry specialty in a particular sector would acquire a company

either having core specialty in another sector or having strong foot hold in the vertically related industry of the acquirer (figure 1).

Figure 1. Various reasons and strategy for acquisition of companies



Source: Ornaghi et al. (2004)

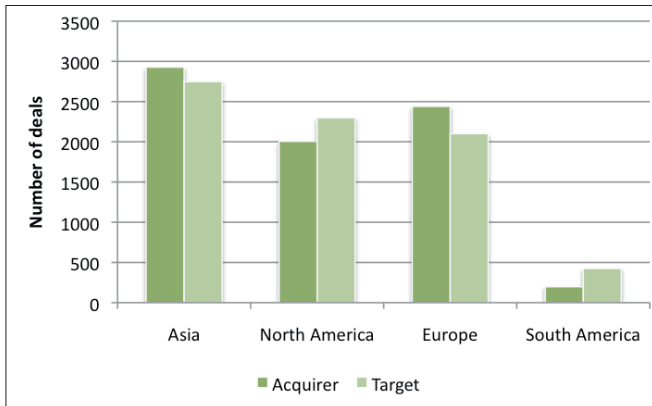
We now turn to the diversification strategies and the extent of ownership control over acquired firms. In particular, we compare intra-regional and international M&As, and attempt to provide explanations for these differences when they exist. Particular attention is being paid to the R&D intensity of the chemical industry. Using standard industrial code (SIC code) as obtained from Thomsonone database of the target and the acquiring companies and the distinction between core chemicals and vertically related industries, six different diversification strategies were identified as explained in the figure above. When both companies belong to core chemicals, there are two types of acquisitions: Strict and Broad horizontal. When the acquirer had a product line in core chemicals and the target firm belongs to one of the vertically related industries, we get vertical integration. Vertical-Horizontal is the case when the acquiring company was already present in the target firm's industry and vertical

diversification is the opposite of it. When the target firm belongs to core chemicals and the parent firm belongs to one of the five vertically related industries, it is called as vertical-to-core.

Figure 2 breaks down the acquisition deals over the last 10 years involving chemical companies according to region. The dark green bars show the number of deals in which the acquirer was located in a particular geographical region. The fact that the acquirer is located in a particular geographical region does not mean that the target is also located there. The light green bars show the geographical location of the target company.

Most of the deals were in Asia followed by Europe and North America. As we have already discussed, the purpose of the acquisition is to grow in the current market or diversify in the newer market. In many of the deals the target companies are active in sectors other than the chemical sector. So, apart from market diversification, the purpose of these deals is to gain R&D knowledge about the target companies' products. This is another way of innovating faster than by internal development.

Figure 2. Number of deals for last 10 years with the location of the acquirer and the target companies

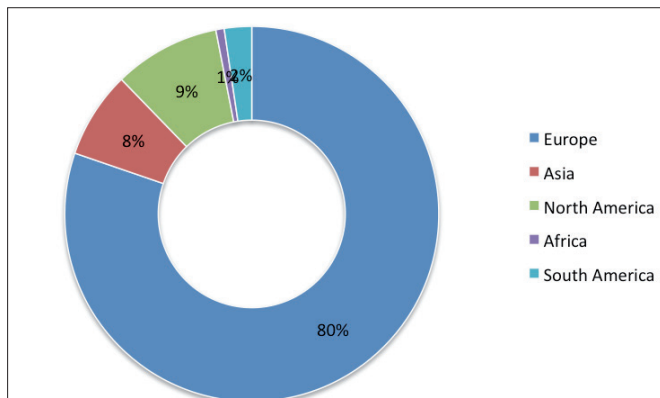


Source: Thomsonone (2014)

5.3 Acquisitions and Mergers of European of chemical companies around the world

As stated earlier, the chemical industry around the world is very active in going for mergers and acquisition either to organically grow or acquire know-how. It is seen that highest deal activities were done in Asia followed by Europe and North America. This can be due to higher availability of cash in Asia or more market opportunity in this region. As we already discussed, the purpose of the deals are to have organic growth in the same market or diversification in the newer market. It is observed in many deals that the target company is active in a different sector than that of the chemical sector of the acquirer company. So the purpose of such deal apart from market diversification is to gain the R&D knowledge of a given product. This has been another way of gaining innovation faster than internal development.

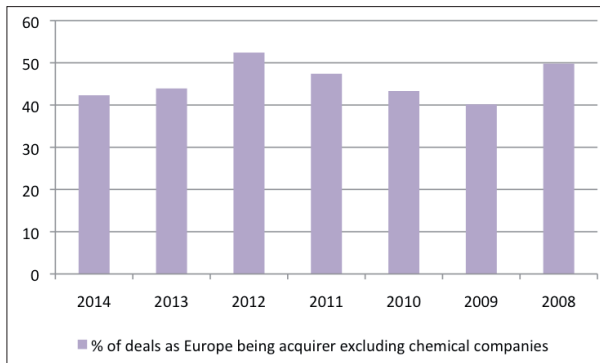
Figure 3. Geographical distribution of the target chemical companies when the acquirer company is located in Europe



Source: Thomsonone (2014). Graph: Author

Figure 3 shows how the target chemical companies are geographically distributed when the European chemical companies are the acquirer. It is seen that when the acquirer chemical companies are located in Europe, they prefer to acquire a European company. Acquisition from other region is very nominal moving around 8 to 9 % for Asia and North America respectively.

Figure 4. Percentage of deals in which European companies being the acquirer and the target companies are non-chemical companies



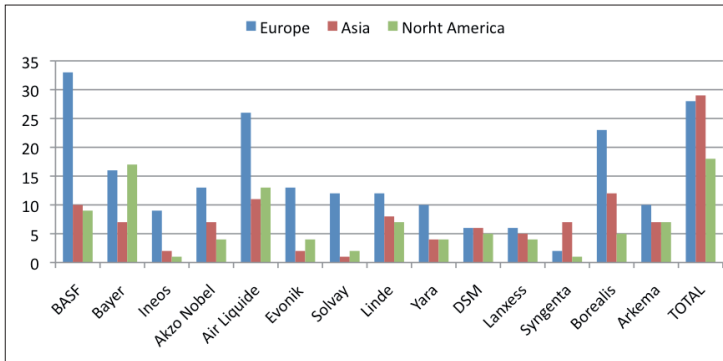
Source: Thomsonone (2014). Author's calculation, Graph: Author

If we see in details the acquiring strategy of European chemical companies over the last five years (figure 4), it is observed that a huge percentage of acquisition is done for non-chemical companies. It depicts a typical intent of these companies for diversification and acquiring know-how which is not part of their core competencies.

5.4 Top European companies' acquisition strategy

The figure 5 shows the acquisition strategy of the top chemical companies headquartered in Europe. It shows a mixed strategy of acquisition over various geographical regions. For most companies such as BASF, Air Liquide, Ineos, Evonik and Solvay, there is a strong inclination for acquisition of European companies. On the other side, for some other companies such as Bayer, DSM and Arkema, there is a tendency to do acquisition more globally.

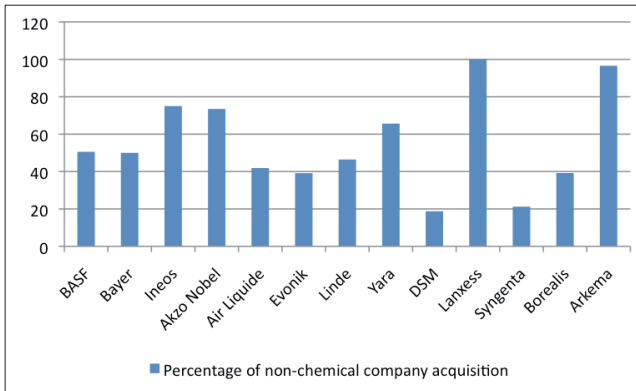
Figure 5. Geographical distribution of acquisition of top chemical companies around Europe, Asia and North America



Source: Thomsonone (2014). Author’s calculation and graph

The figure 6 shows the percentage of non-chemical company acquisition of the large European chemical companies for the last ten years. These companies have huge competencies in chemical and related sector, but lacked the know-how of some other sectors they wanted to step in.

Figure 6. Percentage of non-chemical companies acquired by the top chemical companies for the last 10 years



Source: Thomsonone (2014). Author’s calculation and Graph

So they acquired companies from other sector to quickly gain the technical knowledge and thus accelerate the innovation. It is seen Lanxess and Arkema mainly stick its acquisition strategy for chemical company, while for BASF which is the largest chemical company of the world; almost 50 % of their acquisition were outside chemical sector. A similar trend was observed for Bayer, who published one of the highest numbers of patents for the last ten years. They acquired 50 % of the companies outside their core competences of chemical and pharmaceutical. So it is seen that most of the large chemical companies in Europe are using acquisition as a tool for acquiring the know-how and knowledge from sectors where they did not have core competency.

5.5 Individual company analysis

We will now study in details some of the deals that the top chemical companies under took in recent past and the reasons for such deals. We have picked up those deals whose purpose was to acquire a new product development or a new process or technology. The basic deal information was taken from Thomsonone 2014 database, and it is followed by further analysis in order to justify the main cause of such deal. For each deal, the first statement states the details of the deal while the second statement states the actual reason for the acquisition.

1. BASF

1. BASF New Business GmbH, a unit of BASF SE, acquired the entire share capital of Deutsche Nanoschicht GmbH, a Rheinbach-based provider of coating technologies services, in a leveraged buyout transaction. 06/06/2013 GERMANY

- The purpose of the transaction for BASF SE was to bring new innovative technology to market.

2. BASF AS (BASF), a wholly-owned subsidiary of BASF SE, completed a tender offer to acquire the entire share capital of Pronova BioPharma ASA. 11/21/2012 NORWAY

- The purpose of the transaction was for BASF AS to strengthen its position in the market for omega-3 fatty acids.

3. BASF SE of Germany acquired Becker Underwood Inc (Becker), an American based manufacturer and wholesaler of specialty bio-agronomic and colorant chemical products. 09/20/2012 US

- The purposes of the transaction were for BASF SE and Becker Underwood Inc to develop and market new types of products for agriculture and expand their business particularly in the seed treatment market, to create a global business unit with the integration of their businesses, and to create value for their customers.

4. BASF SE of Germany acquired ITWC Inc, a Malcom- based manufacturer of polyurethane systems and polyester polyols solutions. 07/03/2012 US

- The purposes of the transaction were for BASF SE to expand market in North America, to offer new products and to strengthen its operations.

5. BASF SE acquired Equateq Ltd, a London-based manufacturer of chemicals. 05/09/2012 UK

- The purpose of the transaction was for BASF SE to extend its omega-3 products for the pharmaceutical and dietary supplement industries.

2. BAYER

1. Bayer AG acquired the entire share capital of STEIGERWALD Arzneimittelwerk GmbH, a Darmstadt-based manufacturer of pharmaceutical products. 05/16/2013 GERMANY

- The transaction was for Bayer AG to strengthen its position on the pharmaceutical products manufacturers market.

2. Evelyn Acquisition Co, a special purpose acquisition vehicle formed by Bayer HealthCare LLC, a majority- owned unit of Bayer AG's Bayer Healthcare AG subsidiary, completed its tender offer to acquire the entire share capital of Conceptus Inc (Conceptus), a Mountain View-based manufacturer and wholesaler of permanent birth control devices. 04/29/2013 US

- The purpose of the transaction was for Bayer HealthCare LLC to broaden its portfolio in the field of contraception and to offer new products to its clients.
- 3. Bayer CropScience AG, a unit of Bayer AG, agreed to acquire PROPHYTA Biologischer Pflanzenschutz GmbH, a Malchow-based provider of biotechnology research services. 01/08/2013 GERMANY
 - The purposes of the transaction were for Bayer CropScience AG to strengthen its fruits and vegetables business and to allow new products and solutions into its portfolio.
- 4. Bayer HealthCare LLC, a majority-owned unit of Bayer AG's Bayer Healthcare AG subsidiary, acquired Teva Animal Health Inc, a Saint Joseph-based manufacturer and wholesaler of animal health products, from Teva Pharmaceutical Industries Ltd. 09/14/2012 US
 - The purpose of the transaction was for Bayer HealthCare LLC to offer new products and services to their clients.
- 5. Bayer CropScience AG of Germany, a unit of Bayer AG, acquired AgraQuest Inc, a Davis-based biotechnology company. 07/03/2012 US
 - The purposes of the transaction were for Bayer CropScience AG to build a leading technology platform for green products, to create synergies and value to the company and its customers, to strengthen its strategically important fruits and vegetables business and to expand its existing biological pest control portfolio.

3. INEOS GROUP

1. INEOS Enterprises Ltd of UK, a unit of INEOS Group AG, agreed to acquire two production facilities of Sasol Solvents Germany GmbH, a Hamburg-based manufacturer of solvents and a unit of Sasol Ltd. 12/17/2013 GERMANY
 - The purpose of the transaction was for INEOS Enterprises Ltd to expand its product portfolio.
2. Ineos Borex AG, a unit of INEOS Group AG of Switzerland, agreed to acquire the Polyacrylonitriles Business owned by Mitsui Chemicals Inc, a Minato, Tokyo-based manufacturer and wholesaler of chemical products. 05/27/2013 Japan

- The purposes of the transaction were for Ineos Barex AG to create synergies and strengthen its operations.

3. INEOS Group AG of Switzerland signed a Letter of Intent to merge its European chlorvinyls activities with the European chlorvinyls activities of Solvay SA, in the formation of a joint venture. Upon completion, INEOS was to own 50% and Solvay the remaining 50% interest of the joint venture. 05/07/2013 BELGIUM

- The purpose of the transaction for INEOS Group AG was to strengthen its operations and create synergies, for Solvay SA was to focus on its core assets.

4. Ineos ChlorVinyl of the UK, a unit of Kerling PLC, acquired PVC business of Tessenderlo Chemie NV, a Tessenderlo-based manufacturer of inorganic chemicals, for EUR 110 mil (USD 158.914 mil) in cash. The transaction was to include VCM, Chlor-Alkali, and part of Organic Chlorine Derivatives in Belgium, Netherlands and France. 06/14/2011 BELGIUM

- The purposes of the transaction were for Tessenderlo Chemie NV to transform itself into a specialty group and for Ineos ChlorVinyl to strengthen its operations.

5. INEOS Nitriles of the US, a unit of INEOS Group Ltd, acquired the Teesside located Seal Sands Site of BASF SE of Germany, a Ludwigshafen-based manufacturer of chemical products. 03/13/2008 UK

- The purpose of the transaction for BASF SE was to divest its Seal Sands Site as part of its strategy and to focus on the core assets of its polyamide value chain.

4. AKZO NOBEL

1. Salvador AG, a wholly-owned subsidiary of Akzo Nobel NV (Akzo), completed a tender offer by acquiring the remaining 29.5% stake, or 5.872 mil ordinary shares, which it did not already own, in Schramm Holding AG (Schramm), an Offenbach-based manufacturer of coating solutions, for EUR 7.318 (USD 10.101) in cash per share, or a total value of EUR 42.972 mil (USD 59.313 mil). Concurrently, Akzo agreed to acquire a 70.5% interest in Schramm. 06/30/2011 GERMANY

- The purposes of the transaction were for Akzo Nobel NV to expand its presence in Ania and to strengthen its operations on the speciality coatings market.

2. Akzo Nobel NV (Akzo) of the Netherlands acquired the carved-out coatings business of SSCP Co Ltd, a Seongnam-based manufacturer of coating materials, for an amended total value of KRW 52 bil (USD 44.876 mil). Originally, Akzo agreed to acquire the carved-out coatings business of SSCP Co Ltd, a Seongnam-based manufacturer of coating materials, for a total value of KRW 54.25 bil (USD 50.995 mil). 06/30/2011 SOUTH KOREA

- The purpose of the transaction was for Akzo Nobel NV to strengthen operations in specialty plastic coatings.

3. Akzo Nobel NV (Akzo) of the Netherlands acquired a 70.5% interest, or 14.033 mil ordinary shares, in Schramm Holding AG (Schramm), an Offenbach-based manufacturer of coating solutions, from SSCP Co Ltd, for EUR 142 mil (USD 205.197 mil) in cash. Concurrently, Akzo launched a tender offer to acquire the remaining 29.5% interest in Schramm. Upon completion, Schramm will be delisted from Hong Kong Stock Exchange. 06/30/2011 GERMANY

- The purposes of the transaction were for Akzo Nobel NV to expand its presence in Asia and to strengthen its operations on the speciality coatings market.

4. Akzo Nobel Industrial Finishes AB of Sweden, a unit Akzo Nobel NV, acquired the wood adhesives activities of Kronochem GmbH (KG), located in the Czech Republic, Romania, Bulgaria and Slovakia, a Bischweier-based manufacturer of chemicals. KG was a unit of Kronospan GmbH. 04/28/2009 CZECH REPUBLIC

- The purposes of the transaction were to strengthen Akzo Nobel Industrial Finishes AB's portfolio and boost its technological capability.

5. Akzo Nobel Farbe & Heimtex GmbH, a unit of Akzo Nobel NV's Akzo Nobel Deco GmbH unit, acquired Joh Peters sen GmbH & Co KG, a Viersen-based manufacturer of paints, wallpapers, carpets. 01/14/2009 GERMANY

- The purpose of the transaction for Akzo Nobel Farbe & Heimtex GmbH was to strengthen its business.

5. AIR LIQUIDE

1. Air Liquide SA to acquire Plug Power Inc for USD 2.60 million

- The purpose of the transaction was for Plug Power Inc to strengthen its operations.

2. Schuelke & Mayr GmbH of Austria, a unit of Air Liquide SA, acquired Merz Hygiene GmbH, a Frankfurt am Main-based manufacturer of disinfection products, from Merz GmbH & Co KGaA. 05/03/2013 GERMANY

- The purpose of the transaction was for Air Liquide SA to strengthen its position on the hygiene products market.

3. Air Liquide Canada acquired Arrow Welding & Industrial Supplies Inc, an Edmonton-based wholesaler of industrial equipment. 01/22/2013 CANADA

- The purpose of the transaction is to strengthen and expand the presence of Arrow Welding in its primary market.

4. Societe d'Exploitation de Produits Pour les Industries Chimiques SA, a unit of Air Liquide SA, acquired BiotechMarine SAS, a Pontrieux-based manufacturer and designer of cosmetics products. Terms were not disclosed. 01/07/2013 FRANCE

- The purpose of the transaction was for Air Liquide SA to reinforce its position in the field of healthcare specialty ingredients.

5. Air Liquide Industrial US LP, a unit of Air Liquide SAs American Air Liquide Holdings Inc, acquired Progressive Resources Inc, an Elk City-based provider of oil field services. 01/03/2013 US

- The purpose of the transaction was for Air Liquide Industrial US LP to expand its product offering and operations to its clients.

6. EVONIK

1. Evonik Industries AG of Germany, a unit of RAG- Stiftung, acquired SurModics Pharmaceuticals Inc, a Birmingham-based manufacturer of pharmaceuticals, from SurModics Inc, for USD 30 mil in cash. 11/01/2011 US

- The purposes of the transaction were for SurModics Inc to focus on its full resources to advance its core Medical Device and IVD businesses and to strengthen SurModics' company profile.
2. Evonik Industries AG of Germany, a unit of RAG- Stiftung, acquired the Solsilc plant of Fesil AS, a Ranheim-based manufacturer and wholesaler of ferrosilicon (FeSi) and silicon metal (SiMetal). 10/31/2011 NORWAY
- The purpose of the transaction was to further develop and industrialize the Solsilc-process.
3. Evonik Industries AG (Evonik), a subsidiary of RAG-Stiftung, acquired the entire share capital of Hanse chemie AG, a Geesthacht-based manufacturer of chemical products. Concurrently, Evonik planned to acquire Nanoresins AG. 03/25/2011 GERMANY
- The purpose of the transaction was for Evonik Industries AG to strengthen its operations on the chemical specialties market.
4. Evonik Industries AG (Evonik), a subsidiary of RAG-Stiftung, acquired the entire share capital of nanoresins AG, a Geesthacht- based manufacturer of nanoparticles. Terms were not disclosed. Concurrently, Evonik acquired hanse chemie AG. 03/25/2011 GERMANY
- The purpose of the transaction was for Evonik Industries AG to strengthen its operations on the chemical specialties market.
5. Evonik Industries AG, a subsidiary of Rag- Stiftung agreed to acquire Resomer business of Boehringer Ingelheim Pharma GmbH & Co KG. 01/14/2011 GERMANY
- The purpose of transaction was for Evonik Industries AG will complement the EUDRAGIT business of Evonik - functional excipients for oral dosage forms - and will strengthen Evoniks pharmaceuticals market segment in line with its stated strategic intent. Additionally Evonik will be able to expand its expertise in new pharmaceutical application areas.

7. SOLVAY

1. Solvay SA of Belgium acquired Chemlogics Group LLC, a Paso Robles-based manufacturer of specialty chemicals, for USD 1.345 bil in cash. 10/07/2013 US

- The purposes of the transaction were for Solvay SA to strengthen its Novicare business and other key operations, offer new products, and expand geographical and market presence. As a result of the acquisition, synergies are expected to be accretive.
2. Rhodia Inc, a unit of Solvay's SA Rhodia SA subsidiary, agreed to merge its certain assets with certain assets of OAO "SIBUR Holding", a Saint Petersburg- based manufacturer of petrochemical products, and unit of SIBUR Ltd, to form a joint venture named Ruspav. Upon completion, Rhodia is to own 50% and SIBUR HOLDING the remaining 50% of the joint venture. 10/09/2012 RUSSIA
- The purpose of the transaction was for OAO "SIBUR Holding" to allow to offer new products and services to its clients as well as to expand presence in selected markets.
3. Solvay SA of Belgium acquired a fluorspar mine, from N&N Group. 01/13/2011 BULGARIA
- The purpose of the transaction was for Solvay SA to extend development of its fluorinated chemicals business.
4. Solvay SA of Belgium acquired a 13% stake in ACAL Energy Ltd, a Cheshire-based manufacturer of fuel cell system. 12/03/2008 UK
- The purpose of the transaction was for ACAL Energy Ltd to accelerate the development of its fuel cell technology FlowCath.
5. Solvay Pharmaceuticals SA to acquire Innogenetics NV for USD 340.46 million
- The purpose of the transaction was to continually develop and expand Solvay Pharmaceuticals SA's diagnostic business.

8. LINDE

1. Linde AG of Germany agreed to acquire Calea France SAS, a Sevres-based provider of home health care services. 12/17/2012 FRANCE
- The purpose of the transaction was for Linde AG to improve position on the French homecare market.
2. Linde Canada Ltd, a unit of Linde AG, acquired Contact Welding Supplies Ltd, a London-based manufacturer and wholesaler of industrial, medical and specialty gasses and related welding products. 10/02/2012 CANADA

- The purpose of the transaction was for Linde Canada Ltd to strengthen its market in the southwestern Ontario.
3. Linde AG acquired the Continental-European homecare business of Air Products & Chemicals Inc, an Allentown-based manufacturer and wholesaler of gases and chemicals. 01/09/2012 GERMANY
- The purposes of the transaction were for Linde AG to expand its competencies and scale up its product and service offering.
4. BOC Ltd, a wholly-owned unit of the BOC New Zealand Holdings Ltd subsidiary of Linde AG's BOC Group PLC unit, acquired the remaining 50% interest, which it did not already own, in Elgas Ltd, a liquefied petroleum gas {LPG} manufacturer and wholesaler, from its joint venture partner, AGL Energy Ltd. 10/02/2008 AUSTRALIA
- The purpose of the transaction was for Linde AG to further achieve synergies in its gas production and distribution operations.

9. YARA

1. Yara International ASA of Norway agreed to acquire H+H Umwelt-und Industrietechnik GmbH, a Hargesheim-based manufacturer and wholesaler of catalytic reduction systems. 01/13/2014 GERMANY
- The purpose of the transaction was for Yara International ASA to develop its portfolio of NOx reduction systems.
2. Yara International ASA of Norway agreed to acquire ZIM Plant Technology GmbH, a Hennigsdorf-based manufacturer of irrigation monitoring products. 11/18/2013 GERMANY
- The purpose of the transaction was for Yara International ASA to improve its position within the growing fertigation segment.
3. Yara International ASA agreed to raise its stake to 35% from 30% by acquiring a further 5% stake in Burrup Holdings Ltd, an ammonia manufacturer, from Mr. Pankaj Oswal. 09/16/2008 AUSTRALIA
- The purposes of the transaction were to increase Yara International ASA's position in a low-cost gas area and to strengthen its contractual rights to downstream upgrading and marketing from Burrup Holdings Ltd in an interesting market for both its industrial and fertilizer products.

4. Yara International ASA acquired Saskferco Products Inc (SP), a manufacturer of nitrogen fertilizers, from Mosaic Co (MC) and Investment Saskatchewan Inc (IS), for an estimated 1.6 bil Canadian dollars (\$1.59 bil US). 07/14/2008 CANADA

- The purpose of the transaction was for Mosaic Co to focus on their core potash and phosphate businesses, with the proceeds from the sale to be used for the planned expansions of their Saskatchewan potash mines and other non US assets.

5. Yara International ASA of Norway acquired the remaining 65% interest, which it did not already own, in Phosyn Ltd, a manufacturer of pesticides and chemicals. 03/22/2006 UK

- The purpose of the transaction was for Yara International ASA to expand its specialty plant nutrition business

10. DSM

1. DSM Venturing BV of the Netherlands, a unit of Koninklijke DSM NV, acquired an undisclosed minority stake in Viocare Inc, a Princeton-based developer of wellness and nutrition-based software. 09/13/2011 US

- The purpose of the transaction was for Viocare Inc to further expand and mature its business.

2. DSM Venturing & Business Development of the Netherlands, a unit of Royal DSM NV, acquired an undisclosed minority stake in Bioprocess Control AB, a Lund- based manufacturer of automation equipment for biogas producers. 01/11/2010 SWEDEN

- The purpose of the transaction was to optimize the production efficiency of biogas processes of the companies.

3. DSM Venturing & Business Development of the Netherlands, a unit of Royal DSM NV, acquired Segetis Inc, a Golden Valley-based manufacturer of monomers. 01/07/2010 US

- The purpose of the transaction was to increase DSM Venturing & Business Development's focus on exploiting synergy between its Life Sciences and Material Sciences activities.

4. DSME E&R Ltd, a majority-owned unit of Daewoo Shipbuilding & Marine Engineering Co Ltd, acquired an 80% interest in Sunshin

Exploration & Mining Co Ltd, a Seoul-based gold mining company.
11/10/2009 SOUTH KOREA

- The purpose of the transaction was for DSME E&R to step into gold mine business.

11. LANXESS

1. Lanxess AG of Germany acquired PCTS Specialty Chemicals Pte Ltd, a manufacturer and wholesaler of speciality chemicals, from Nipsea Technologies Pte Ltd, a unit of Nippon Paint Co Ltd. 04/05/2013 SINGAPORE

- The purposes of the transaction were for Lanxess AG to gain access to a complementary portfolio of biocides and to expand the business in Asia-Pacific region.

2. LANXESS AG acquired Bond-Laminates GmbH, a Brilon- based manufacturer of carbonfibre strengthened plastics from Ringstad Cato AS. Terms were not disclosed. 09/12/2012 GERMANY

- The purpose of the transaction for LANXESS AG was to strengthening its innovative product portfolio of lightweight materials to the automotive industry.

3. LANXESS AG of Germany acquired an undisclosed minority stake in BioAmber Inc, a Plymouth-based manufacturer of organic chemicals. 02/22/2012 US

- The purpose of the transaction was for LANXESS AG to strengthen its operations in the renewable raw materials market.

4. Lanxess Corp, a subsidiary of Lanxess AG, acquired Verichem Inc, a Pittsburgh-based manufacturer of biocides. Terms were not disclosed. 11/10/2011 US

- The purposes of the transaction were to broaden global biocide manufacturing platform and strengthening focus on megatrend urbanization.

5. Rhein Chemie Rheinau GmbH, a wholly-owned subsidiary of LANXESS AG, acquired the tire release agent business of Wacker Chemie AG, a Munich-based manufacturer and wholesaler of chemicals. 07/08/2011 GERMANY

- The purpose of the transaction was for Rhein Chemie Rheinau GmbH to concentrate on its core business through streamlining its portfolio of products and solutions.

12. SYNGENTA

1. Cimo Compagnie Industrielle de Monthey SA, a unit of Basf SE and Syngenta AG, agreed to acquire a power plant in Monthey from Alpiq Holding AG, a Lausanne-based provider of electric utility services. 12/13/2013 SWITZERLAND

- The purpose of transaction was for Cimo Compagnie Industrielle de Monthey SA to strengthen its operations in the field of electricity production.

2. Syngenta Crop Protection AG of Switzerland, a unit of Syngenta AG, completed a tender offer to acquire the entire share capital of Devgen NV, a Ghent- based manufacturer of biotechnology products. 09/21/2012 BELGIUM

- The purposes of the transaction were for Syngenta AG to reinforce its position in global rice market, to expand its toolbox for development of integrated rice offers and to expand RNAi technology for new biological insect control solutions. The purposes of the transaction were for Devgen NV to reach growers more quickly, enabling vital improvements in crop productivity and protection.

3. Syngenta AG acquired Pasteuria Bioscience Inc, an Alachua-based biotechnology company. 09/19/2012 US

- The purpose of the transaction was to allow Pasteuria Bioscience to sell its products to the global market.

4. Syngenta AG of Switzerland agreed to acquire the Professional Products insecticide business of El du Pont de Nemours & Co Inc {DuPont}, a Wilmington-based manufacturer of chemical and electronic products. 08/29/2012 US

- The purposes of the transaction were for Syngenta AG to expand their presence, increase their portfolio in the US, and create synergies with DuPont-Professional Prod Bus.

5. Syngenta Seeds Inc, a wholly owned unit of Syngenta AG acquired the remaining 50% interest, which it did not already own, in GreenLeaf Genetics LLC, an Omaha-based provider of research and development services, from its joint venture partner, Pioneer Hi-Bred International Inc and a wholly owned unit of El du Pont Nemours & Co. Terms were not disclosed. 11/08/2010 US

- The purposes of the transaction were for Syngenta Seeds Inc to pursue independent licensing strategies for corn and soybean genetics and biotechnology traits, to enhanced offer for independent seed companies and to expand its portfolio of traits and germplasm.

13. ARKEMA

1. Arkema SA of France, acquired a 24.9% stake in Ihsedu Agrochem Pvt Ltd, a Mumbai-based producer and wholesaler of castor oil. 04/11/2013 INDIA

- The purpose of the transaction was for Arkema SA to consolidate its position in the castor oil market.

2. Arkema SA acquired an undisclosed majority interest in Adhesifs et Composites Polymer SAS. 04/03/2013 FRANCE

- The purpose of the transaction was for Adhesifs et Composites Polymer SAS to strengthen its operations and expand its presence in foreign markets.

3. Arkema SA acquires specialty alcoxylate industrial business of Societe d'Exploitation de Produits Pour les Industries Chimiques SA. 11/08/2011 FRANCE

- The purpose of the transaction was for Arkema SA to expand its specialty surfactant range intended in particular for niche markets such as warm asphalt mix for road construction, industrial detergency, and the oil and gas business.

4. Arkema SA acquired Cray Valley SNC, a Paris- based manufacturer and wholesaler of gel coats and resins, from Total SA. Concurrently, Arkema acquired Cook Composites & Polymers Co and Sartomer USA LLC. 12/07/2010 FRANCE

- The purpose of the transaction was for Arkema SA to strengthen its downstream acrylics activities.

5.6 Conclusion

It can be concluded from the above analysis that Asia has the highest number of M&A deals and is closely followed by Europe and North America. European chemical companies tend to acquire much more companies from Europe. Over 40 % of the deals of the European chemical companies are with non-chemical related company. In case of large chemical companies, a mixed strategy is noticed. BASF, Air Liquide, Ineos, Evonik and Solvay were more inclined to acquire European companies while Bayer, DSM and Arkema have been making acquisition globally. For most of the large chemical companies, a big percentage of companies acquired did not deal directly with basic chemicals. From the above analysis and specific examples of the deals, we test positive the hypothesis that large chemical companies take M&A as a route to acquire innovation.

CHAPTER 6. INDUSTRIES, UNIVERSITIES AND RESEARCH ORGANIZATION COLLABORATION TO DRIVE INNOVATION

6.1 Introduction

When companies and universities work together to push the frontiers of knowledge, they become a powerful engine for innovation and economic growth. Silicon Valley is a clear example. For over five decades, a dense web of rich and long-running collaborations in the region have given rise to new breakthrough technologies at an incredible pace, and transformed industries while modernizing the role of the university. Similar activities are also observed in chemical industry in Europe. Technologies from different industries are also increasingly being combined to create new products and services. A fundamental challenge for the successful development of these inter-industry and university innovations is to combine the previously unconnected technologies in entirely new product architecture. This chapter covers various research collaborations happening in European chemical industry between industries and Universities or Research center and studies if such collaboration is impacting the innovation trend of the companies.

6.2 Industry-University collaboration: A driver toward innovation

For an elite group of world-class research universities, this kind of strategic collaboration is top priority and the most productive collaborations are strategic and long-term, according to the practitioners. They are built around a shared research vision and may continue for a decade or beyond, establishing deep professional ties, trust and shared benefits that work to bridge the sharp cultural divide between academia and industry. Strategic partnerships between companies designed to run for five to ten years delivering greater and often unanticipated benefits to all parties through

a virtuous circle of interactions. For the university, they provide a longer stream of secure funding that can bolster academic strength along with helping modernize teaching and learning by fostering an exchange of ideas and developing people with the skills and competences needed as new innovations transform markets and industries. Above all, long-term alliances build the vital human capital needed to make the industry-industry and industry-university collaborations work. It is the human ties, understanding and trust on both sides of the partnership that count most.

Creating more strategic industry-university partnerships would substantially improve Europe's climate for innovation. The modernization of Europe's higher-education systems is a need to strengthen the links between higher education, research and business to drive innovation. The European Commission launched a number of initiatives to enhance closer and more effective ties between the three corners of the knowledge triangle, including the European Institute for Innovation and Technology (EIT), the Knowledge Alliances pilot project and the University-Business Forum.

The aim of such initiative is to complement – and add more of a business perspective to – a growing body of academic studies on the state of European industry-university partnerships.

The increased incentives to collaborate with industry have controversial side effects on the production of scientific research itself. Nelson (2004) argues that industry involvement might delay or suppress scientific publication and the dissemination of preliminary results, endangering the “intellectual commons” and the practices of “open science” (Dasgupta and David, 1994). Florida and Cohen (1999) claim that industry collaboration might come at the expense of basic research: growing ties with industry might be affecting the choice of research projects, “skewing” academic research from a basic towards an applied approach.

6.3 Research collaborations

There are specific programme on ‘Cooperation’ supports covering all types of research activities carried out by different research bodies in trans-national cooperation and aims to gain or consolidate leadership in key scientific and technology areas.

The main types of such cooperation as supported by various government organizations are:

1. European Union Research Funded Projects
 - FP 7
 - FP 6
 - FP 5
 - Other (FP 4, FP 3, FP 2, FP 1, CIP, EAEC, ECSC, ENG, ENV, JRC etc.)
2. German Government Funded Projects
 - The Federal Ministry of Education and Research (BMBF)
 - The Federal Ministry for Economic Affairs and Energy (BMWi)
 - The Federal Ministry of Food and Agriculture (BMEL),
 - The Federal Ministry of Health (BMG),
 - The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)
 - The Federal Ministry of Labour and Social Affairs (BMAS)
3. The French National Research Agency
4. Dutch Government Funded Projects
 - NWO
 - The Technology Foundation STW
 - SenterNovem
5. Spanish Government Funded Projects

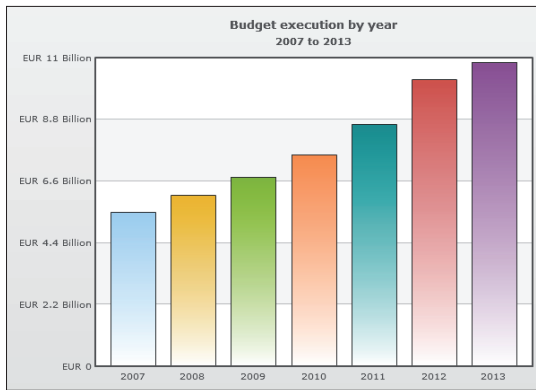
In this chapter we will focus on the European Union funded research projects. There are three prime EU funded research projects as stated above: FP7, FP 6, FP 5. The following part of this section tries to understand in details of these funding platforms.

EUROPEAN UNION FUNDED PROJECTS:

The budget of the European Union Research Funding is devoted in supporting cooperation between universities, industry, research centers and public authorities throughout the EU and beyond. The Cooperation programme is sub-divided into ten distinct themes. Each theme is operationally autonomous but aims to maintain coherence within the

Cooperation Programme and allowing for joint activities cutting across different themes, through, for example, joint calls. The ten identified themes reflect the most important fields of knowledge and technology where research excellence is particularly important to improve Europe's ability to address its social, economic, public health, environmental and industrial challenges of the future. Important themes identified in the Strategic Research Agendas (SRAs) developed by the ETPs are therefore covered by the Cooperation programme. The last EU funded project, FP7 allocated EUR 32 413 million to the Cooperation programme.

Figure 1. The budgeted execution of EU FP7 research funding



Source: Research and Innovation FP7 (2014)

European Technology Platforms (ETPs) were set up with the aim of defining medium to long-term research and technological objectives and developing roadmaps to achieve them. Their aim was to contribute to increasing synergies between different research actors, ultimately enhancing European competitiveness. All ETPs have brought together stakeholders, reached consensus on a common vision and established (and in some cases already revised) a strategic research and innovation agenda (SRIA). Some of them have also developed an implementation plan detailing the actions required to implement the SRIA.

Across all these themes, support to trans-national cooperation between industry and academia is implemented through:

- Collaborative research
- Coordination between national research programmes
- Joint Technology Initiatives
- Technology Platforms

6.3.1 COLLABORATIVE RESEARCH

The bulk of EU research funding in FP7 goes to collaborative research, with the objective of establishing excellent research projects and networks able to attract researchers and investments from Europe and the entire world. The Commission's consultation on the future of European research showed very strong support for European funding for trans-national collaborative research, though a common concern was that there should be a lower number of partners in consortia and a greater focus on smaller projects than was the case under the Sixth Framework Programme (FP6). The 6th Framework Programme funded European Research and Technological Development from 2002 until 2006.

6.3.2 COORDINATION BETWEEN NATIONAL RESEARCH PROGRAMMES

The European Commission showed a strong support for more coordination of national research programmes from all categories of contributors. Framework Programme 7 supports in reducing its fragmentation in several national and regional research programmes by favouring the development of joint calls, joint programmes and actions supported together by several Member States and the Commission and also enhances the complementarity and synergy between FP7 and activities carried out under intergovernmental structures such as EUREKA and COST.

6.3.3 JOINT TECHNOLOGY INITIATIVES

For a limited number of European Technology Platforms, the scale and scope of their strategic research agendas and the resources involved justified setting up long-term public-private partnerships in the form of Joint Technology Initiatives. These initiatives, combine private sector

investment and/or national and European public funding, including grant funding from the Research Framework Programme and loan finance from the European Investment Bank.

6.3.4 TECHNOLOGY PLATFORMS

European Technology Platforms (ETPs) have been set up in a number of areas where Europe’s competitiveness, economic growth and welfare depend on important research and technological progress in the medium to long term. They bring together stakeholders, under industrial leadership, to define and implement a Strategic Research Agenda (SRA). The ETPs have contributed to the definition of the themes of the Cooperation programme, in particular in research areas of special industrial relevance (figure 2).

Figure 2. European funded project themes

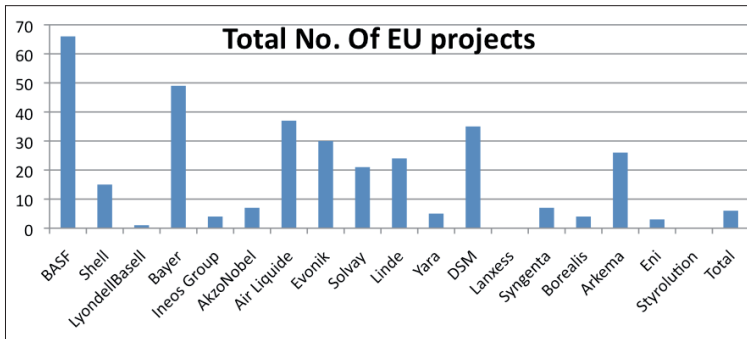
Bio-based economy	Energy	Environment	ICT	Production and processes	Transport
EATIP	Biofuels	WssTP	ARTEMIS	ECTP	ACARE
ETPGAH	EU PV TP		euRobotics	ESTEP	ERRAC
Food for Life	TPWind		ETP4HPC	EuMaT	ERTRAC
Forest-based	RHC		ENIAC	FTC	Logistics
Plants	SmartGrids		EPoSS	SusChem	Waterborne
FABRE TP	SNETP		Networld 2020	Nanomedicine	
TP Organics	ZEP		NEM	ETP-SMR	
			NESSI	Manufature	

Source: CORDIS (2014)

6.4 Participation of the top European Chemical companies in EU funded projects

From the various data analyzed, it is seen that all the top European chemical companies actively participate in EU funded projects. The data for the last 20 years shows BASF is leader in participating in EU funded project. This is followed by Bayer, Air Liquide and Evonik. Although, there is positive force of EU funding which drives these companies to participate in these projects, but it also shows that they are willing to co-operate not only with research institutes and universities but also work with their competitors in driving research and innovation (figure 3).

Figure 3. Total number of EU projects for last 20 years in which the top European chemical companies participated



Data Source: CORDIS1 (2014). Author's calculation and graph

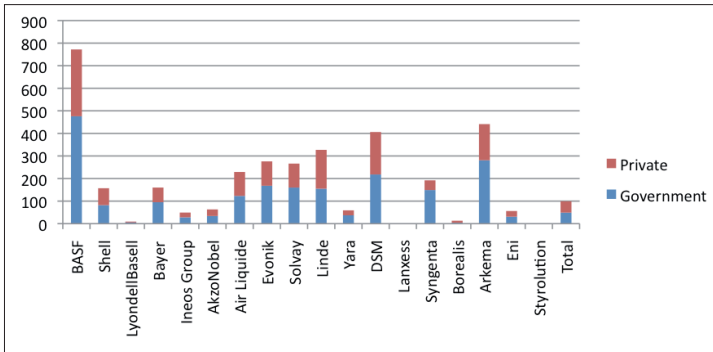
Each of the project in which these companies took part was further analyzed in order to get detailed understanding of the type of projects and the partners. Although the type of project theme varies, but in cases where companies are involved, they tend to be more application oriented. Let us take example of an EU funded research project: A common European approach to the regulatory testing of nanomaterials. The project falls under FP7 framework with total cost of 49 Million Euro. It has 63 partners including top chemical companies: BASF, Bayer, and Arkema. Over 75 % of the participants are government institute or universities. In terms of private companies involved in this project, they were selected based

on their speciality areas such as Veneto Nanotech Spa from Italy who are specialized in Nano-technology. This type of projects drives research and innovation forward but the results are highly unlikely to be patented, given the number of partners and also due to openness of such projects. Another example of BASF's participation in EU project which involves fundamental research is "Developing the Next Generation of Biocatalysts for Industrial Chemical Synthesis". A collaboration of industrial and academic partners had identified the key technology fields of amine synthesis, polymers from renewable resources, glycoscience and wider oxidase application as four key areas where the next generation of biocatalysts that will lead to improvements in both economic and environmental performance of the chemical manufacturing industries. Most of the partners of this project are universities, but there are some private companies as partners also. Most of the private companies are small, but very specialized in the field of the project.

In some cases, two different entities of the same company can be a partner of a project as seen in the project, "The Plant Cell Wall Training Consortium" where Bayer Bioscience and Bayer Cropscience are two separate partners. It is seen as a common phenomenon that these big chemical companies do not partner in these projects with a single entity, rather they participate either as an individual business or individual location entity.

If we look further into how these companies are participating, we see a distinct trend. Some companies are participating more with government organizations while others are in project which has good distribution of private and government organizations. By government organization, we mean universities, colleges and publicly funded research institutes. The figure 4 shows the distribution of the private and government identities in terms of the total participants.

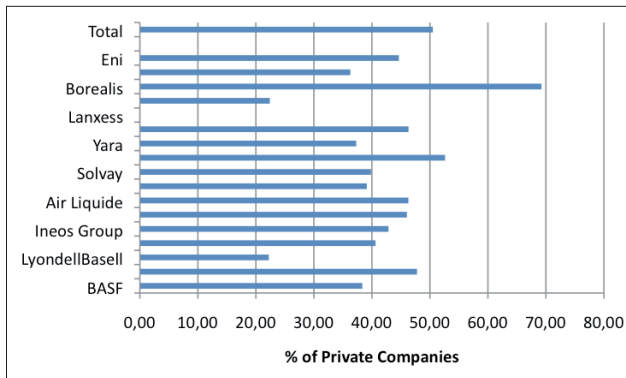
Figure 4. The private company and government partners in the EU projects in which top European chemical companies are involved



Data Source: CORDIS1 (2014). Author's calculation and graph

Figure 5 shows that in these EU project, where one of the partner is the companies under current study, there are 40 -70 % of the participants who are from private sector companies.

Figure 5. Percentage of private companies in the EU projects

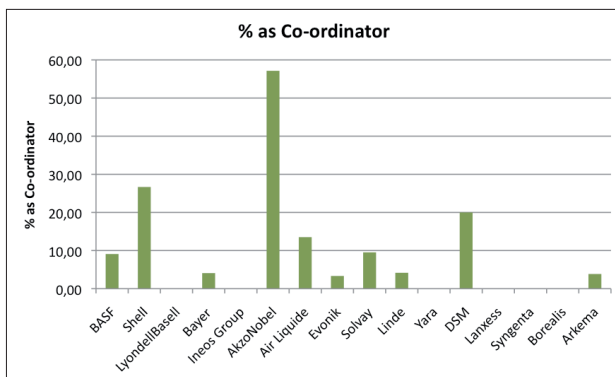


Data Source: CORDIS1 (2014). Author's calculation and graph

Although the top chemical companies participate in a lot of EU funded projects, there is a general tendency that they want to be participant rather

than the coordinator. In most cases they are coordinator in less than 20 % of the projects they participate. This may be due to the fact that this involves significant investment in resource to co-ordinate EU projects. The only company which is somewhat out of the box is Akzo Nobel which is co-ordinator in almost 56 % of all projects they participate (figure 6).

Figure 6. Percentage of EU projects in which the top chemical companies participated and in which they are the coordinator of the project



Data Source: CORDISI (2014). Author's calculation and graph

We have seen previously that some of the top EU chemical companies are collaborating amongst themselves while participating in EU funded projects. Now we will like to evaluate if these companies are jointly filing patents for invention disclosure. For this study we have picked up the top patenting companies as the base companies and then searching the database if they have partnered with the rest of the top 15 companies in filing jointly any patent (figure 7).

Figure 7. Number patents filed jointly by the top 4 base companies with rest of the top European chemical companies

		Base company			
		BASF	Bayer	Air Liquide	Solvay
Comparing Companies	BASF		11	0	0
	LyondellBasell	0	0	0	0
	Bayer	11		0	0
	Ineos Group	0	17	0	23
	AkzoNobel	0	0	0	0
	Air Liquide	0	0		0
	Evonik	0	0	0	0
	Solvay	0	0	0	
	Linde	11	0	0	0
	Yara	0	1	0	0
	DSM	8	0	0	0
	Lanxess	0	0	0	0
	Syngenta	0	1	0	0
	Borealis	0	1	0	0
	Arkema	1	1	0	0

Data source: Thomson innovation. Author's analysis

Assumptions for the above data:

- Assignee/Applicant information is not updated when reassignments are made.
- The Assignee/Applicant-Standardized is the Assignee/Applicant name as it has been standardized by the EPO (via the INPADOC/DocDB data).
- The Assignee/Applicant-Original is the Assignee/Applicant name exactly as provided by the patent issuing authorities; it has not been standardized or normalized.

It is seen that the companies do not collaborate extensively with each other, but some of them partner to some degree to file joint patents. This is seen between BASF and Bayer, Linde and BASF and Solvay and Ineos group.

6.5 Conclusion

Various government agencies in Europe are encouraging research collaboration between the industry and government agencies (universities and research centers). European Union has several funding projects to encourage such collaboration. Top European companies actively participate in the EU funded research projects. In most cases, they want to be collaborator rather than coordinator. In such projects, the members are very even distributed, with private organizations consisting of around 30 to 40 % of total number of participants. There is very little collaboration between these top companies in terms of filing new patents. From the above analysis it is seen that university and research institute collaboration results in various successful R&D projects both in fundamental science and applied research. Such research may necessarily not result in patent application but definitely result in moving forward innovation and R&D. Thus the second part of the third hypothesis that industry and academia has impact on innovation is tested positive in this chapter.

CHAPTER 7. IMPACT OF CHEMICAL REGULATION ON INNOVATION OF EUROPEAN COMPANY

7.1 Introduction

Chemical companies designing new or redesigning existing products in Europe today need to consider both regulatory and environmental performance requirements in their strategy development, as well as during their product development processes. Economic aspects are also very important in order for a business to achieve financially sustainable product development. REACH is a regulation of the European Union, adopted to improve the protection of human health and the environment from the risks that can be posed by chemicals, while enhancing the competitiveness of the EU chemicals industry. It also promotes alternative methods for the hazard assessment of substances in order to reduce the number of tests on animals. In principle, REACH applies to all chemical substances; not only those used in industrial processes but also in our day-to-day lives, for example in cleaning products, paints as well as in articles such as clothes, furniture and electrical appliances. Therefore, the regulation has an impact on most companies across the EU. The aim of this chapter is to describe the impact of the new chemical regulation (REACH) on R&D and innovation activities of the chemical companies of Europe.

7.2 The new chemical regulation in Europe: REACH

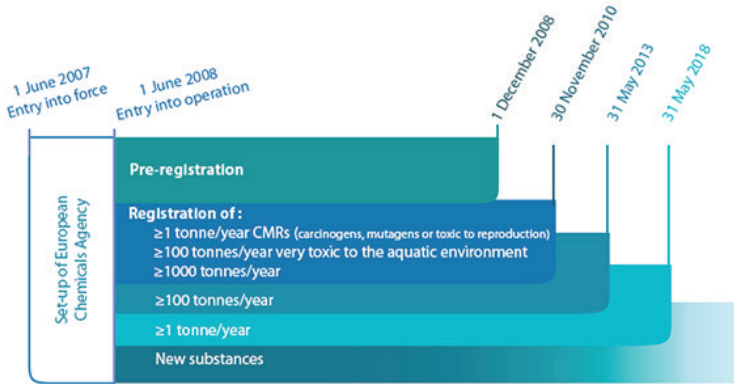
The directive for Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) was adopted by the European Union (EU) in December 2006, and requires companies importing or producing chemicals (>1 tonnes/year) in the EU and EEA regions to register these chemicals with the EU's Chemicals Agency (ECHA). REACH requirements are relevant for both individual substances and substances in mixtures (e.g. paint), although the registration demand is for substances only. Companies

manufacturing or importing substances are required to register the substance's identity, classification and labelling, test results and propose further toxicity tests for the substance, exposure potential to humans and different environmental compartments, and recommendations for safe use. The requirements for REACH increase with quantities of chemicals imported, or produced. Quantities greater than 10 tonnes/year/producer or importer mean that a risk assessment ("Chemical Safety Report", CSR) is required for the substance. If a chemicals company does not comply with REACH, it cannot sell its products in the markets of the European Union or the European Economic Area (Commission of the European Communities, 2007).

Firms have also reported that in recent years they are also often busy implementing a wide range of chemical industry and related initiatives both of EU and industry origin, for example: CLP, revision of the Seveso Directive, RoHS, Responsible Care and the Global Product Strategy, IPPC Directive, etc. in addition to REACH.

REACH places the responsibility on industry to carry out chemical safety assessments and manage the risks that chemicals may pose to health and the environment. REACH entered into force on 1st June 2007 to streamline and improve the EU's former legislative framework on chemicals. The aims of REACH are (ECHA, 2010; van Leeuwen and Vermeire, 2007): to improve the protection of human health and the environment from the risks that can be posed by chemicals; to enhance the competitiveness of the EU chemicals industry; to promote alternative methods for the assessment of hazards of substances; and to ensure the free circulation of substances within the internal market of the EU. The figure 1 below shows the timeline of the REACH implementation. The REACH regulation came into force on 1st of June, 2008. Although the pre-registration need to be finished by 1st of December, 2008 the first stage of registration needed to be completed by 30.11.2010. This was an important date as the companies who could not satisfy the registration process of the product could not sell them anymore. There were a subsequent registration date and the final one in May of 2018.

Figure 1. The timeline of the REACH registration process



Source: Clariant (2014)

7.3 RESEARCH SURVEY

A survey was under taken by Center for Strategy & Evaluation Services (CSES) to study the impact of REACH on innovation of the chemical companies. Although the study covered all size of companies, but the bulk of the respondents were from large chemical companies. According to EU grouping of chemical companies, companies having more than 250 employees are considered as large company. In this study, 57 % of respondent were from large companies. There was no separation made in this study between large and very large companies (table 1).

Table 1. Company size of respondents by category in terms of employees

	N°	%
<50	126	22
50-249	118	20
250+	327	57
No response	6	1
Total	577	100

Source: CESE Survey (2012)

The following table (table 2) shows that bulks of the respondents were either manufacturer of chemical or formulator of chemical substances or mixtures. They consisted almost 55 % of the total respondents.

Table 2. Response to the question: Please indicate in what role you will be answering this questionnaire

	N°	%
Research and Development organisation (including Contract Research Organisations)	26	4.5
Manufacturer of chemical substances	192	33.3
Importer of chemical substances or mixtures	55	9.5
Producer of articles that contain chemical substances	52	9.0
Importer of articles that contain chemical substances	14	2.4
Formulator (mixer) of chemical substances or mixtures	121	21.0
End user of chemical substances or mixtures in professional activities or in industrial activities where substances or mixtures are used as a processing aid and do not form part of the final product	28	4.9
Distributor/ retailer of chemical substances, mixtures or articles that contain chemical substances intended to be released	24	4.2
Other	47	8.1
No response	18	3.1
Total	577	100.0

Source: CESE Survey (2012)

The characteristics of substances become more transparent as a result of REACH.

Some substances will be taken from the market. This increased knowledge and the necessity for substitution will stimulate innovation. In total 18 studies do discuss innovation as a relevant aspect related to the REACH proposal. Most of these studies expect positive aspects for innovation. Some studies also described the negative effects of REACH on innovation.

The following survey question somehow shows how innovative the European chemical industry is in terms of developing new chemical substance. Almost 40 % either did not respond or did not think it to be relevant. It is also interesting to see 4.5 % responded that they had placed between 1001 and 10000 new chemical substance. This number corresponds to the percentage of very large chemical companies in Europe (table 3).

Table 3. Response to the question: How many chemical substances did you place in the market in 2010 (including substances contained in articles)?

Options	N°	%
1	14	2.4
2-10	72	12.5
11-50	81	14.0
51-100	54	9.4
101-1,000	60	10.4
1,001-10,000	26	4.5
>10,000	7	1.2
Don't know	34	5.9
Not relevant	118	20.5
No response	111	19.2
Total	577	100.0

Source: CESE Survey (2012)

The next question looks into the source of innovation of the companies. It is believed that there can be three general source of innovation: Inside the company, Partnering with another company, other companies or institution. The survey question in the following table 4, addresses this question.

Table 4: Survey question: What would you say the sources of your innovations are in general? If more than one, please rank in importance (1st as most important, 3rd as least important)

Options	Mainly your enterprise or enterprise group		Your enterprise or enterprise group together with other enterprises or institutions		Mainly other enterprises or institutions	
	Nº	%	Nº	%	Nº	%
1 st	205	62.7	98	36.8	59	28.1
2 nd	58	17.7	106	39.8	33	15.7
3 rd	28	8.6	27	10.2	78	37.1
Don't know	36	11.0	35	13.2	40	19.0
Total	327	100.0	266	100.0	210	100.0

Source: CESE Survey (2012)

7.4 Data Evaluation and analysis

Let us now evaluate the key learning from the survey. The following question is judging if the access to REACH information has acted as a stimulus for innovation. It was obvious from the response that there was no positive impact as 70 to 80 % of the people said no (table 5).

Table 5. Survey question: Has the development of, or access to, any of the following sources of information acted as a stimulus to product conception and innovation in your organisation?

Options	Registration dossier with Technical dossier and Chemical Safety Report		Development of the Safety Data Sheets (SDS)/(eSDS)		Substance Information Exchange Forum (SIEFS)	
	Nº	%	Nº	%	Nº	%
Yes	65	17.3	102	25.6	33	9.3
No	293	77.9	284	71.4	296	83.4
Don't know	18	4.8	12	3.0	26	7.3
Total	376	100.0	398	1.0	355	100.0

Source: CESE Survey (2012)

The following question enquired if the additional cost for testing of new substance a dis-incentive to innovation, the answers did not show it to have a negative effect with around 40 % supporting it (table 6).

Table 6. Was the additional cost for testing of new substances (as opposed to the situation for existing substances) a disincentive to innovation for you before the REACH Regulation was implemented?

Options	N°	%
Yes - a lot	56	17.9
Yes - moderately	90	28.8
No, not at all	120	38.5
Don't know	46	14.7
Total	312	100.0

Source: CESE Survey (2012)

The next survey question focuses on the substitution of the chemicals which is not in accordance to REACH protocol. This also shows development of new chemical product which in some way is bringing innovation to the company (table 7).

Table 7. What has been the effect of the placing of substances on the authorisation list for your firm?

Options	We launched initiatives to develop new substances to substitute them		We launched initiatives to find alternative formulations of existing substances to substitute them		We withdrew them from our product portfolio		We requested substitution of those substances by our suppliers		We took no special action	
	N°	%	N°	%	N°	%	N°	%	N°	%
Yes	57	24.9	116	43.4	105	44.1	105	41.0	89	46.4
No	129	56.3	98	36.7	90	37.8	109	42.6	84	43.8
Don't know	14	6.1	9	3.4	12	5.0	9	3.5	10	5.2
Total	200	87.3	223	83.5	207	87.0	223	87.1	183	95.3

Source: CESE Survey (2012)

The table below summarizes the final conclusion of the study. It is seen that 44 % of the respondent were negative or very negative in their views about the impact of REACH on innovation (table 8).

Table 8. Overall, what would you say has been the effect of REACH on innovation at your firm to the present, as compared to the pre-REACH situation?

Options	% All	% SME
Very positive	1	1
Somewhat positive	12	10
Neutral	29	28
Somewhat negative	30	37
Strongly negative	14	21
Don't know	14	3
Total	100	100

Source: CESE Survey (2012)

The next response also throws negative light on the views the chemical companies have on the future perspective of REACH on innovation and they send out a negative view that according to them, there is no change in scenario with respect to REACH (table 9).

Table 9. Do you see the position changing in the future?

Options	% All	% SME
Yes, it will become more positive	10	3
Yes, it will become more negative	24	38
No change	38	32
Don't know	28	27
Total	100	100

Source: CESE Survey (2012)

7.5 Discussion based on the survey

An important element, which is often described in studies on REACH, is the effect of the regulation on innovation. The most important factor

that has influenced the impact of the REACH Regulation on innovation has been the evolving economic situation. When the Regulation became active at the beginning of 2007 the world was on the verge of what was to become the greatest economic and financial crisis since the 1930's, and at time of writing (2014) slow but sustainable and meaningful recovery has been emerging. As a result company finances have remained highly strained, especially for large companies, and recruitment constraints have also impacted REACH implementation operations. It can be stated that it was not an auspicious environment for the launch of new investments in innovative projects.

As a result of REACH, the characteristics of substances become more transparent and it also resulted in some substances being taken out from the market. REACH proponent believes that this increased knowledge and the necessity for substitution will stimulate innovation. There are studies that expect positive effects, especially from the environmental NGOs and the European Commission. Based on the survey and the data obtained, in this section it is shown the positive as well as negative effect of REACH regarding innovation.

It is also believed that REACH Regulation will create an information database through gathering, capturing and disseminating data from the chemical industry which will act as a spur to product conception, development and marketing. There is evidence that data has been created through testing, captured and disseminated through the ECHA website. Even if this is not the fully open system for example a university environment, there has been an increased level of openness and scrutiny as a result, and some benefits have been evident, contributing to data generation and creation of IP. In case of large chemical companies, the Material Safety Data Sheet (MSDS) seems to have made the strongest contribution to stimulating new product conception.

Every company has their own IP strategies which depend on the role of IP in their business and costs of protection of IP. Feedback from interviews and the innovation survey so far suggest that whether or not a patent is filed for, the costs of IPP related to REACH can be challenging or even prohibitive.

In many cases the companies do not want to have their development copied, so they have tended to use as generic and unspecific descriptions as possible. There are certain portions of the directive that provide some incentive to companies to use such an approach. Many large companies

complained that a higher share of turnover was spent on R&D than average due to REACH. Since there is now the compliance aspects that has to be considered by firms, there are grounds to expect that what may be the “normal” time lag for innovation to occur as a result of an external factor such as regulation, may be extended, and it is probably too early to be able to assess the full impact of the Regulation on innovation.

It was observed from the survey that there has been a significant redirection of skilled, sometimes highly skilled, personnel in firms from R&D and innovation-related activities to compliance work as a result of the implementation of the Regulation. It was particularly true for large companies and they think the shift will be permanent. More than half of survey respondents reported that as a result there has been an increase in expenditure on R&D and related innovative activities. Interviews with large firms suggest those that were not financially constrained increased expenditure to maintain R&D activity. During the survey, a concern was raised by the respondent about how much of this has really been new as it is claimed that much has been related to chemicals of which the properties are already well known, as for the first deadline of 2010 many of the large volume chemicals in question are well known and have been in use for considerable periods.

In case of large companies, the evidence from the fieldwork also suggests that links with universities and networks developed tended to focus on the compliance/ regulatory elements of REACH rather than pure research and there is a great deal of activity throughout the EU in this respect. This resulted many firms establishing external relationships, most of which have been with various service providers, especially consultants, but these have not contributed particularly to innovation. Many companies have had to fund the extra cost requirements related to implementing the Regulation from their usual sources, and feedback from interviews suggests that this is easier for larger firms than smaller ones, especially in the current economic environment.

Rate of return from R&D investment was negatively impacted by REACH compliance costs, while uncertainties about actual costs and their timing in the case of innovation projects have not helped financing decision-making in general. REACH regulation generated scope of innovative activities to include more work on new substances, particularly among large firms, who are also responsible for most innovation in the

industry, but barriers to R&D and innovation in new substances still remain.

The several steps for substitution mechanisms within REACH: registration, the candidate list, authorisation and restriction, have had various impacts on innovative activities. Registration costs can have an impact on the decision to register a new substance or use, or use of an existing substance in innovative ways and this can in turn also influence the availability of substances within supply chains for future use in innovation. It has also been observed that companies carry out product changes purely with a view to avoiding regulatory burdens of REACH, or perfectly harmless eco-friendly substances are withdrawn because of registration costs. It seems that the return on investment in new registrations needs to be more certain and possibly higher to compensate for increases in costs, risks and uncertainties.

Due to increased openness and scrutiny driven by the Regulation, it is a concern of the companies over the ability to protect IP. The fieldwork has confirmed that extensive activity in the areas of product, process, marketing and innovation change is occurring as a result of the implementation of the Regulation. A significant number of survey respondents – think that REACH has not provided enough IPP to promote innovation. Firms also often think that the additional costs placed on requesting IPP are too high, especially when the requests may not be granted. Large firms that use patents to protect IP do not consider REACH patent friendly. There are also widely held views that the protection of CBI within REACH remains insufficient.

In many instances companies have considered the activities to ensure compliance with the Regulation as a distraction from their normal, planned innovation activities (also organizational and marketing innovation) and to be unintended consequences of the Regulation. Increases in time-to-market as a result of the Regulation and increased supply chain rigidities resulting from changes in toll manufacturing arrangements have not been supportive of innovation. Companies often rely on other tools than patents filed to generate innovations – for example time to market and creation of custom “recipes”. However, the survey did ask firms to compare the current situation as regards innovation with the pre-REACH situation, and some two-fifths indicated that they thought it had worsened, as opposed to just over a tenth who thought it had improved. Additionally, they thought it would worsen in the future than would improve.

Due to complexity of REACH regulation and cost, it has been argued that some non-EU locations are getting more attractive for undertaking innovative activities. Based on the data provided, it appears that some such delocalisation of innovative activities has occurred, although REACH may not always have been the only or even the main driver.

7.6 Conclusion

The chemical regulation (REACH) has a big impact on R&D activities of the chemical companies in Europe. The chemical products which have not been pre-registered before the due date could not be sold any more until they go through the registration process. The bulk of the respondent of the survey carried out by CSES was from the large chemical companies who are manufacturer of chemical product. According to the survey, there is a very strong negative effect of REACH on innovation. High amount of R&D resources is being used for REACH compliance need. The compliance cost of REACH has negative effect on further investment for R&D. There is a great concern for IP due to more openness of the Information.

It can be concluded from above survey and following studies that indicated that they had found knowledge generated stimulated product conception and innovation, larger firms were less positive than SMEs. Among survey respondents that indicated a “substantial” shift in resources from R&D and innovative activity to REACH compliance, the share of small firms was high (compared to the overall presence of such firms in the survey), especially in the case of formulators, and also for medium-sized firms, although the increase was not as marked. More SMEs also saw this shift as permanent than large firms, and indicated the response as one of having increasing expenditure on R&D to compensate for this in the long run.

CHAPTER 8. EUROPEAN CHEMICAL CLUSTER AND GEOGRAPHICAL DISTRIBUTION: AN IMPACT ON INNOVATION

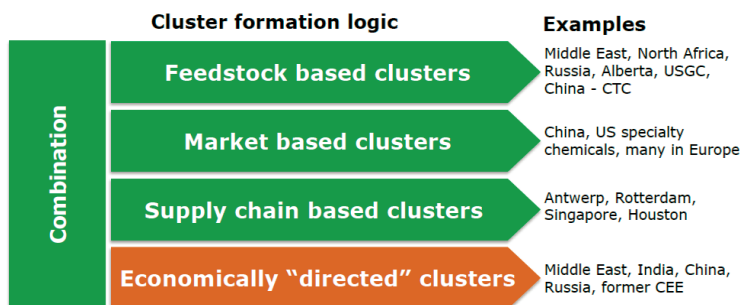
8.1 Introduction

According to Porter (1998), clusters are geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. It is geographically limited concentration of mutually related Business units, associations and public or private organizations centering on a specific economic focus (Gordon and McCann, 2003). A high concentration of manufacturing companies and Service providers, but also associations and public or private organization that engage to create an environment for production, innovation and the creation of new business development. Clusters include, for example, suppliers of specialized raw material, suppliers of components, machinery, and services, and providers of specialized infrastructure such as water, electricity or fire fighting support. This chapter explains the structure and geographical distribution of European chemical cluster and its impact on innovation.

8.2 Components of European Chemical Cluster

Clusters normally extend both vertically and horizontally in value chain. Clusters also often extend downstream to channels and customers and laterally to manufacturers of complementary products and to companies in industries related by skills, technologies, or common inputs. In such clusters there is outsourcing of related services attracting third party investments in transportation, warehousing, general services, waste treatment, and a wide range of utilities. Finally, many clusters include governmental and other institutions-such as universities, standards-setting agencies, think tanks, vocational training providers, and trade associations-that provide specialized training, education, Information, research, and technical Support.

Figure 1. Four main drivers of chemical clusters

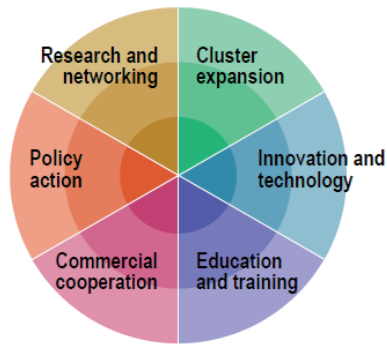


Source: Plessis (2010)

There are four reasons for the formation of chemical clusters (figure 1). Feedstock based clusters are very common reason for chemical clusters around the world. For Europe, supply chain based cluster is the basis for its existence. The interaction and interdependence of companies creates complementary synergies and a combination of skills and incentives which are difficult to reproduce on an isolated basis. This is also a source of innovation to both companies. Unique opportunities in collaboration across a wide range of activities including capital investment, improved utilization rates and plant occupancies, swap arrangements, shared facilities, cluster carbon footprint reduction etc.

Almost two thirds of Europe’s chemical production is in the cluster. Most of the large chemicals and especially from Europe are located in these clusters. The top chemical clusters are Port of Rotterdam, Antwerp port, Ruhr: chemsite and chemcologne, Tarragona chemical cluster, and Rhine- chemiePark Hoechst and BASF.

Figure 2. Various components of a cluster



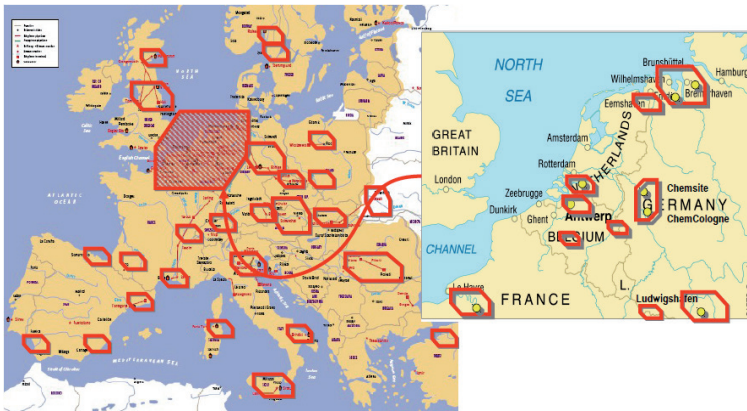
Source: Ketels (2007)

Figure 2 shows how various components play a significant role in the survival and continuation of a chemical cluster.

8.3 Distribution of European chemical cluster

Europe has over 300 chemical production sites, the majority of which are located in clusters. Most of these clusters have evolved historically around either a raw material source, or as a supplier to the downstream industry. As the raw material supply and the downstream industries have evolved, so these clusters have adapted to these changes. There are a few examples of “on-purpose” clusters which have been developed more recently. In general Europe’s chemical industry clusters are highly integrated along the product value chains and benefit from competitive infrastructure, utilities and services.

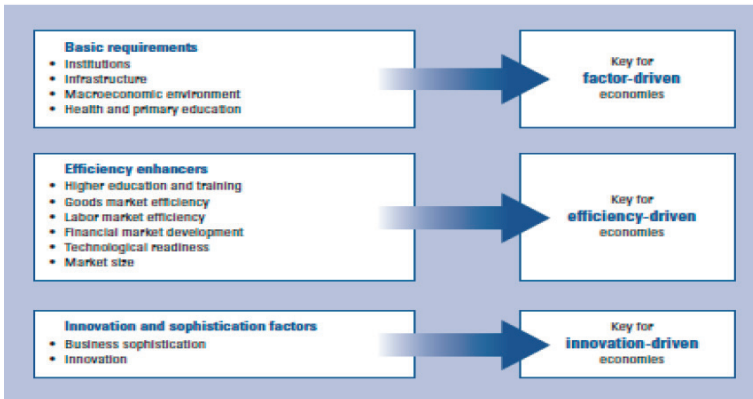
Figure 3. The chemical cluster in Europe



Source: Plessis (2010)

There are four components in order to turn a cluster to a mega cluster. There are few basic requirements such as institution, infrastructure and education. Then come the factors which act as efficiency enhancers such as market size, labour market, financial market and technology readiness. The ultimate component of a mega-cluster is innovation drive (figure 4).

Figure 4. Key components of a mega-cluster



Source: Plessis (2010)

The mega-clusters: Port of Rotterdam, Antwerp Port, Rhine and the regions around it produces 2/3 of the total productions of all the European clusters.

Figure 5. Europe's chemical mega clusters

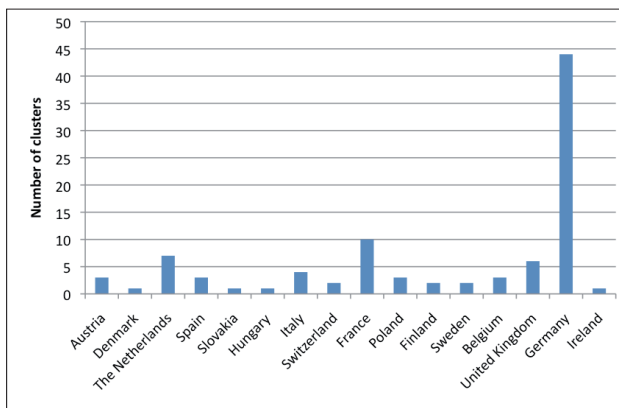


Source: Plessis (2010)

Advantage of having strong chemical clusters in Europe is improved cost competitiveness from integration along the product value chains. There is synergy benefit from shared utilities, services and infrastructure which also leads to increased investment due to improved cost competitiveness. There is also lower logistics cost due to a competitive offering of services within the cluster. The collaboration mindset of cluster members results in collaborative research and development. This results in cluster innovation. Total cluster performance is better than the sum of the individual cluster members' performance on a stand-alone basis.

Figure 7 shows how various components play a significant role in the survival and continuation of a chemical cluster. The figure 6 shows the number of chemical clusters distributed over various EU countries. Germany have the largest number of 44 chemical clusters followed by France with only 10 as distant second while Netherlands with 7 is in the third position.

Figure 6. Number of chemical clusters in each European country



Source: ECSPP (2014)

8.4 Impact of chemical cluster on European Innovation

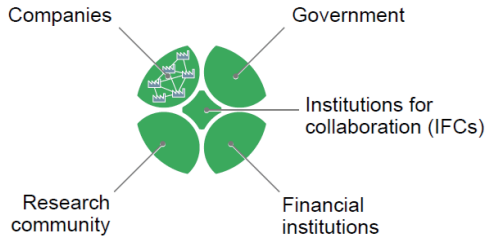
In order to study the chemical cluster's impact on European Innovation, we will study three chemical clusters. The first one is Tarragona chemical cluster located in Spain and the second one is Axelera chemical cluster located in France while the third one is Port of Antwerp chemical cluster.

8.4.1 CASE STUDY I: TARRAGONA CHEMICAL CLUSTER

Chemical cluster in Tarragona consists of the south and north poles, which are linked to the nearby port via road and pipeline. The main raw material –crude oil and natural gas- are all imported. Natural gas is imported in the form of LNG and then processed in several gasification facilities along the coast around Barcelona and Cartagena. Natural gas is also provided via the Trans Pyrenean pipeline link Calahorra from Lacq in France, and from the Maghreb-Europe Gas pipeline from Algeria to Spain. Crude oil is provided by ship from various sources to several terminals. The Tarragona cluster is linked to the Spanish natural gas distribution network.

In addition to enhancing productivity, clusters play a vital role in a company's ongoing ability to innovate. Some of the same characteristics that enhance productivity have an even more dramatic effect on innovation and productivity growth.

Figure 7. The components of Tarragona Chemical cluster



Source: ECSPP (2014)

Because sophisticated buyers are often part of a cluster, companies inside clusters usually have a better window on the market than isolated competitors do. Chemical companies plug into customer needs and trends with a speed difficult to match by companies located elsewhere. The table 1 below shows the chemical companies that make up the Tarragona chemical cluster.

Table 1. The companies of Tarragona chemical cluster

<p>Tarragona North</p> <p>Asfaltos Españoles, S.A.</p> <p>LyondellBasell Poliolefinas Ibérica, S.L.</p> <p>Basf Española, S.L.</p> <p>Basf Sonatrach Propanchem, S.A.</p> <p>Bayer Material Science, S.L.</p> <p>Celanese Chemicals Ibérica, S.L.</p> <p>Clariant Ibérica, S.A.</p> <p>Compania Logistica De Hidrocarburos Clh, S.A.</p> <p>Dow Chemical Ibérica, S.L.</p> <p>E.On Generación, S.L.</p> <p>Ercros Industrial, S.A.</p> <p>Hércules Química, S.A.</p> <p>Industrias Químicas Asociadas, Lsb, S.L.</p> <p>Kemira Ibérica, S.A.</p> <p>Elyx Polimeros, S.L.</p> <p>Messer Ibérica De Gases, S.A. Unipersonal</p> <p>Productos Asfálticos, S.A. (Proas)</p> <p>Repsol Butano, S.A.</p> <p>Sekisui Speciality Chemicals Europe, S.L.</p> <p>Tarragona Power, S.L.</p> <p>Terminales Portuarias, S.L.</p> <p>Terminales Químicos, S.A.</p> <p>Transformadora De Etileno, Aie</p> <p>Vinilis, S.A.</p>	<p>Tarragona South</p> <p>Carburos Metálicos, S.A.</p> <p>Dow Chemical Ibérica, S.L.</p> <p>Messer Ibérica De Gases, S.A. Unipersonal</p> <p>Repsol Petróleo, S.A.</p> <p>Repsol Química, S.A.</p> <p>Vinilis, S.A.</p> <p>Alcover</p> <p>Catalana De Tractament D'olis Residuals, S.A. (Cator)</p> <p>Flix</p> <p>Ercros Industrial, S.A.</p> <p>Kemira Ibérica, S.A.</p> <p>Tortosa</p> <p>Ercros Industrial, S.A.</p>
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Source: ECSPP (2014)

Some of the chemical companies provide intermediate product which is used as feed stock for other companies in the cluster, while other produce final product which goes for industrial and consumer use. As a result there is a continuous relationship between the supplier and customer in the cluster. The table 2 below shows the list of the raw product, intermediate and final product of the Tarragona chemical cluster. Since the customer and supplier are in the same region it helps them to come together and thus helps in product innovation.

Table 2. Products of the Tarragona chemical cluster

Raw product / feed stock	Intermediate product	Final product
Monomers	Acetaldehyde	Paper Industrial
Ethylene	Ethyl Acetate	Additives
Polypropylene	Vinyl Acetate	Water Industrial
Benzene	Acetic Acid	Additives
Octane	Acrylonitrile	Special Products
Other Cracking	Butadiene	Vinyl Derivatives
C4 Fraction	Styrene	Tensoactives
Aromatic Component	Methyl Methacrylate	Polyolefines
FO Pyrolysis	Ethylene Oxide	H.D. Polyethylene
Inorganic	Ethylene Glycol	L.D. Polyethylene
Chlorine	Propylene Oxide	Lineal Polyethylene
Sodium Hydroxide	Propylene Glycol	Polypropylene
Chlorhydric Acid	Vinyl Chloride	Compounds
Ammonium Sulfate		
Gases		
Nitrogen		
Oxygen		
Hydrogen		
Carbonic Anhydride		
Plastics		
PVC		
ABS Resins		
Styropor Expandable		
Polystyrene		
Polyalcohol		
Isocyanate		

Source: ECSPP (2014)

This ongoing relationship with other entities within the cluster also help companies to learn early about evolving technology, component and machinery availability, service and marketing concepts, and so on. Such learning is facilitated by the ease of making site visits and frequent face-to-face contact.

Clusters do more than make opportunities for innovation more visible. They also provide the capacity and the flexibility to act rapidly. A Company within a cluster often can source what it needs to implement innovations more quickly. Local suppliers and partners can and do get

closely involved in the innovation process thus ensuring a better match with customer's requirements.

Companies within a cluster can experiment at lower cost and can delay large commitments until they are most assured that a given innovation will work out. In contrast, a Company relying on distant suppliers faces greater challenges in every activity it coordinates with other organizations-in contracting, for example, or securing delivery or obtaining associated Technical and Service Support. Innovation can be even harder in vertically integrated companies, especially in those that face difficult trade-offs if the innovation erodes the value of in-house assets of current products or processes must be maintained while new ones are developed. In this cluster, also belong several research institutes and the Tarragona University. There is a close cooperation with these reach centers and the university with the chemical companies belonging to the cluster.

- Chemistry Technology Centre (CTQ)
- Institute of Chemical Research of Catalonia (ICIQ)
- Rovira i Virgili University (URV)
- Catalan Government Department of Education (Secondary Schools: Comte de Rius; Pere Martell; Vidal i Barraquer)
- Chambers of Commerce, Industry and Navigation of Reus, Tarragona, Tortosa
- Chamber of Commerce and Industry of Valls

There are also several opportunities of the doctoral research of the Tarragona university at the companies located in the cluster. The university provides analytical and other capabilities which many of these chemical companies might be lacking for research.

Reinforcing the other advantages for innovation is the sheer pressure-competitive pressure, peer pressure, constant comparison-that occurs in a cluster. For all these reasons, Tarragona chemical cluster can remain centers of innovation for decades.

If companies in a cluster are too inward looking, the whole cluster suffers from a collective inertia, making it harder for individual companies to embraces new ideas, much less perceive the need for radical innovation. The government organizations play a critical role in this collaboration for innovation and R&D. The list below lays down the government organizations that participate in Tarragona cluster build-up.

- Catalan Government - Tarragona Delegation
- Council of Tarragona
- Spanish Government – Tarragona Delegation
- City Councils: Alcover, La Canonja, Constantí, Flix, El Morell, Perafort, La Pobla de Mafumet, Reus, Tarragona, Tortosa, Salou, Valls, Vila-seca

Collaboration supports provided by Spanish government are: 1. Promote the implementation of large industrial research projects that increase the scientific and technological capacity of firms and research organizations 2. Expand and optimize total use by companies and research organizations, public and private infrastructures existing research in Spain 3. Extend the culture of R & D cooperation between all actors in the science-technology-enterprise system 4. To mobilize the participation of SMEs in industrial research projects of great magnitude 5. Contribute to the participating firms to compete in international markets with innovative products and services and promote a more efficient access to international consortia programs of cooperation in scientific research and technological development and in particular the Framework Programme of the European Union.

More important to ongoing competitiveness is the role of location in innovation. Therefore locational decisions must be based on both total systems cost and innovation potential, not on input cost alone.

Geographic, cultural, and institutional proximity leads to special Access, closer relationships, better Information, powerful incentives, and other advantages in productivity and innovation that are difficult to tap from a distance.

Other components of the cluster are utilities, storage and disposal service provider.

Table 3. Other important components of the Tarragona chemical cluster

Utilities	Storage	Disposal
Power/ Electricity	Tanks	Effluent Management (under construction)
Steam	Caverns	
Water (different grades)	Warehouses	
Natural Gas		
Effluent Management		
Industrial Gases		

Source: ECSPP (2014)

8.4.2 CASE STUDY II: AXELERA CHEMICAL CLUSTER

This case study focuses on one cluster, Axelera to identify the role it plays in innovation and, in particular in REACH-related innovation. Axelera – a Pôle de compétitivité à vocation mondiale Chimie-Environnement Lyon & Rhône-Alpes was created in 2005 with the aim to “accelerate the development of sustainable chemistry at national and international levels. With 307 members in 2014, Axelera has demonstrated both its attractiveness and its ability to bring people together. Two third of the network is made up of large sized companies. There are 200 R&D programmes being conducted, for a total budget of over €627 million. Members include private companies (from very small SMEs to some of the largest global multi-nationals), research organisations, training and education organisations and institutional actors. With 126,000 students across the urban area, more than 500 public and private research laboratories, 10,000 researchers and 18 higher education establishments, the Lyon urban area offers world-class training and research potential in a variety of sectors, including chemistry and engineering, life sciences, information sciences, human and social sciences, etc.

The case study starts by looking at the role of chemical clusters in general, identify the difference between clusters in general and the slight variations in the structures of “pôles de compétitivité” before looking at Axelera’s activities. It will then go on reviewing some of the projects related to substitution of chemicals. In addition to looking at individual organisms and companies involved in innovation, the case study also looks at the dynamics of the cluster and the impact REACH has had (if any) in its capacity to generate innovative solutions and products.

The pole’s main research interests are (Business Greater Lyon, 2014):

- chemistry in the service of the great societal challenges: sustainable building, renewable energy, vehicles, electronics;
- preservation of natural habitat: air, water, soil, agrochemicals;
- total recyclability of materials;
- chemicals from vegetable material;
- the factory of the future and eco-designed processes

The impact of REACH on R&D and innovation in Axelera

At Axelera, some research projects have emerged that are specifically aimed at substitution within the framework of REACH. Rather than having a purely 'chemical' approach to the issue surrounding substitution, Axelera has developed a holistic approach to REACH in particular and the regulatory framework in general.

Some of Axelera's projects are thus not aimed purely at substitution in the way generally understood when talking about the regulation but at a wider reflection on the need of the substance. The current approach has been developed by the synergies created by having chemical engineers working alongside professionals from other sectors with a more intimate knowledge of the issues they face.

The largest number of projects funded in Axelera is funded by the ANR (Agence Nationale de la Recherche), a national organisation proposing calls for research projects in France which launches regular calls of projects in the chemical sector. At first, projects including elements of innovation and substitution relating to the regulation were not branded as "REACH" projects. This is the case, for instance, of a project on solvents. While the results can be used to substitute substances either placed on the candidate list or restricted, it was 'independent' of REACH. It is nevertheless likely that the regulation did play a role in the development and thinking behind it. In recent years, projects and calls for projects with a clear 'REACH-related' label especially focussed on substitution have emerged.

Axelera also tries to promote knowledge about the opportunities of the regulation in creating innovation. A final interesting aspect of Axelera with regard to the REACH Regulation is the development of a regional testing platform to conduct toxicological and eco-toxicological testing on substances. This testing platform is expected to play an important role in the innovative capacity of the region and structure the research, development and innovation processes of the pole and the wider region.

Specific project examples

Axelera is typical of the clusters approaching the new regulatory framework REACH as an opportunity to develop new innovative solutions with different types of partners rather than seeing it as a burden.

NESOREACH (New “eco-friendly” Solvent for REACH substitution) is a project aiming at substituting existing solvent with alternatives with less hazardous properties. The project’s aim is to develop predicting methods for solvents within the framework of the REACH regulation. The project is specifically related to certain types of enamelling varnishes which use large amounts of toxic solvents such as N-methylpyrrolidone, phenol and cresol. In the current process, those solvents are burned during the glazing process and thus release potentially toxic products. The project investigates mechanisms involved in the polymerisation process and carry out polycondensation reactions to evaluate the properties of the new non-toxic solvents for the said applications.

Another interesting project that has taken place at Axelera is the “intensification des procédés”. The project’s aim was to set up new and innovative tools including environmental efficiency, manufacture performance and adequacy of the processes. The project developed lab tools to optimise energy efficiency, a pilot reactor to gather basic data allowing for a more efficient industrial extrapolation. This allows tests on new substances to be developed in parallel and identify any issues that would prevent the commercialization of substances at an early stage, thus reducing the cost of non-viable substances and increasing the efficiency of research.

The projects taking place in Axelera are interesting and innovative in that they are not only purely chemistry-related but have a wider scope, including studies on the research and innovation processes and therefore approach issues in a global fashion. This approach is embedded in the strategy objectives of the pole.

8.4.3 CASE STUDY III PORT OF ANTWERP CHEMICAL CLUSTER

The cluster, the Port of Antwerp (table 4), is considered a world-scale refinery and the largest chemical refinery in Europe. The port has historically and organically grown rather than emerged from a direct clustering initiative, therefore it is not considered a typical plug and play environment. The Port of Antwerp functions through an open market concept where companies are not governed or spurred on by associations. There is a high degree of integration between business processes within the port; however each company is ultimately driven individually.

Table 4. Main companies in the port of Antwerp cluster

BASF	Eastman	Total (Refinery)
Styrolution	Evonik	ExxonMobil (Refinery + Petro. Chem.)
Air Liquide	Bayer	Total (Olefins + Polymers)
Erochem	Ashland	Nippon Shokubai
IBR (Refinery)	Monument Chemical	Kuraray
Solvay	Lanxess	Praxair
Ineos	Lubrizol	3 M
Monsanto	Borealis	

Source: Port of Antwerp (2014)

During the current research, the Port Authority was found to be the main governing support system for the chemical and petro-chemical activity. The chemical cluster of Antwerp is found to be substantially more developed than most chemical cluster initiatives identified in other regions. With regard to eco-innovation, the cluster excelled in environmental performance on a European level.

Key Environmental Challenges as identified by the Cluster Organisation

The Port Authority identified various environmental challenges including CO₂ recuperation, waste and water treatment. To counter the effects of their industrial activity, the organisation works to preserve and develop nature reserves, bio mass and wind energy. Due to the scale of the cluster's activities, and its high energy consumption and outputs, the cluster Authority has taken a holistic viewpoint toward environmental targets.

The cluster Authority has an internal environmental department consisting of approximately 40 employees who carry out various studies and collaborative research projects with industries to identify and implement eco-innovative solutions for the industry. The incentives which drive eco-innovation differ largely across the value chain. In general, legislation, market incentives and European competitiveness are the primary drivers to eco-innovation uptake.

Eco-Innovation activity undertaken

The Port Authority has been increasing its promotion activity toward eco-innovation constantly. It promotes practices in two core focus areas: calculating the clusters overall carbon footprint (which is also part of its social responsibility targets), and increasing energy diversity to reduce the industry's high dependency on oil. The petrol chemical industry relies heavily on oil prices. As oil is a rather fluctuant and volatile product, it needs to stabilize this overall cost using independent energy source which are more stable by nature (in terms of pricing).

The cluster approaches companies individually to promote such initiatives - since the Port Authority is an independent entity, it is not perceived as a competitor - and they are able to collaborate effectively using a one-on-one approach. Within the European context, the cluster organisation collaborates with other ports on various eco-innovative projects and environmental standard setting. An example of this is a project setup to initiate CO₂ recuperation through the European Shipping Index.

The cluster's core targets for the coming five years clearly place emphasis on increasing efficiency and research into optimization, targets include:

1. *Mobility* – Large-scale redevelopment of infrastructural work is planned to gain efficiency and reduce logistics;
2. *Expansion* – The cluster needs to constantly develop itself to remain competitive.

Expansion possibilities focus on land procurement or optimization of existing land;

3. *Environment* – The main focus is to tackle the carbon footprint of the industry as a whole by increasing sustainability. This is a generic goal which entails widespread research and a diverse approach toward eco-innovation solutions.

An example of innovation of Antwerp port cluster

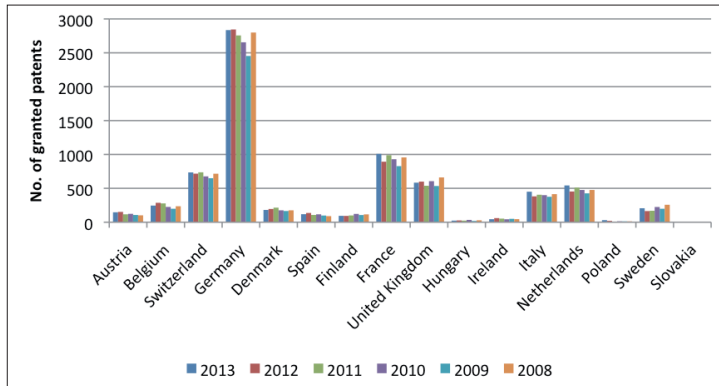
The Antwerp Port Authority, in early 2010, in collaboration with the Left Bank Corporation unveiled their plans to develop a large wind farm in the port area in collaboration with private internal and external partners.

The port was identified by the Flemish Wind Energy Association (VWEA) and the Flemish Minister of Energy as being a suitable location for wind farming along with a current plan to develop a bio-mass power plant, are concrete steps taken by the Port Authority to maximize on the potential for renewable energy development within the port. These are strong examples as how Antwerp port cluster is driving innovation. In February 2011, the projects was further developed and unveiled to be a 200 million EUR wind farm.

8.4.4 Geographical distribution of chemical cluster and its impact on innovation

The chemical clusters in Europe are concentrated over few specific regions. This can be due to specific government policy or availability of environment for its growth. In any case, it definitely influences the area in which it exists and also has specific character inherent from that region.

Figure 8. Number of granted EU patents in chemistry and chemical engineering for the last five years



Source: European Patent Office (2013). Author's calculation and graph

It is interesting to understand how the innovation in terms of number of granted patent is distributed over various European countries. We saw earlier that Germany host the largest number of 44 clusters which account for 47 % of all European clusters. In terms of granted EU patent

in chemistry and chemical engineering, Germany has the largest number of 2835 which is around 40 % of the total EU chemical patent for the year 2013. France holds the second largest number of 11 % of all EU chemical cluster while it has 14 % of all EU granted patents. So there is a direct relation between the number of cluster in a particular country and number of granted EU patents in chemistry and chemical engineering (figure 8).

Table 5. The cluster and granted EU patent for 2013 distribution over different European company

Country	Number of clusters	% of total cluster	Patents granted 2013	% of granted patent
Austria	3	3,23	146	2,02
Denmark	1	1,08	181	2,50
The Netherlands	7	7,53	542	7,49
Spain	3	3,23	118	1,63
Slovakia	1	1,08	1	0,01
Hungary	1	1,08	23	0,32
Italy	4	4,30	450	6,21
Switzerland	2	2,15	735	10,15
France	10	10,75	1008	13,92
Poland	3	3,23	30	0,41
Finland	2	2,15	94	1,30
Sweden	2	2,15	206	2,84
Belgium	3	3,23	245	3,38
United Kingdom	6	6,45	583	8,05
Germany	44	47,31	2835	39,15
Ireland	1	1,08	44	0,61

Source: European Patent Office (2013). Author's calculation

The big exception to the above stated relation is Switzerland. It has 2 chemical clusters but accounts for over 10% of the granted patent. This can be due to a lot of research done in specialized institutes and university (table 5).

8.4.5 Innovation ranking of the clusters in different region

According to European Cluster Observatory (2014), the amount and quality of knowledge circulating and spilling over between chemical firms located in a cluster is dependent upon the cluster's size, the degree to which it is specialized in chemical products and the extent to which the locality or the region is geared towards and focused upon production in the relevant industries comprising the cluster. These three factors are size, specialization and focus which reflects whether the cluster has reached 'specialised critical mass' to develop positive spill-overs and linkages for innovation.

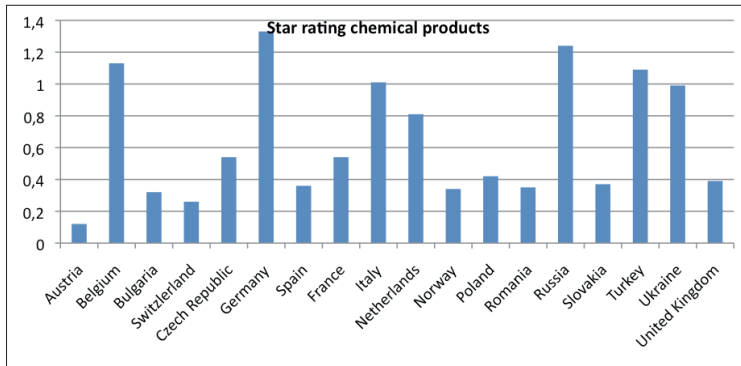
The European Cluster Observatory (2014) shows the extent to which clusters have achieved innovation by employing measures of these three factors as described below, and assigning each cluster a 'stars' number depending on how many of the below criteria are met.

- *Specialisation*: if a region is more technically specialized in a specific cluster category than the overall economy across all regions, this is likely to be an indication that the economic effects of the regional cluster have been strong enough to attract related economic activity from other regions to this location, and that spill-overs and linkages will be stronger. If a cluster category in a region has a specialisation quotient of 2 or more it receives a star.
- *Size*: The 'size' measure shows whether a cluster is in the top 10% of all clusters in Europe within the same cluster category in terms of the number of employees. Those in the top 10% will receive one star. If employment reaches a sufficient share of total European employment, it is more likely that meaningful economic effects of clusters are present.
- *Focus*: The 'focus' measure shows the extent to which the regional economy is focused upon the industries comprising the cluster category. This measure relates employment in the cluster to total employment in the region. The top 10% of clusters which account for the largest proportion of their region's total employment receive a star.

The figure 9 shows the star rating of all the chemical clusters distributed over 27 European countries. Germany leads the race with highest star rating followed by Russia and Belgium. Germany has the largest number

of chemical cluster which can impact the innovative collaboration of the chemical firms.

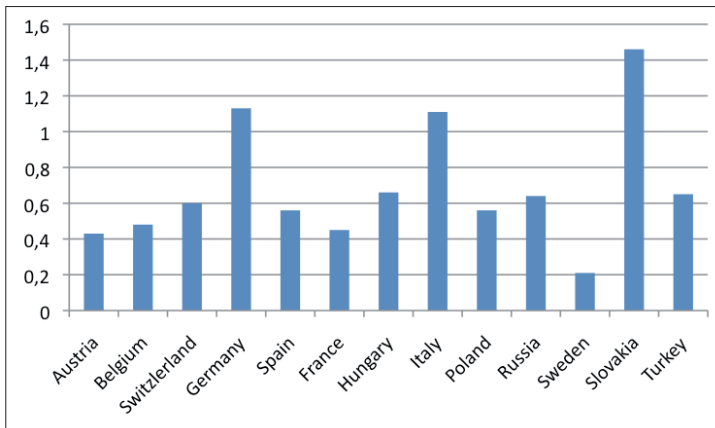
Figure 9. Innovation star rating of various chemical clusters in Europe according to chemical observatory



Data source: Cluster Observatory (2015). Graph: Author

The plastic industry is a key component of chemical industry in Europe and almost all large chemical companies in Europe is involved in production of it. So innovative collaboration of the plastic industry in chemical cluster is significantly important. The figure 10 shows the innovation star rating of the chemical clusters in the field of plastics. It was surprising to see Slovakia leading the race followed by Germany and Italy.

Figure 10. Innovation star rating of plastics producing companies in EU chemical clusters



Data source: Cluster Observatory (2014). Graph: Author

8.5 Conclusion

In Europe, there are over 300 chemical production sites which are located in clusters. Germany has the largest number of chemical cluster followed by France as distant second. Clusters do play a significant role in driving innovation of the European chemical industry. Alexera, Port of Antwerp and Tarragona chemical cluster are good examples of clusters which have been actively playing a role in innovation. It is seen that EU patents in chemistry and chemical engineering are not uniformly distributed over the region. Germany is the home for the largest number of EU patents in chemistry followed by France, UK and Switzerland. It is also seen that there is a strong relationship between the number of chemical clusters in a particular country and the number of granted patent for that country.

CHAPTER 9. INNOVATION IN MARKETING IN CHEMICAL COMPANIES: DIGITAL MARKETING

9.1 Introduction

Economic and business trends are making it crucial for chemical industry to find new method for managing their operations and their business. As an example, chemical manufacturers and oil refiners face complex global supply chains, increased and dynamic regulatory requirements, rising costs of feedstock and energy, and mergers and acquisitions that result in disconnected computer systems. One way to achieve new efficiencies that can help address these business challenges is to leverage new developments and trends in technology to establish a unified set of information technology (IT) architecture principles. On the other side, the rapid development of new interactive media such as on-line and the World Wide Web has taken most consumer marketers by surprise. Many are struggling to “guesstimate” the likely impact of interactive media on consumer marketing, wondering what they should do and how they should go about doing it. Those who move forward do so with mixed success. A recent analysis (Westerman et al., 2012) of nearly a hundred web sites of Fortune 500 consumer marketing companies shows that most of today’s interactive media marketing applications are very inspiring. There is emerging evidence that new media represent both a tremendous opportunity and a serious threat for marketers today. Digitalization is an emerging business model that includes the extension and support of electronic channels, content and transactions. Companies are embracing this strategy to transform their businesses, while balancing electronic capabilities with traditional business practices (hard-copy documents and correspondence, face-to-face interactions, and call center volume). The phenomenon of digitization is reaching an inflection point.

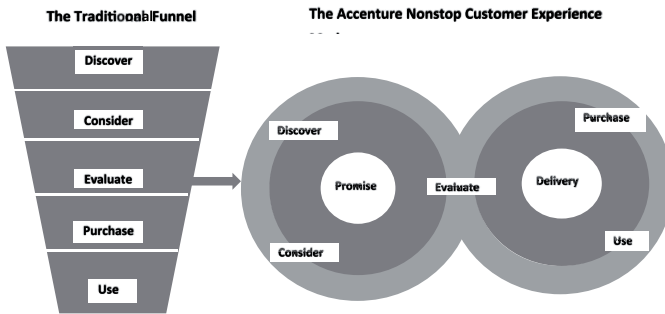
9.2 Impact of digitalization on product sale

Digital technology is changing all. At the simplest level, we've always known that consumers tend to go through a multistage journey as they make purchasing decisions. Yet most companies still concentrate marketing resources on only two stages: brand marketing up front to woo consumers when they first consider products, and promotions at the final point of sale to sway them as they are about to make a purchase.

Consumers who used to seek out family and friends for word-of-mouth product recommendations now read online reviews, compare features and prices on Websites, and discuss options via social-networking sites. This information flow not only empowers consumers but also allows marketing departments to be part of the conversation consumers have as they actively learn about product categories and evaluate choices. In fact, both business-to-consumer (B2C) and business-to-business (B2B) purchasers increasingly want marketers to help them make smart decisions. They just don't want to feel subjected to the hard sell—they expect marketers to engage them, not dictate to them. Digital business leaders seek new sources of growth and results from using technology to extend the potential of products and services, resulting in higher performance through new combinations that can benefit the organization's customers, its workforce and its trading partners. Digital is also entirely relevant to business-to-business (B2B) industries.

The figure 1 shows in the left the traditional path a customer will follow during a purchasing decision. He would come to know a product from the word of mouth as he discovers a new product. He would consider different options and evaluate the various offerings. Based on the evaluation criteria and result he would make purchasing decision and use the product. These steps would follow a linear path one after another and would require significant time. According to Accenture (2014), with the advance of digitalization, the purchasing decision is no more linear as seen from the graph in the right. The activities work parallel in reaching the decision step.

Figure 1. New customer dynamics



Source: Accenture (2014)

According to Oxford Economics, online sales are projected to reach \$20.4 trillion in 2013, representing 14 percent of the global economy and growing faster than sales in traditional channels. Of the world's 7 billion people, there are more than 6 billion mobile subscriptions and 3 billion active users of the Internet. Digital technologies drive change from the outside in. Technologies such as mobility, analytics, social media and cloud are intrinsically customer-focused, giving customers the information and connections to change the meaning at every moment of truth. Growth is no longer a matter of creating new products and marketing playbooks that move customers through linear purchasing processes. Creating smarter, seamless and secure experiences at every moment of truth defines expectations in the digital world. Customers in turn expect their experiences to be constant, continuous, customized and cross-channel. Growth no longer depends solely on pushing customers through the funnel; increasingly, it is tied to delivery of continuous customer experiences.

By coordinating the consumer's end-to-end experience, companies could enjoy revenue increases of 10 to 20 percent as shown in table 1.

Table 1. Trend in customer engagement to increase sells

Capture Internet Traffic	Increase Consumer Engagement	Capture Qualified Leads	Build Consumer Loyalty	= Increased online revenue
Capture 50-100% of fair-market share of traffic	Meet or exceed 50 % of best competitor’s engagement rate	Convert 10-15 % of engaged traffic into qualified leads Convert 20 % of loads into sales	Build 60 % loyalty rate. Achieve 40 % sales conversion rate annually from loyalists	Earn 10-20 % of total incremental revenue from new and loyal customers through online channels

Source: Accenture (2014)

Moving from a one-way, company-driven sales mentality to a two-way relationship with consumers requires core changes in the way marketers do business. While some of them have adjusted effectively, most simply tried everything that came to mind, because they weren’t sure what would work. Companies have explored digital-marketing vehicles such as video ads, sponsored content, and online promotions. New forms of targeted online ad delivery have emerged. Web sites have been overhauled, and microsites for specific products or promotions have multiplied. Companies are buying thousands of search terms across their lines of business, and new agencies keep popping up to serve marketers’ increasingly keen desire for innovative content, user tools, or social experimentation. While these initiatives usually make sense, their implementation often doesn’t: most companies merely add them to their other operations and thus stretch their organizations financially and operationally. In our experience, companies must thoughtfully integrate such initiatives by focusing on four core sources of value.

9.3 Innovation in Marketing: Digital Marketing Strategy

As many other industrial sectors, digital marketing in the chemical sector has the website as the core component of their digital marketing strategy. Website could be textual, visual or aural content that is encountered in a website. It may include text, images, videos, sounds and animation. It

is seen all the top chemical companies have an elaborate website which is the window for information of the company to the outside world. When the website of these companies were analysed in details, seven key components were observed: Search Engine Optimization, Pay per click, Development, Social Media, Content Management, Additional Marketing, Content, Social Media, software. For our current study, we have focused on three digital marketing tools which are being extensively used in chemical industry: Blogging, Article Marketing, E-commerce, social Media Marketing.

Figure 2. Various components of digital marketing strategy of a chemical company



Source: Author

Each of the components of the digital marketing can be sub-divided into several sub components. These sub-components are shown in table 2.

Table 2. Sub-components of the digital marketing relevant to chemical industry

Search Engine Optimization on (SEO)	Development	Pay-per-click (PPC)	Social	Software	Additional Marketing	Content
Link Building	CMS	Search	Facebook	Technologies	CRO	PR
Multi-lingual	Mobile	Ad Schedule	Twitter	Reporting	Shopping Feed	Blogs
On Page	Bespoke	Mobile	Linkedin		Cookie/Audit Law	Articles
Mobile	Design	Display	Youtube		Email Marketing	Content
Local			Google+			
			Other			

Source: Author

Search Engine Optimization (SEO) is a process by which a website or a webpage is ranked as the page is viewed by visitors the number of times. The more the page or website is viewed, the more it is ranked higher in search results by the search engine. There are several activities related to SEO in chemical industry website. They can be broadly classified into link building through blogging, article marketing, mobile, local, multi-lingual, mobile and local digital marketing. We have seen that chemical companies are activity involved in link building as seen from the following data.

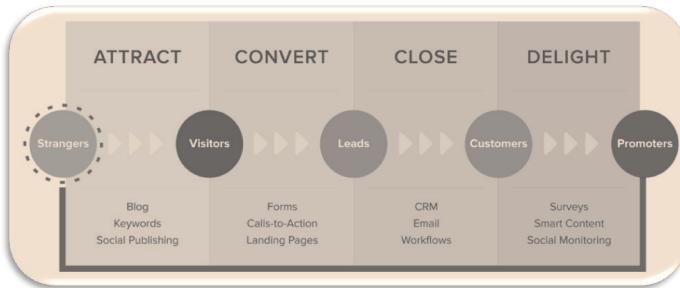
The search engine optimization is used extensively by the companies in driving to their website. A good example is when we type a key word of a particular product in search engine Google; we see that Google finds not only the website of the company but also the specific product pages. The product web pages are search built that is indexed very well by top search engines. One way the companies have achieved this is by using the right key words.

Another way of driving customer to the company website is by putting links in the blogs and other websites. Customers not only read the review of the product but also encouraged to click the links in the discussion blogs to visit the company website.

Blogging is one of the most popular Internet marketing techniques. On the professional side, a blog for marketing can give a company an identity and a “voice,” gaining visibility on the Web. It can generate word-of-mouth interest and display current work. It is a way for to write about a product and tell the story behind it. It allows others to get involved with

a product by leaving comments. The blog can be noticed by the media bringing the requests for interviews. It is a way of educating clients without being too preachy. The figure 3 shows the steps how blogs can be helpful in building reliability of a product or company.

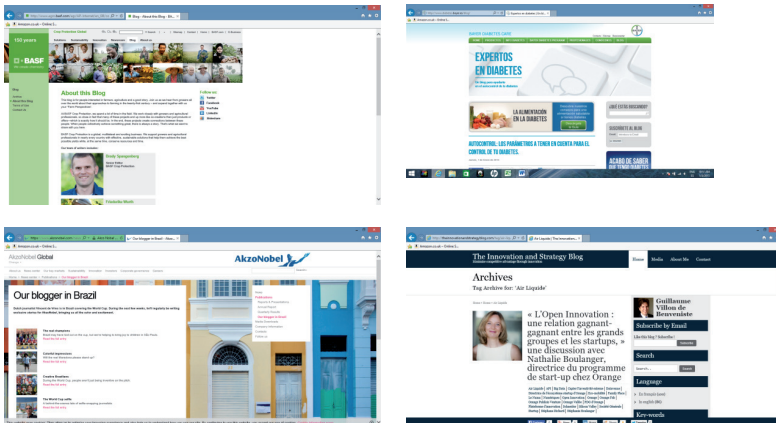
Figure 3. The steps which the blog undertake to achieve marketing goals

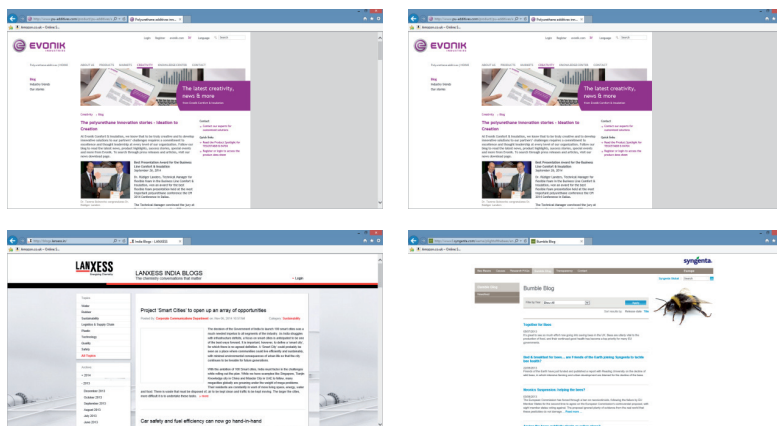


Source: Adapted from I-Scop (2015)

The figure 4 below show extracts of the blogs of some of the top chemical companies. It is seen that the companies have their own blogs while some of them have blog for specific business and also specific products.

Figure 4. Website with blog web page

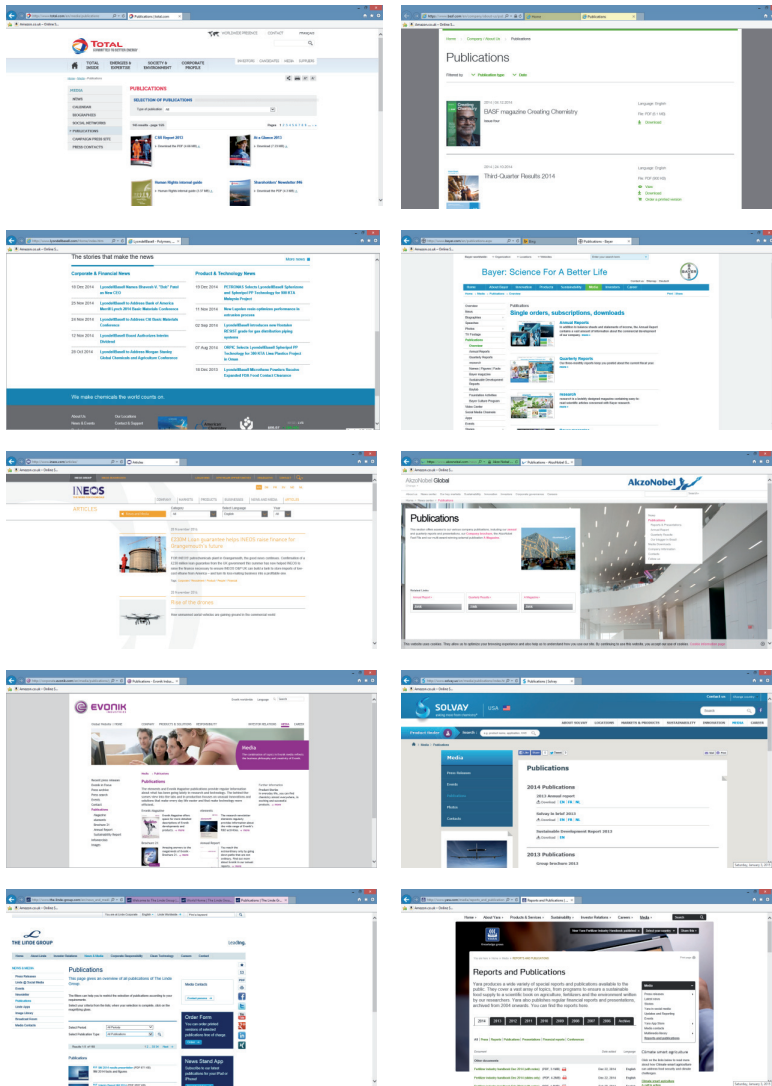


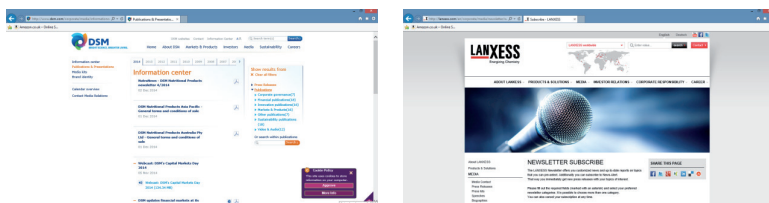


Source: Individual company webpages (2014)

Article marketing is a type of advertising in which businesses write short articles about themselves, their company or their field of expertise as a marketing strategy. Internet article marketing is used to promote the authors expertise of their market, products or services online via article directories. Article directories with good web page ranks receive a lot of site visitors and may be considered authority sites by search engines, leading to high traffic. These directories then give PageRank to the author's website and in addition send traffic from readers. Articles and article directories attract search engines because of their rich content. Business Owners, Marketers and Entrepreneurs attempt to maximize the results of an article advertising campaign by submitting their articles to a number of article directories. However, most of the major search engines filter duplicate content to stop the identical content material from being returned multiple times in a search engine results page. The figure 5 shows screen shot of the article page or publications of the top chemical companies under study.

Figure 5. Article and publication web pages of the top chemical companies

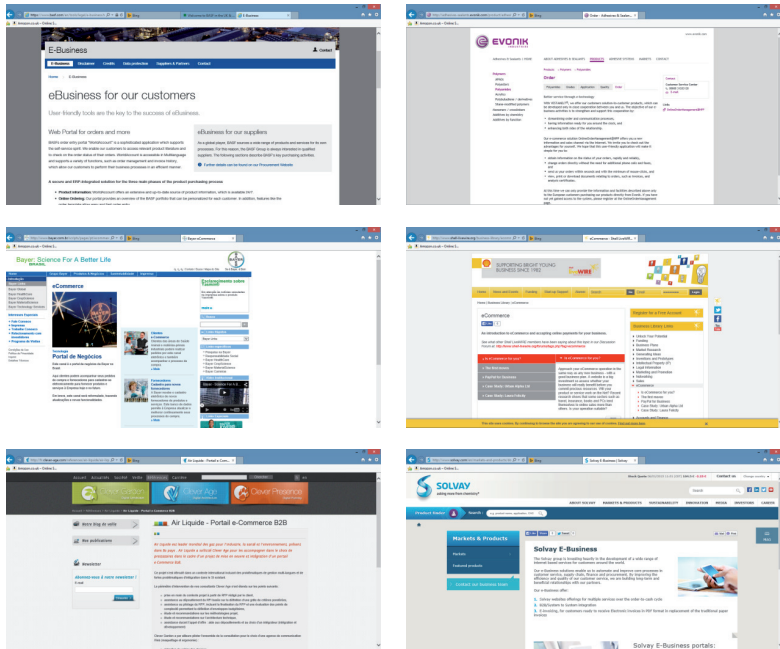




Source: Individual company webpages (2014)

Electronic commerce, commonly known as E-commerce or eCommerce, is trading in products or services using computer networks, such as the Internet. Electronic commerce draws on technologies such as mobile commerce, electronic funds transfer, supply chain management, Internet marketing, online transaction processing, electronic data interchange (EDI), inventory management systems, and automated data collection systems. Modern electronic commerce typically uses the World Wide Web for at least one part of the transaction's life cycle, although it may also use other technologies such as e-mail. It is seen that the top chemical companies in Europe has in most case e-commerce website where they sell some of their products (figure 6).

Figure 6. E-commerce web page of the top chemical companies



Source: Individual company webpages (2014)

Social media marketing refers to the process of gaining traffic or attention through social media sites. Social media often feeds into the discovery of new content such as news stories, and “discovery” is a search activity. Social media can also help build links that in turn support into SEO efforts. Many people also perform searches at social media sites to find social media content. Social connections may also impact the relevancy of some search results, either within a social media network or at a ‘mainstream’ search engine.

Social media marketing programs usually center on efforts to create content that attracts attention and encourages readers to share it with their social networks. A corporate message spreads from user to user and presumably resonates because it appears to come from a trusted, third-party source, as opposed to the brand or company itself. Hence, this form

of marketing is driven by word-of-mouth, meaning it results in earned media rather than paid media.

Social media has become a platform that is easily accessible to anyone with internet access. Increased communication for organizations fosters brand awareness and often, improved customer service. Additionally, social media serves as a relatively inexpensive platform for organizations to implement marketing campaigns.

It is seen that all the top chemical companies are involved strongly in social media marketing. The table 3 shows the study of the top chemical companies websites and the social media link available on their website. All the companies under study is seen to be focussed on social media marketing having involved with top five social media: Facebook, Twitter, LinkedIn, Google+, Youtube. Many of them also have a RSS Newsfeed which provides latest updates of the companies (table 3).

Table 3. Active involvement of social media channels by the top European chemical companies

	Facebook	Twitter	LinkedIn	Google+	Youtube	Flickr	Slideshare	Instagram	Xing	Pinterest	RSS Newfeed
BASF	x	x	x	x	x	x					x
Shell	x	x	x	x	x	x					
Lyondell-Basell	x	x	x	x	x						
Bayer	x	x	x	x	x						x
Ineos Group	x	x			x						x
Akzo Nobel	x	x		x	x	x	x				
Air Liquide		x	x								x
Evonik	x	x	x	x					x		
Solvay	x	x	x		x						
Linde	x	x	x	x	x				x		
Yara	x	x	x		x		x				x
DSM	x	x	x	x	x						x
Lanxess	x	x	x		x						
Syngenta	x	x	x		x						x
Arkema	x	x									x
Eni	x	X	X	x	x	x	x	x		x	
Styrolution		X	X	x	x						
Total	x	X									x

Source: Author

Table 4 shows the activities of top chemical companies in various social media domain. Since all of them have Facebook page, “likes” on the Facebook was taken as an important statistics for analysis. Shell leads the list with over 5 million likes, followed by Total as distant second and Bayer as the third. In terms of Tweets, Total is the leader followed by Syngenta and DSM. In terms of followers on Twitter, Bayer is the leader with over 101000 followers. Youtube has established itself has a strong social media channel through video. Most of the chemical companies under study have YouTube channel and it is seen that shell has highest numbers almost 24000 subscriber followed by BASF with almost 5000 subscriber.

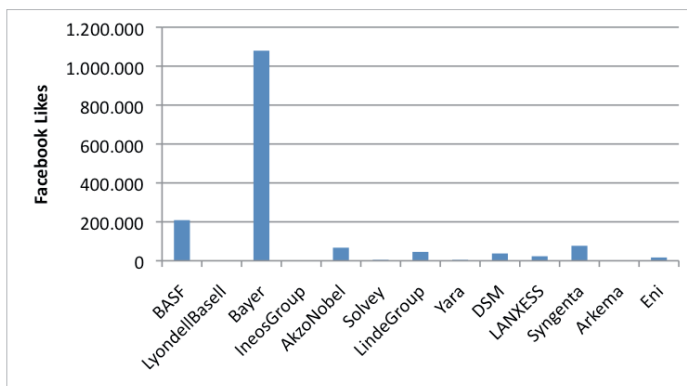
Table 4. Degree of engagement of top chemical companies in various social media channels

	Facebook	Twitter					LinkedIn	Google+	Youtube	
	likes	Tweets	Following	Followers	Favorites	Lists	Followers	Views	Subscribe	
BASF	208,562	2,590	683	26.4k	364	6	268,993	3,322	1,455,859	4806
Shell	5,375,981	1,632	130	260k	8		1,236,175	229,306	2,241,993	23,941
LyondellBasell	1,312	313	1,964	3,355	18	1	31,762	75	35,270	38
Bayer	1,079,279	1836	1801	101k	1,362		310,454	1958	689,256	910
IneosGroup	609	410	186	3,599	3					183
AkzoNobel	67,016	1,428	682	11.3k	84			608	281,715	776
LindeGroup	45,575	1,395	1,232	5,640	181	6	49,652	544	266,996	705
Yara	4,419	2,398	1,367	3,647	175		49,652			756
DSM	37,337	5,481	437	66.7k		1	55,617		311,772	1,071
LANXESS	23,063	900	95	3,092	305	1				232
Syngenta	76,799	5,920	1,521	33.9k	5,786	4	82,148			
Arkema	1460	546	233	2,409	2	10				
Eni	16,830	2,115	397	14.1k	518	1	178,037	122	85,620	3,847
Styrolution		21	6	52	7		65	17	2,560	18
Total	2,042,088	7,133	371	52.1k	109					

Data Source: Individual Websites; Author’s calculation

Figure 7 shows a comparative graph as how the Facebook page is liked by the visitor. It is seen that Bayer is way ahead than most of the chemical companies and seen to be very active in their Facebook website. Distant second is BASF while for most other activity is pretty low. This shows that even though every chemical company has a Facebook page, they are not very active there and do not emphasize the importance of Facebook marketing. On the other hand the oil companies even though not appearing in this graph are way ahead of chemical companies in terms of activity at the Facebook page.

Figure 7. Facebook likes of various chemical companies



Source: Author

9.4 Information technology challenges faced by the Chemical Industry in Europe

Chemical companies have specific concerns relating to cyber security, supply chain and logistics. At the same time, trends like big data, cloud computing and social media have begun to exert an influence on the industry. Chemical companies are moving in and out of markets as their strategy dictates, so portfolio churn is an issue. Margins are tight, so mitigating costs is on the list. Data management and security, especially in new markets, is a concern. Global regulation is another. And while everyone has a basic ERP system, companies are looking upstream and downstream in their value chain, trying to find ways to reduce costs and increase margins.

According to Ray Adams (IBS Chemicals Solution Manager at SAP), IT is helping to integrate groups like R&D to drive down cycle times in the commercialization process.

Some segments like coatings and ink companies introduce hundreds of products each year. They have to commercialize these things quickly. IT provides the tools and mechanisms to make that as seamless as possible, integrating into finance, the regulatory environment, into environmental health and safety databases, and flowing into the manufacturing environment.

9.5 Conclusion

From the above study it can be concluded that chemical industry in Europe is adapting digitalization in a fast pace compared to many other sectors. The digitalization has increased profitability by 10 – 20 %. Digital marketing has become integral part of marketing strategy of the top chemical companies in Europe. Blogging and article marketing is being extensively used to educate the customer and promote their products. The companies under study are extensively involved in social media marketing and video channels.

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The European chemical industry is key to economic development and wealth. It creates modern products and materials, and provides virtually all sectors of the economy with technical solutions. The European chemical industry supplies virtually all sectors of the economy and accounts for 17.8% of the total sales of chemicals in the world. It is one of the largest and most R&D-intensive manufacturing sectors in all the advanced economies, and its innovative patterns and productivity growth processes can have profound impacts on economic growth as a whole. In a recent study, Tullo shows that 19 of the top 50 global chemical companies are headquartered in Europe and they make 14.5% of all sales of chemicals in the world. The purpose of this book is to provide an overview of the status of the European chemical industry and the problems it currently faces. According to specialists, innovation and research are key to securing the future of the European chemical industry. Research and development is one way in which companies can ensure future growth by developing new products or processes to improve and expand their operations. The book discusses investment in research and development in the European chemical industry in general and also in the top fifteen European chemical companies in particular. In order to understand research strategy and trends in innovation, we analyze R&D investment, the patent landscape, university-industry collaboration and the regional distribution of chemical companies.

