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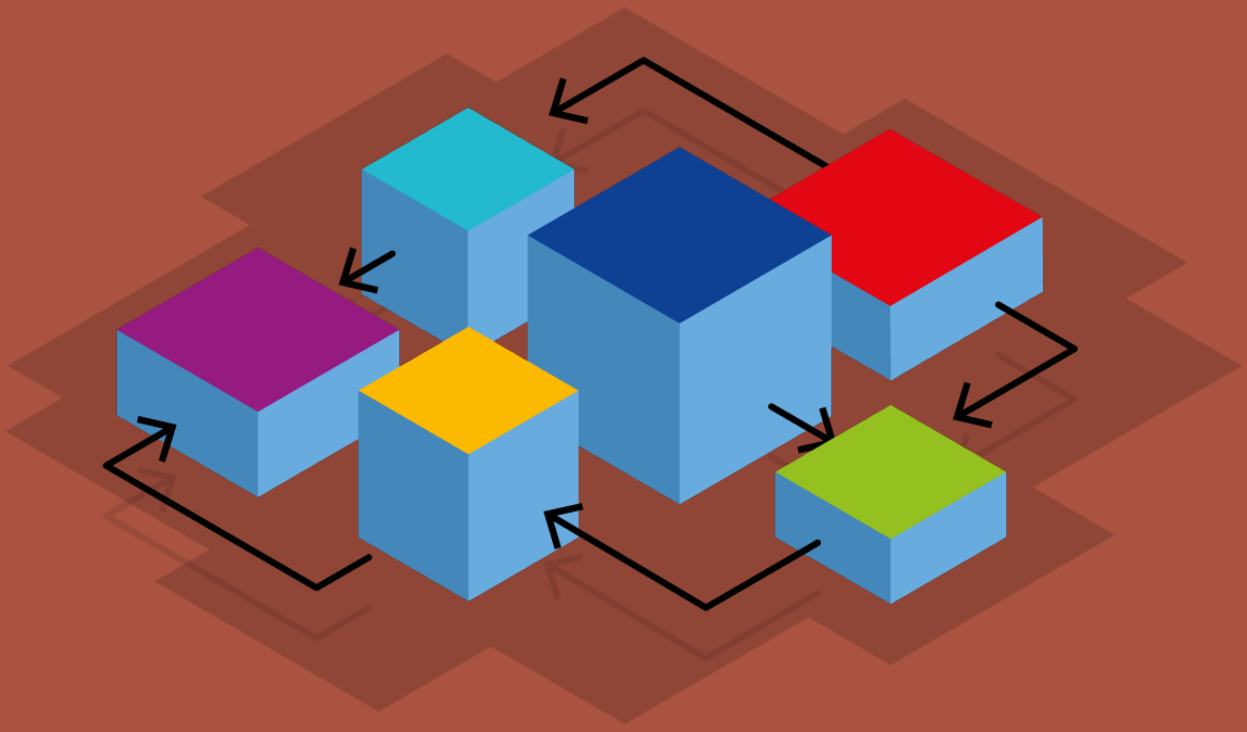

European Cluster Observatory

REPORT

European Cluster Trends

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Internal Market, Industry, Entrepreneurship and SMEs

European Cluster Observatory in Brief

The European Cluster Observatory is a single access point for statistical information, analysis and mapping of clusters and cluster policy in Europe that is foremost aimed at European, national, regional and local policy-makers as well as cluster managers and representatives of SME intermediaries. It is an initiative of the "SMEs: Clusters and Emerging Industries" unit of the European Commission's Internal Market, Industry, Entrepreneurship and SMEs Directorate-General that aims at promoting the development of more world-class clusters in Europe, notably with a view to fostering competitiveness and entrepreneurship in emerging industries and facilitating SMEs' access to clusters and internationalisation activities through clusters.

The ultimate objective is to help Member States and regions in designing smart specialisation and cluster strategies to assist companies in developing new, globally competitive advantages in emerging industries through clusters, and in this way strengthen the role of cluster policies for the rejuvenation of Europe's industry as part of the Europe 2020 Strategy.

To support evidence-based policy-making and partnering, the European Cluster Observatory provides an EU-wide comparative cluster mapping with sectoral and cross-sectoral statistical analysis of the geographical concentration of economic activities and performance. The European Cluster Observatory provides the following services:

- **a bi-annual "European Cluster Panorama"(cluster mapping)** providing an update and enrichment of the statistical mapping of clusters in Europe, including for ten related sectors (i.e. cross-sectoral) and a correlation analysis with key competitiveness indicators;
- **a "European Cluster Trends" report** analysing cross-sectoral clustering trends, cluster internationalisation and global mega trends of industrial transformations; identifying common interaction spaces; and providing a foresight analysis of industrial and cluster opportunities;
- **a "Regional Eco-system Scoreboard"** setting out strengths and weaknesses of regional and national eco-systems for clusters, and identifying cluster-specific framework conditions for three cross-sectoral collaboration areas;
- **a "European Stress Test for Cluster Policy",** including a self-assessment tool accompanied by policy guidance for developing cluster policies in support of emerging industries;
- **showcase modern cluster policy practice through advisory support services to six selected model demonstrator regions**, including expert analysis, regional survey & benchmarking report, peer-review meeting, and policy briefings in support of emerging industries. The policy advice builds also upon the policy lessons from related initiatives in the area of emerging industries;
- bring together **Europe's cluster policy-makers and stakeholders at the European Cluster Conferences** 2014 and 2016 for a high-level cluster policy dialogue and policy learning, and facilitate exchange of information through these webpages, newsletters, videos, etc.

More information about the European Cluster Observatory is available at the EU Cluster Portal at: http://ec.europa.eu/growth/smes/cluster/observatory/

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Introduction

This preliminary report presents the results of the analysis that attempted to identify trends in industrial and cluster dynamics and paid particular attention to cross-sectoral links and internationalisation trends. All of this work has been conducted within the framework of the European Cluster Observatory.

The objective of the study was to identify and analyse trends in where and how clusters of related industries are transforming themselves and where new specialisation patterns give rise to the renewal, or the development, of emerging industries. The research aims to support policy-makers, cluster practitioners and companies to identify transformation trends at an early stage and to facilitate further policy efforts in this respect. It is intended to contribute to an improvement in the implementation of regional smart specialisation strategies and it should also help European regions identify areas of collaboration where industrial trends cut across not only sectors, but also, geographical borders.

In the first phase of the European Cluster Observatory, ten emerging industries were identified, based on a co-location analysis that was presented in the 2014 European Cluster Panorama. These emerging industries are: **Advanced Packaging, Biopharmaceuticals, Blue Growth, Creative Industries, Digital-based industries, Environmental industries, Experience industries, Logistical Services, Medical Devices, and Mobility Technologies**. This report follows up on this analysis and explores the most recent trends in these ten industries. The key research questions of this study were the following:

- What are the **global mega trends in industrial transformations**? What are the opportunities for cluster organisations and SMEs to collaborate globally and which are the areas, markets, and suitable strategic partners in third countries that have the greatest potential to foster SME internationalisation?
- What are the **cross-sectoral dynamics of industrial transformations** that can lead to the further development of emerging industries and new patterns of geographical clustering?
- How will the industrial transformation trends identified across industries and across nations, or globally, affect **future industrial structures and the development of emerging industries** by 2020? What are the inherent policy implications of the identified trends?

The analysis focused primarily on the European Union Member States together with Norway and Switzerland, but it also took account of global trends in terms of industrial dynamics and cluster development. The work builds upon the activities conducted in the first and second phases of the European Cluster Observatory,[1] during 2006-2008 and 2009-2011 respectively, and also during the extension period of the European Cluster Observatory[2] in 2011-2013. The report is structured as follows:

The first chapter presents the ten selected emerging industries that are the focus of this report and summarises the identified on-going trends in terms of cross-sectoral linkages and geographical patterns. It also highlights three so-called 'collaboration spaces' that span across most of the emerging industries and provide a basis for cooperation between, and development of, a wider range and type of clusters.

The second chapter pursues these ten emerging industries from a global perspective by describing global mega trends that shape future trends and outlines potential opportunities for internationalisation. The final version of this report, which will also include the cluster foresight exercise, will be ready in July 2015.

1 http://www.clusterobservatory.eu/index.html
2 http://www.emergingindustries.eu/

1. Global Megatrends affecting Industrial Transformations

This first Chapter identifies the global mega trends that shape most of the future development of emerging industries. According to the definition that EEA provided in 2007, Mega Trends[3] are *"those trends visible today that are expected to extend over decades, changing slowly and exerting considerable force that will influence a wide array of areas, including social, technological, economic, environmental and political dimensions."*

Global mega trends can be understood as a sustainable force on a global and macro-economic level, influencing the developments of business, economy, society, cultures and personal lives, on local as well as on a global level. Thus, the mega trends are also defining the appearance of the future world and regulating its pace of change.

The effects of mega trends are comprehensive, but above all, they affect the economic environment. The mega trends must be considered as the framework in which economies have to function. As a result, companies have to align their strategic decisions to the influences of these trends, if they are to maintain their competitiveness and safeguard it in the future.

First if all this study explored which of the ten industries are affected by which of the mega trends, and which industries might possibly reinforce which mega trends by their reactions to these trends. So, throughout the study, consideration was given to the questions of whether and how the industries were, in turn, influencing the trends that were impacting on them. While the first part of the study followed the definition of mega trends and their main effective direction, the second part explored the assumption that a trend could be reinforced or weakened by a sector or industry within its ambit of influence. A relevant example could be the impact of the mega trend 'Consumerisation, proliferation and ubiquity of IT' on the IT industries. Due to the ability of this industry to speedily produce new generations of mobile end devices, the diffusion of the initiating trend will be continuously accelerated and also extended to other branches and markets.

The impact of trends on the industry is referred to here as being 'downstream' and the possible reactions of the industry, as being 'upstream'. This downstream and up-stream relationship can be visualised as matrices and these will be subject to further consideration.

Mega trends can be seen as the fundamental catalysts for growth in markets through their influence on several determining factors, such as consumer behaviour and business processes. Thus, they can be seen as providing a major support, and a strong foundation, for the introduction of new products and services. Additionally, by influencing price, performance, availability and quality improvements, mega trends also unlock latent demand and revitalise growth in existing, mature markets, whilst harnessing additional resources to promote the growth of new market opportunities.

Mega trends provide a tail wind to back the progress of emerging industries that accelerates their growth and guarantees a high rate of growth over a considerable period of time. These major growth opportunities are often found where mega trends interlink with growth sectors in national or regional economies such as ICT, health care, renewable energies, environmental industries and business and consumer services.

[3] *European Environment Agency (EEA), GMT Report 2007*

Prevailing Mega Trends

The following trends have been identified by the results of the study as being important and long-lasting mega trends and these have been included in a set of mega trends to be all further investigations.

In this study, current mega trends were not the only ones to be included, because the experience and perceptible impacts of these trends on emerging industries may, as yet, be low. Existing, long-lasting trends were also included, which have already undergone certain developments, for example, 'carbon foot-print reduction' has been extended to embrace self-restriction, renewable energy and the efficiency of applications.

Innovation dynamics

Innovation is a major driver of economic growth and development, but its appearance is changing. Fundamental trends can be observed in cloud, mobile and social applications that are reshaping the technology industry. Companies need to embrace the full spectrum of innovation — incremental, breakthrough and radical - in both their R&D and their business model strategies.

With the emergence of disruptive innovation, the introduction of new technologies, products or services can be regarded as an effort to promote change and to gain advantage over the competition. However, the innovation process itself is changing. This is because the acquisition of the required knowledge is becoming more and more challenging. Knowledge is now 'liquid' in that it is randomly distributed across several sources or 'knowledge carriers' with an enormous regional spread, it is highly mobile, and it is challenging in an interdisciplinary sense.

Cross-linkage of subjects and objects (Internet of Things)

The use of computers and Internet linkages to manage an increasing spectrum of societal functions, including critical infrastructure, has a broad range of social, economic, commercial, legal and security implications. The number of devices connected to the Internet now exceeds the total number of humans on the planet, and is expected to rise to 50 billion by the end of the decade. For manufacturers, the implications of this emerging 'Internet of Things' are huge, and around 80 to 100 percent of all manufacturers will be using relevant applications by then.

The rise of the cross-linkage between subjects and objects has been driven by the convergence of markets and, at the same time, by innovations in enabling technologies. Future products will have vastly extended capabilities, they will offer new forms of value and they will be able to perform far beyond their primary function. This transformation is shifting the sources of value and differentiation to software and services, and is creating entirely new business models.

Consumerisation, proliferation and ubiquity of IT

Accessing information on mobile devices, tablets or personal computers is increasingly becoming a user-friendly experience that is almost taken for granted. The IT interfaces benefit from the effects of economies of scale, driven by the consumer sector and performance, reliability and functionality and are well-balanced and also most of the consumer IT goods can also be used for a variety of business processes. This is a situation, which now appears to be well-established, but future practices will be determined by the fast paced development in the production of new generations of human interface devices. The influence of the trend is always present, but 'the way of doing' fluctuates dramatically.

Customers, as well as employees, have become accustomed to unprecedented ease of use in the way they access information online, whether through mobile devices, tablets or personal computers. They expect applications to be as simple, intuitive and task-oriented as online banking, participating in the social media or making restaurant reservations. This trend towards simpler, task-oriented functions is partially driven by the screen size of mobile devices but it still applicable despite the nature of the interface that is used.

Therefore, companies have to develop enterprise applications that are easier to learn and thus, improve productivity. Secondly, they need to develop applications that are easier to use on smartphones and other mobile devices. Both trends will require commitments to application development tools that address multiple platforms and also to increased security and privacy that ensure data integrity in all cases.

Impact of Social Media

In this context, social media should be seen as the sum of the tools, services, and communication techniques that facilitate connections between peers with common interests. They include the online technologies and practices that people use to share content, opinions, insights, experiences and perspectives and also include the mass media.

On the one hand, with their enormous reach and easy access, they can facilitate social networks in which single users or entire user groups can have an intense and on-going discussion on product characteristics and performance. At the same time, they also have a noticeable influence on the methods and the results of product selection processes. Online social networks enable interactive information sharing between customers that is faster and more convenient.

On the other hand, the whole dynamics of marketing have been changing, and rather than investing in mass TV or radio channel advertisements, companies are becoming more consumer-centred as a result of those interactions with their customers conducted through social media. Though such direct interactions, the companies are in a better position to understand the needs of their markets. Social media can offer more immediate and in-depth feedback than that which can be offered by using traditional methods of market research and customer surveys.

Big Data

Big Data is currently not a precise term. It can be seen as a characterisation of an accumulation of all kinds of data, arousing terabytes or petabytes of data sets that are growing exponentially and being too large, too raw, or too unstructured to accommodate the traditional approach to analysis using relational database techniques. By applying Big Data to their challenging business issues, companies are reshaping their operations and, thereby, upgrading their business results. Big Data will transform every aspect of the organisation, from its strategy and business model design though marketing, product development, recruiting and human resources to its actual operations. Organisations will be far more data-driven at all levels.

The amount of data in our world is increasing exponentially and a large portion of this data comes from the interactions between the mobile devices being used by people in the industrialised countries, as well as those in the developing world. Researchers and policy-makers are beginning to realise the potential for channelling this torrent of data into actionable information that can be used in a commercial manner. As a result, the use of Big Data, as a resource, will deliver real business value to enterprises.

Personalisation of Products and Services

This should be understood as the use of systems, which combine the low unit cost of mass production processes with the flexibility of individual customisation, and thus, aim to offer customised products and services at reasonable prices. Such an approach has been engendered by changes in customers' behaviour including a decrease in brand loyalty. ‘Personalisation of Products and Services’ is a concept that implies that a company can provide its customers with the opportunity to choose the product specifications that they want or require.

In responding to these changes in customer orientations, companies often try to react by putting a wider variety of products on the market, but this often leads to too much complexity and more expensive production. However, a solution can be offered by the principle of mass customisation. The target

market is not a differentiated market, but the mass market. This can be achieved by varying a few features from a customer perspective but these are aspects that are crucial to the individualisation of the product and often relate to design features or fit. Frequently, however, these products are also based on modularisation, which means that the product can be assembled from a variety of building blocks. A special sector in which such individualisation is taking place is the field of personalised medicine. Individual approaches can offer better diagnoses, earlier interventions, more efficient drug therapies and customised treatment plans. These approaches are based on a genomic blueprint and can determine each person's unique disease susceptibility, define preventive measures and enable tailor-made therapies to be deployed to promote well-being.

Immediate availability of products and services

The pervasive challenge to emerging industries is ensuring a constant presence in the environment of the global market. The global market is a buyer's market and the immediate availability of products and services makes efficiency a high priority. Wise, timely, and measurable efforts maintain a business' cutting edge and promote growth. This can be seen as a concept designed to satisfy the customers' demand for the immediate availability of products and services, and, in this way, to minimise costs of carrying excess stock and also business disruptions. As it is not enough to simply attract customers with low prices and efficient services, the extended opportunities of information and communication accelerate the customers' processes of selection. The customers also expect that the products or services that they choose should be available immediately and this type of customer behaviour has a distinct effect on any companies' manufacturing processes, as well as its logistical infrastructure.

Changes in geo-economical dynamics

Emerging economies become important markets, in both size and growth. Emerging markets are increasingly changing from low-cost production locations to large consumer markets. Perspectives for the future growth of European clusters and their cluster members may very well depend on their ability to adapt their business models to these economies.

New regions appeared some years ago as a potential driver of the future of the world. Demographics, territorial scale, low production costs, easy access to commodities were all signs of impending changes in the geo-economic axis. A middle class is created and becomes interesting as it provides growth potential. However, these regional markets were often located in areas that had both unstable political bases and unpredictable economic conditions. Emerging economies are becoming important markets, in both their size and growth. Emerging markets are changing more and more from low-cost production locations to increasingly large consumer markets but hopes for future growth may very well depend on the ability to adapt existing business models to these economies.

In the past few years, these pro-convergence drivers seem to have changed course. The promising development in the emerging markets has apparently come to an end. Emerging economies have slowed down. In contrast, the US is recovering and Europe may be coming out of its recession. This, of course, has also had an impact on the future outlook on the direction of capital flows and investments.

Changes in entrepreneurship culture (crowd funding, etc.)

The role of entrepreneurs, especially in emerging industries, is vital in technology breakthroughs and alternative funding systems for new ventures have emerged, for instance, in the form of crowd funding. Rather than relying on the opinions of experts, crowd funding enables millions of individuals to make decisions about which entrepreneurial projects they want to test and support. The increasing mobility of young people and new experiences that this offers, plus the ability to link IT competence with other application fields in an interdisciplinary approach can provide new sources of entrepreneurial ideas and concepts.

Convergence of products, device and services

This trend represents a merging of corporate and consumer capabilities within IT devices. Costumers and companies are using the same technology devices and they are using them for similar activities, such as accessing corporate data to gain better insight into immediate and ongoing relationships including spare parts management, maintenance services and package shipments. This convergence of devices and services will demand new business models and present opportunities for new revenue streams. Convergence, which is increasingly occurring along many different dimensions, will also influence traditional business concepts.

Shortening of product lifetime cycles

The shortening of life cycles means that the need to replace a product or service more rapidly is being recognised across many industries as is the fact that if a company is too slow to introduce a product to market, it risks launching goods that have already been developed and supplied by other competitors. This challenging environment means that accurate demand planning and forecasting have never been more imperative and so businesses must adopt a more coordinated approach to their supply chain management. In addition, experience-based efforts or processes such as design or pre-aging tests have to be replaced by new, more intelligent solutions.

A key reaction to this trend is the introduction of technology that enables organisations to quickly and effectively manage operations and to gain a greater perspective of the entire value chain. The sophistication of value chain management will continue to grow, with organisations increasingly using inventory principles along the entire life cycle of a product, for example to maximise the speed of the market launch of a product, of introducing a re-branding, applying forecasting and planning technologies, or of providing variations to respond seasonal factors. As a product proceeds through its life cycle, the demand characteristics change and organisations must be committed to adapting the value chain strategy if they are to maintain competitiveness by making the necessary changes at a moment's notice.

Carbon foot-print reduction

A CO_2 footprint can be calculated for people, organisations, countries and events. The size of the CO_2 footprints of the different possibilities or proposals for action can be taken into account when making decisions. Businesses are investing in understanding their supply chain emissions and verifying the carbon footprint of their products. They also communicate the results of these investigations to their customers because they recognise the potential in consumers switching to their lower-carbon alternatives and the fact that this could greatly increase the value of product differentiation.

Consumer demand for lower-carbon products and services is growing, despite the tough economic climate. People understand that the manufacture, distribution, sale and disposal of the products they buy come at a high price in terms of carbon emissions across the value chain. They are increasingly prepared to change their shopping habits to help minimise the 'embodied carbon' or 'carbon footprint' that is associated with their purchases. Leading businesses are also responding to these changes by measuring and reducing their impact and developing new businesses on this basis.

1.1 Mega Trends and Emerging Industries

To analyse the impact of mega trends and to identify the emerging industries, which are exposed to a particularly strong influence of one or more mega trends, both - industries and trends - have been merged in a matrix (see Table 1).

The analysis is based on the idea that on one hand, the mega trends influence the examined industries. On the other hand, this influence can assumable not be non-reactive and the industries are conversely able to influence the trends as a response in the course of their own development.

For the further analysis4, it has been identified, which of the ten emerging industries are strongly influenced by which mega trends – the “downstream” view (the impact of trends on the industry; see matrix, Table 1), and also which of the emerging industries conversely strongly empower which mega trends as the "upstream" view (possible reactions of the industry; see matrix, Table 2). There is no doubt that almost all mega trends more or less impact all ten emerging industries, but there is a common sense that in some areas the impact is more significant whereas in others it is much less significant.

These two approaches have additionally been merged into one consolidated matrix identifying of areas of strong interdependencies (see Table 3) used for further considerations. This Table represents the fields of the strongest reactions in both directions, "downstream" as well as "upstream", however also, in exceptions, influences in only one direction, but then with an extreme effect. There is no doubt that these downstream and upstream effects have a serious impact on the global value chain within the ten emerging industries and will lead to new cooperation models between involved actors. This provides a huge potential for new SMEs in cluster to enter new value chains and industrial niches within the emerging industries.

Table 1: Mega Trends, influencing Emerging Industries – Downstream effects

Mega Trends/ Emerging Industries	Mobility Technology	Medical Devices	Logistical Services	Digital Industries	Experience Industries	Environmental Industries	Creative Industries	Blue Growth Industries	Biopharmaceuticlas	Advanced Packaging
Cross-linkage of subjects & objects	●	●	●	●						
Big data	●	●		●		●			●	
Impact of social media					●		●			
Personalisation of products & services		●	●	●			●		●	●
Immediate availability of products & services	●		●	●						
Changes of geo-economical dynamics	●		●	●		●		●	●	
Innovation dynamics				●					●	
Changes in entrepreneurship culture				●	●		●		●	
Convergence of products, devices and services	●			●						●
Consumerization, proliferation and ubiquity of IT				●						
Shortening of lifetime cycles				●			●			
Carbon foot-print reduction	●			●		●		●		●

● *Downstream (Mega trends influence Industries)*

[4] *Based on an international expert panel (industry, science, cluster managers), scientific studies and desktop analyses*

Table 2: Emerging Industries, influencing Mega Trends – Upstream effects

	Mobility Technology	Medical Devices	Logistical Services	Digital Industries	Experience Industries	Environmental Industries	Creative Industries	Blue Growth Industries	Biopharmaceuticlas	Advanced Packaging
Cross-linkage of subjects & objects			●							●
Big data				●						
Impact of social media				●			●			
Personalisation of products & services		●	●		●					●
Immediate availability of products & services							●			
Changes of geo-economical dynamics										
Innovation dynamics										
Changes in entrepreneurship culture										
Convergence of products, devices and services	●									
Consumerization, proliferation and ubiquity of IT		●		●			●		●	
Shortening of lifetime cycles			●							
Carbon foot-print reduction	●					●		●		

● *Upstream (Industries influence mega trends)*

Table 3: Mega Trends vs. Emerging Industries – Areas of strong Interdependencies (AOSI's)

	Mobility Technologies	Medical Devices	Logistical Services	Digital Industries	Experience Industries	Environmental Industries	Creative Industries	Blue Growth Industries	Biopharmaceuticlas	Advanced Packaging
Cross-linkage of subjects & objects			●							
Big data				●						
Impact of social media			●				●			
Personalisation of products & services		●	●							●
Immediate availability of products & services										
Changes of geo-economical dynamics			●							
Innovation dynamics										
Changes in entrepreneurship culture										
Convergence of products, devices and services	●									
Consumerization, proliferation and ubiquity of IT				●						
Shortening of lifetime cycles										
Carbon foot-print reduction	●					●		●		

● *Areas of strong interdependencies*

The chosen method of analysis considers the effect of trends, as outlined in the methodology report, selective with respect to the direction of action.

All directions of influences have been evaluated by a panel of experts, including the effects of the trends in the emerging industries as well as the influences of the developments in the industries to the trends.

For instance the **Logistics Industry** is faced by challenges raised from the influence of social media and product personalisation. The example shows that there can also be interdependencies between individual trends: A fast growing customer potential is combined with an increasing catchment area, where these customers are located - in emerging countries with an increasing demand due to a noticeable increase of purchasing power, caused by the emergence of a middle-class.

Another example is the case of **Advanced Packaging,** which industry will be heavily challenged by the trend of personalisation, because it plays a crucial role, e.g. as an instrument for significant accentuation of brand-defining areas of a product or branding.[5]

[5] *For more details please refer to: Cluster Internationalisation and Global Mega Trends, Summary Report, 2015*

2. Cross-sectoral Dynamics of Industrial Transformations

This second Chapter focuses on cross-sectoral industry dynamics. It presents the ten emerging industries that have been selected and analyses them in terms of cross-sectoral dynamics and geographical patterns.

In real life, innovations are often nurtured through novel combinations of ideas, technologies, assets and supply chains, which can also connect businesses and industries that had been previously been unrelated. As Marshall noted as long ago as 1920, inventions and improvements in machinery and the general organisation of business rely on the combination of ideas, *"If one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas".* The novel combination of ideas not only happens within one industrial sector, as it can also spread across others. Several ways exist of disseminating knowledge from one industry to another and then using it within the new sector. These include supplier-producer-user links, licensing in or out from other sectors or strategic industrial cooperation.

Clusters are cross-sectoral by their nature, as they refer to a concentration of related industries and institutions, and thus, they can be platforms for innovation and industrial change. They exist and/or survive in a perpetual process that comprises emergence, growth, decline and renewal. Clusters transform and reinvent themselves in response to changes in the external environment or changes initiated within the cluster, which can be amplified through positive feedback between this external environment and the cluster itself. Clusters are therefore in a constant dynamic state, both shaping and being shaped by the industries and by the group of firms in which they operate, which leads to shifting specialisation patterns across Europe.

In order to identify trends in industrial transformations, indications of cross-sectoral linkages have been captured within the ten emerging industries that were identified in the 2014 European Cluster Panorama. The geographical hot spots and cross-regional connections have been singled out where these spill-overs occur most often.

In other words, an approach has been followed where first cross-sectoral trends and their directions are initially identified and, in a subsequent step, the geographical pattern of the links is detected. Their process of transformation is also traced in order to understand their possible future development paths, using a time-series of data and examining the changes to these time-series over a period of time. The analysis enables a reflection on the types and locations of cross-sectoral industrial transformations of first measurable occurrence over the course of time.

This analysis was based on a selected list of indicators that are reliable proxies to predict cross-sectoral trends at regional level and these indicators are also available for the latest years and thus, reflect recent trends. This is an advantage compared to official statistics that usually lag many years behind. This approach also builds upon the previous phases of the European Cluster Observatory and ensures consistency.

The selected indicators are:

- Patenting and co-patenting;
- Mergers and acquisitions;
- Joint ventures, strategic alliances and innovation networks.

In order to identify cross-sectoral linkages between the core and other industries/technological areas, in the case of each emerging industry, all other technologies included those in the patents[6] have been classified using the OECD classification (based on Schmoch, 2008; Schmoch, 2007; and WIPO, 2013). The analysis looked, on the one hand, at the top 20 pairs of technology areas/industries according to the number of patents filed in the two periods of analysis and, on the other hand, it compared the dynamics or growth in patent counts of applications in terms of patenting over the two periods of 1992-2002 and 2002-2012. These are regarded as being long enough periods to be used to identify changes. Cross-sectoral linkages have been also investigated through mergers and acquisitions and joint ventures and alliances, where the two periods 2000-2007 and 2007-2014 have been placed under scrutiny and again, these are long enough periods to support a reflection about trends and changes. The periods are more recent in the case of patenting, as changes tend to take less time to appear as is the case in terms of technological developments. Within all these three indicators, the composition of cross-sectoral links enables an understanding of whether innovation activities within a certain industry are linked to the dynamics of another industry.

The quantitative analysis has been complemented by a qualitative analysis to enrich and contextualise the results of the data analysis. This also helps to redress the limitations of the data. As a result of this complementary analysis, changes in the value chain of each industry have also been depicted.

In the last step of the analysis, the geographical pattern of the most dynamic cross-sectoral linkages that were identified, have been investigated. The objective was to highlight both the regional hot spots and also the communities of regions that were the most closely connected through these cross-sectoral linkages. In order to do so, a social network analysis was performed on the regions that appeared in the data of the most dynamic cross-sectoral linkages, related to the paper and packaging industry.

2.1 Cross-sectoral Trends within Emerging Industries

The ten emerging industries identified through the European Cluster Panorama represent a diverse group of related industries and clusters. Some of them are very broad and ubiquitous such as **Environmental industries**, **Digital-based industries** and **Logistical Services,** which are cross-sectoral by nature, span many other industries and are relevant to many types of clusters. Other emerging industries identified have a well-defined core industry such as **Medical Devices, Biopharmaceuticals, Advanced Packaging** or **Mobility Technologies** that demonstrate new industrial dynamics both through cross-technological spill-overs and cross-industrial linkages. **Blue Growth** is an emerging industry that connects three big industrial themes such as maritime industries, fisheries and offshore drilling. The **Creative and Experience industries** are diverse groups of industries and include many design and human creative and recreational activities. The latter can be analysed through mergers and acquisitions and joint ventures and alliances but cannot be traced through patenting, given the nature of these industries.

The cross-sectoral nature of the Environmental and Digital-based industries has also been shown by the patent analysis, which revealed that around 50-70% of the patents related to these industries that had been filed addressed several technological areas and not only specific environmental or digital technologies. At the other end of the spectrum, industries such as Medical Devices and Packaging are more often related to one core technological area. The shares of cross-sectoral mergers and acquisitions exhibit lower percentages overall that point to the fact that cross-sectoral linkages are sometimes

[6] When patents are filed, each patent is classified to different technological areas, so-called IPC codes, depending on the features of the invention.

less important in industry partnerships. There are, however, exceptions as Environmental and Digital-based Industries that again exhibit high cross-industry activity.

Table 4: Percentage of cross-technological patents related to emerging industries

Name of the emerging industry	Maximum number of different technological areas named in the patent	Percentage of patents with several technological areas named	Percentage of Mergers and Acquisitions (M&As) with a cross-sectoral pattern
Advanced Packaging	45	35.33	21.49
Biopharma	191	40.19	23.08
Blue Growth	30	52.69	18.13
Creative industries	n/a	n/a	64.4
Digital-based industries	110	52.11	98.2
Environment: alt. energy	80	72.39	87.64
Environment: recycling	60	81.51	85.23
Experience industries	n/a	n/a	45.2
Logistical Services	18	38.61	11.16
Medical Devices	47	34.82	26.74
Mobility Technologies	48	47.58	53

A further analysis of patent trends across all the eight core industries (where a patent analysis has been possible) shows that while patenting activity decreased over the most recent period, with other studies pointing to the effects of the economic and financial crisis, the share of patents that mention several technological areas, in the total number of patents increased over the years. This indicates that more interdisciplinary research and technological collaboration has existed in the economy.

The analysis of mergers and acquisitions revealed that in some of the industries, cross-sectoral activity takes place close to the core industry and along more traditional value chain linkages, while in others there are dynamic cross-sectoral patterns emerging in relation to industries, whose linkages used to be weak and hence, these dynamic patterns were less expected. Weaker linkages that gained importance are also often related to enabling industries that bring a new source for advancement in the product or service. For instance in the case of Logistical Services such enabling linkages have been the ICT, transportation and machinery industries. Cross-sectoral dynamics close to the core industry have been identified in Advanced Packaging, Blue Growth, Experience industries and Mobility Technologies. Nevertheless, industries such as Biopharmaceuticals, Creative industries, Digital-based industries, Environmental industries, Logistical Services and Medical Devices exhibit dynamics related to more unexpected areas. Their strong links appear to have decreased slightly in importance, which can also reflect the fact that these links have become well-established.

The analysis also revealed a pattern of certain types of linkages predominantly taking place across the ten emerging industries and these refer to mainly linkages that enable new applications of certain technologies or solutions (e.g. in the area of environmental services and ICT or linkages related to nano-technology); taking inspiration from other industries and develop new products and services (e.g. medical devices and mobility technologies); and traditional linkages that have been existed for long but constitute an important driver behind industrial development (e.g. health care packaging).

The regional analysis revealed that most of the cross-sectoral activity is linked to metropolitan areas or capital cities, which might be less surprising since cities usually are a good source for knowledge spill-overs and offer a good framework in which to develop cross-sectoral links. It should also be highlighted that the most active regions are usually to be found in the Western and Northern part of Europe. It

is important to bear in mind that the analysis relies on specific indicators that cannot capture all the ongoing dynamics, but even with this limitation, it is somewhat alarming that several parts of Europe remain white in the maps in the following sections of this report, as this reflects no or low cross-sectoral activity. The links between European regions are usually forged within relatively limited geographical areas meaning that the regions that cooperate in cross-sectoral activity are those that are closer together. Hence, there are patterns of Northern Continental Europe, UK and Ireland working together, and the same is true of France and Southern Europe and Germany and Central Europe.

The value chain analysis also showed that while in certain cases cross-sectoral activity happens on the upstream side closer to research and development, there are lots of dynamics on-going on the downstream application side of the industries. For instance in the case of Digital-based Industries, linkages to other industries occur predominantly as other industries being users of information technology to enhance their existing processes and products or even create new ones.

In the following sections, the results and key highlights of the quantitative and qualitative analyses are summarised for each emerging industry. These are also discussed in detail and depth in the ten industrial reports that were prepared as part of this study. These industry reports are available at http://ec.europa.eu/growth/smes/cluster/observatory/cluster-mapping-services/trend-report/index_en.htm

2.1.1 Advanced Packaging

The paper and packaging industry plays an essential role in modern life by improving the accessibility and distribution of a range of products such as food or consumer goods. Packaging fulfils important functions such as protecting the goods from external damage, enabling distribution through different forms and sizes of packing that keep the products fresh or safe. The industry includes manufacturers of paper packaging, cardboard and cardboard stock, laminated paper containers, paper fibre-based boxes, bags and wrapping paper and also manufacturers of metal, glass or plastic containers and packaging.

Advanced packaging solutions increasingly rely on sophisticated printing and converting machinery to deliver the quality, efficiency and innovation that the market demands. New packaging can substantially reduce the costs of freight and logistics and it can play an important role in protecting not only the product but also the environment.

When looking at different indicators that reflect trends at specific stages in the industrial value chain, the paper and packaging industry demonstrates the most dynamic cross-sectoral linkages related to other industries and technological areas in the table below. In all the three data samples, the focus was on identifying industry linkages that showed a growing patent, M&A or JVA count. Nevertheless, it is important to bear in mind that when simply looking at the figures, a larger percentage change may be evident but this can also reflect a change, which appears to be large simply because it has been made in relation to a much smaller baseline figure. Hence, both the strength of the linkage, the total number of linkages and the dynamics over periods and years should be taken into account. The cross-sectoral linkages in which a significant growth has been identified are summarised Table 5.

Table 5: Dynamic cross-sectoral linkages related to Advanced Packaging

Core industry under analysis	Link to other industries showing positive dynamics related to the core industry	Growth over periods (percentage change)	Total number of cross-sectoral linkages
Captured through patenting (reflecting trends in upstream activities such as research and technology):			
Packaging	Micro-structural and nano-technology	3.72	255
Packaging	Engines, pumps, turbines	1.31	1219
Packaging	Furniture, games	1.29	3414
Packaging	Handling (mechanical engineering e.g. devices which apply lifting, robotics etc.)	1.26	1052
Packaging	Medical technology	1.22	6248
Captured through mergers and acquisitions (reflecting trends in downstream activities such as production and services):			
Packaging acquired:	Machinery	1.27	25
Packaging acquired:	Power	1.20	11
Packaging acquired:	Other Materials	1.12	51
Packaging was a target of:	Computers & Peripherals	6.00	11
Packaging was a target of:	Food & Beverage	4.50	11
Packaging was a target of:	Water & Waste Management	3.00	12
Captured through joint ventures and alliances (reflecting trends in strategic business activities often with an international character):			
Packaging	Chemicals & allied products	1.81	31
Packaging	Electronic components	1.11	19

Note: Detailed calculations and data are available in the industry reports that were prepared as part of this study. They are available at http://ec.europa.eu/growth/smes/cluster/observatory/cluster-mapping-services/trend-report/index_en.htm

The cross-sectoral linkages identified above demonstrate that the industry is very much driven by developments in the areas of **new materials and nano-technology,** on the one hand, and in the areas of **mechanical engineering and machinery**, on the other.

As the analysis of M&As pointed out, there are also other industries that the paper and packaging industry serves the most in terms of innovative solutions such as **medical devices, drugs, food and beverage, computers and peripherals**. As the literature review revealed, the development of the packaging industry is linked to the development of consumer preferences, demographic and lifestyle changes and environmental concerns. It is important that the producers of the product and of packaging work together at an early stage so that they can ensure that the needs for packaging solutions are met. The most recent trends show more demand for personalised packaging, new design, easy-handling and environmental-friendly solutions.

Interestingly, cross-technology **patenting activity related to environmental technologies has declined recently**. However, this can also reflect the fact that a phase of more active research and technology development is being followed by a focus on the commercialisation. This might indeed be the case, as links, such as mergers and acquisitions, appear when considering other parts of the value chain.

A relevant crossover between the packaging, printing and computer industries is **digital-print for packaging**. The packaging industry has traditionally relied on analogue printing and has only recently started to adopt digital printing technologies. Using these new solutions, packaging producers can reach new customers in a more personalised and flexible manner and even, more importantly, in-

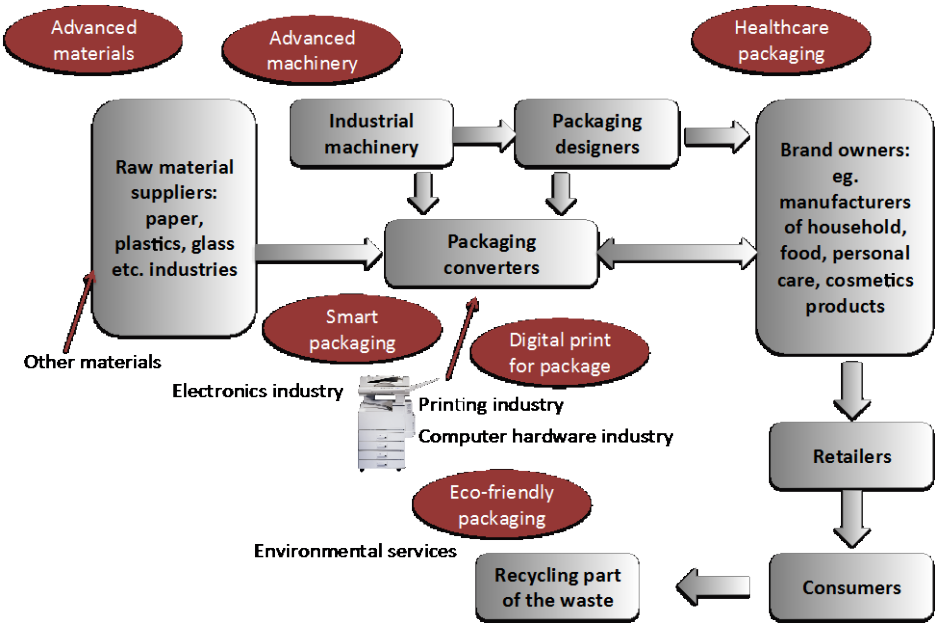
crease their production efficiency and reduce inventory time. Although digital technologies related to packaging show a decline in terms of patenting activity, this might be similar to the case related to environmental technologies and might reflect a maturity in terms of technology development.

Packaging innovations have many connections to technological advances in the areas of microelectronics, computer applications or nanotechnology. These new ranges of so-called "**smart packaging**" can help, for instance, in delivering data on the product, in monitoring freshness and in communicating product quality.

Development in the area of packaging depends on increases in the use of **advanced packaging materials**. This is also reflected in the strong connection in mergers and acquisitions between 'Paper and Packaging' and 'Other Materials' industries. New materials include innovations in cellulose composites, ceramics, polymers, the development of new bio-based materials and recovered fibres.

Advanced packaging does not only need new materials and methods but also innovative packaging equipment. New **packaging machinery** is now being developed at the crossover of packaging, machinery, electronics and ICT industries. Figure 1 depicts these cross-sectoral trends along the value chain of the paper and packaging industry.

Figure 1: Cross-sectoral trends in the value chain of the Paper and Packaging industry



Source: Technopolis Group

The regional analysis has shown that the most dynamic hotspots, where most of the cross-sectoral activity took place as captured through patenting, M&As and JVAs, are the following:

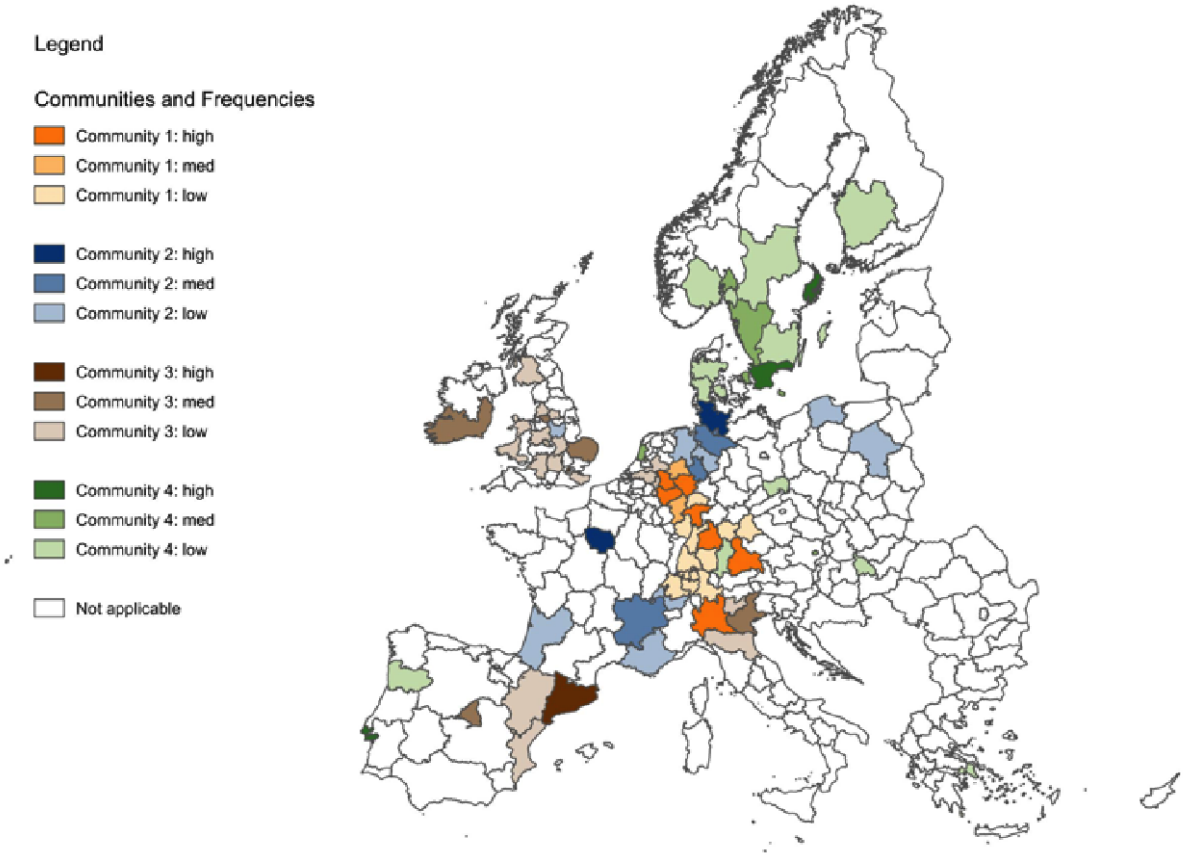
- Capital cities: such Île de France (in France), London (UK), Stockholm (Sweden), Helsinki (Finland), Madrid (Spain), Lisbon (Portugal), Dublin (Ireland), North Holland (Netherlands) but they also include Upper Bavaria (in Germany), Catalonia (in Spain) and Lombardia (Italy);
- West Sweden, Lower Austria, Greater Manchester (UK), Leicestershire (UK), Pomorskie (Poland), Central Denmark and South Sweden are other regions that show relatively high cross-sectoral activity.

The highest number of linkages indicates regions with high cross-sectoral activity, whilst the results of a social network analysis can shed additional light on the connections that exist across geographic borders. The social network analysis identified four communities of regions that were the closest connected through cross-sectoral linkages. These communities are centred round specific node regions that are not always the same as regions with the highest number of linkages and are:

- Community 1 – Köln (Germany);
- Community 2 – Schleswig Holstein (Germany);
- Community 3 – London (UK);
- Community 4 – Lower Austria (Austria).

Figure 2 depicts these communities, in different colours, and the regional hot spots, in darker colours.

Figure 2: Regions and communities with dynamic cross-sectoral patterns related to Advanced Packaging



Source: Technopolis group prepared with QGIS and based on Patstat and Thomson One data

Notes: based on 2010 NUTS codes. Frequency refers to the level of cross-sectoral dynamics present in the specific region based on the three indicators applied. The colours of the map reflect different communities (C1-C4) that belong together and represent one larger area where cross-sectoral spill-overs happen. The intensity of the colours represents the overall frequency and the most intense colours correspond to the regions with the highest frequencies. In particular: high represents the top 15 regions with cumulative frequency; medium represents regions with cumulative frequency of approximately 60%; and low represents the regions above the median but below the medium group. Colourless regions represent those regions where there is no cross sectoral activity in terms of patents, M&As and JVAs taking place or the frequency of cross sectoral activity is below the median (median=11).

2.1.2 Biopharmaceuticals

The Biopharmaceutical industry is defined as "enterprises focused on discovery and development of biopharmaceutical products for human healthcare, based on tools and approaches from modern biotechnology" (EC, 2009). Pharmaceutical products namely medicines or drugs, are a fundamental component of both modern and traditional medicine (WHO, 2013). Biopharmaceuticals specifically mean "biologic medical products," which are distinct from chemically synthesised pharmaceutical products. In this report both the Biopharmaceutical and Pharmaceutical industries are covered.

When looking at different indicators reflecting trends at specific stages of the industrial value chain, the Biopharmaceutical/Pharmaceutical industry was found to show the most dynamic cross-sectoral linkages related to the other industries and technological areas in the table below. In all the three data samples, the focus was on identifying industry linkages that showed a growth in patent, M&A or JVA counts. The linkages that exhibit a decline are not listed here, although they are discussed in the detailed industry reports. The trends of the industry are summarised in Table 6.

Table 6: Dynamic cross-sectoral linkages related to Biopharmaceuticals

Core industry under analysis	Links to other industries showing positive dynamics related to the core industry	Growth over periods (percentage change)	Total number of cross-sectoral linkages
Captured through patenting (reflecting trends in upstream activities such as research and technology):			
Biopharma	Semiconductors	1.81	745
Biopharma	Micro-structural and nano-technology	1.55	380
Biopharma	Computer technology	1.47	1604
Biopharma	Electrical machinery, apparatus	1.26	780
Biopharma	Food chemistry	1.18	10236
Captured through mergers and acquisitions (reflecting trends in downstream activities such as production and services):			
Biopharma acquired:	Other retailing	1.82	48
Biopharma acquired:	Healthcare Providers & Services	1.81	31
Biopharma acquired:	Water and waste management	1.66	13
Biopharma acquired:	Software	1.61	47
Biopharma was a target of:	Agriculture & Livestock	4.00	15
Biopharma was a target of:	Alternative energy resources	4.00	15
Biopharma was a target of:	Household & Personal Products	1.25	54
Captured through joint ventures and alliances (reflecting trends in strategic business activities often with an international character):			
Biopharma	Measuring, Analysing, and Controlling Instruments	1.00	161
Biopharma	Electronic and other Electrical Equipment and Components	1.22	40
Biopharma	Chemicals and allied products	1.08	190

Note: Detailed calculations and data are available in the industry reports that were prepared as part of this study. They are available at http://ec.europa.eu/growth/smes/cluster/observatory/cluster-mapping-services/trend-report/index_en.htm

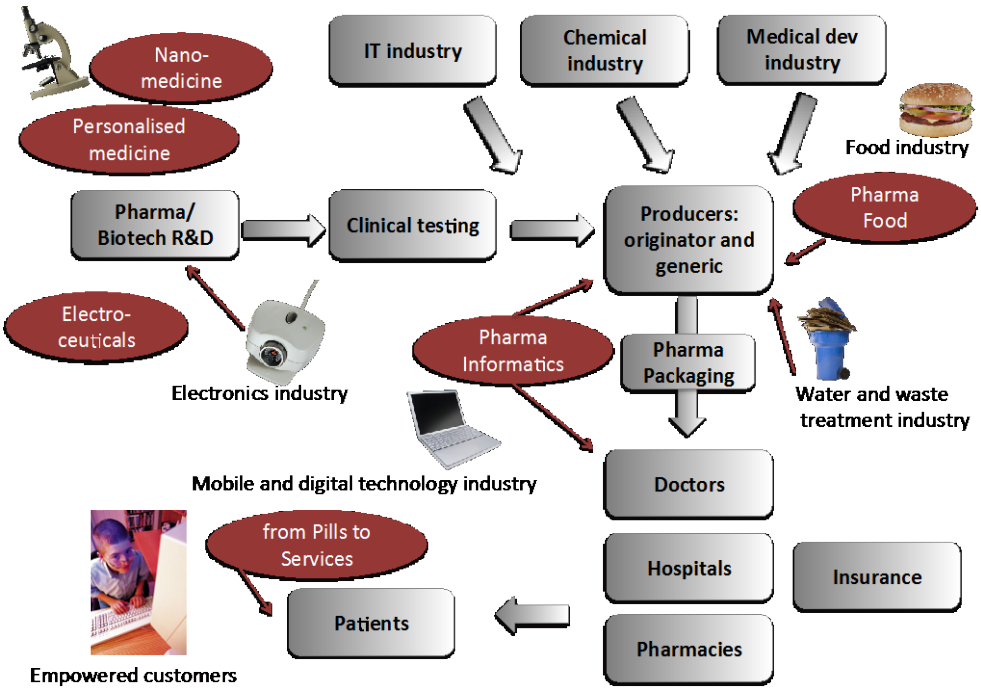
When comparing patenting patterns in terms of the strongest linkages across the periods, the data revealed a relative stability in cross-sectoral patterns. For instance, 'Computer Technology' has become closely connected with other technology areas in the latter years and it links Biopharmaceuticals and Measurement and Analysis of Biological materials.

While 'Chemical Engineering' has become less closely connected to Biopharmaceuticals than it was in the past, '**Food chemistry**' is an area that has become more strongly linked to and has experienced a steady growth over time. As the complementary literature review also highlights, pharmaceuticals and food are increasingly combined in order to use food for medical purposes. A new industry of pro-biotics, pre-biotics, functional foods and re-discovered natural herbs, often called **Nutraceuticals/pharmafood**, is emerging and is producing these new substances with clinically enhanced properties.

Technological areas that have a relatively smaller number of links to Biopharmaceuticals, but are responsible for most of the cross-sectoral patent growth are semiconductors, nano-technology and electrical machinery. These trends have also been confirmed by the literature review and are less surprising patterns. In addition, a new industry niche that became apparent through desk research is the so-called '**Electroceuticals'.** This refers to a new medicinal method that uses electrical impulses, instead of chemicals, to treat diseases. Another area is **Nano-medicine** that can intervene very specifically with biological processes at the molecular level, and it also has the advantage of being rapidly eliminated from the body.

In the more downstream activities of the value chain, the analysis of mergers and acquisitions reveals a similar cross-sectoral pattern to the patenting trends, for instance in software. It also uncovers other interesting cross-sectoral trends such as the dynamics related to services in the area of retailing, healthcare providers and environmental industries like water and waste management and energy and the linkages to household & personal products. In addition, these trends might reflect the fact that the development of the biopharmaceutical industry is very much linked to demographic changes and advances towards more patient-centred healthcare. Many argue that an important new source of revenue for the pharmaceutical industry is to **shift towards a more service-oriented and patient-centred approach - from pills to services -** rather than maintaining the focus on pills. Figure 3 depicts these cross-sectoral trends along the value chain of the Biopharmaceuticals industry.

Figure 3: Cross-sectoral trends in the value chain of the Biopharmaceuticals industry



Source: Technopolis Group

The geographical analysis showed that the most dynamic hotspots are to be found in Rheinhessen-Pfalz, Dusseldorf, Darmstadt, Karlsruhe (Germany), Île de France, Rhone-Alpes (France), Lobardia (Italy), East Flanders (Belgium), South Holland, Gelderland (Netherlands), Lower-Austria, Vienna (Austria) and Central Hungary.

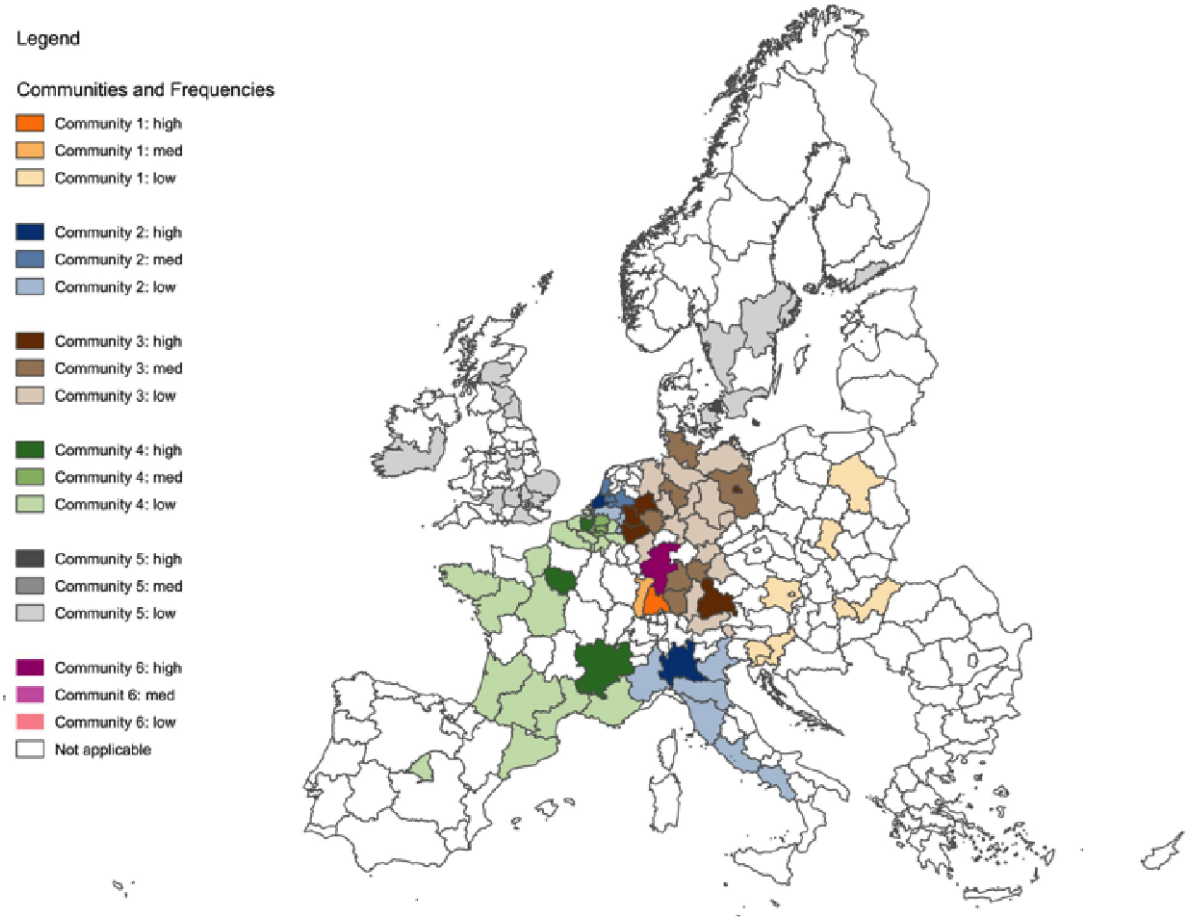
In addition, some of these regions also appear to host some of the top clusters in Europe, based on the analysis of the European Cluster Panorama, 2014. This panorama cited Dusseldorf, Darmstadt, Ile de France and Berkshire, Bucks and Oxfordshire as hosting the top clusters. However, there are others which have less strong clusters but show more cross-sectoral dynamics such as Rheinhessen-Pfalz, South Holland, Lower Austria and Central Hungary.

The highest number of linkages indicates regions with high cross-sectoral activity, whilst the results of a social network analysis can shed additional light on the connections that exist across geographic borders. The social network analysis identified four communities of regions that were the closest connected through cross-sectoral linkages. These communities are centred round specific node regions that are not always the same as the regions with the highest number of linkages. The most central ones are German regions and the communities are geographically concentrated in the North, West and East, as follows:

- Community 1 – Freiburg (Germany) as the most central actor concentrates regions in Central-Eastern Europe, many Austrian, Czech, Polish, Hungarian and Greek regions;
- Community 2 – North Brabant (the Netherlands) as the most central actor concentrates regions in the Netherlands, Italy, Romania;
- Community 3 – Düsseldorf (Germany) as the most central actor concentrates several other German regions;
- Community 4 – Antwerp (Belgium) as the most central actor in terms of chemical-pharma linkages concentrates regions in France, Spain, Portugal and the Netherlands;
- Community 5 - Berkshire, Buckinghamshire, and Oxfordshire (UK) as the most central actor concentrates regions in Sweden, Denmark, UK, Ireland and Switzerland;
- Community 6 – Rheinhessen-Pfalz (Germany) as the central actor includes a smaller community of other German regions and Lithuania.

The 7th community is without any central focus and it includes regions that do not belong to any of the groups above.

Figure 4: Regions and communities with dynamic cross-sectoral patterns in Biopharmaceuticals



Source: Technopolis group prepared with QGIS and based on Patstat and Thomson One data

Notes: based on 2010 NUTS codes. Frequency refers to the level of cross-sectoral dynamics present in the specific region based on the three indicators applied. The colours of the map reflect different communities (C1-C6) that belong together and represent one larger area where cross-sectoral spill-overs also happen. The intensity of the colours represents the overall frequency and the most intense colours correspond to the regions with the highest frequencies. In particular: high represents the top 15 regions with cumulative frequency; medium represents regions with cumulative frequency of approximately 60%; and low represents the regions above the median but below the medium group. Colourless regions represent those regions where there is no cross sectoral activity in terms of patents, M&As and JVAs taking place or the frequency of cross sectoral activity is below the median (median=100).

2.1.3 Blue Growth Industries

Blue Growth industries involve the development and use of oceans, seas, and related infrastructure as well as those of any inland fresh-water sources and their exploitation. Blue Growth industries include all sectors and industries related to the maritime environment and also industries producing, making use of, and treating fresh-water sources. For the purposes of this report they include Maritime transport, Fisheries/fish farming and Deep-sea drilling/Offshore mining.

When looking at different indicators reflecting trends at specific stages of the industrial value chain, Blue Growth industries were found to show the most dynamic cross-sectoral linkages related to the industries and technological areas in the table below. These trends are summarised in Table 7.

Table 7: Dynamic cross-sectoral linkages related to Blue Growth industries

Core industry under analysis	Links to other industries showing positive dynamics related to the core industry	Growth over periods (percentage change)	Total number of cross-sectoral linkages
Captured through patenting (reflecting trends in upstream activities such as research and technology):			
Blue Growth	Digital communication	7.00	121
Blue Growth	Analysis of biological materials	4.33	119
Blue Growth	IT methods for management	3.50	111
Blue Growth	Computer technology	3.17	131
Blue Growth	Organic fine chemistry	1.33	210
Blue Growth	Engines, pumps, turbines	1.04	575
Captured through mergers and acquisitions (reflecting trends in downstream activities such as production and services):			
Blue Growth acquired:	Alternative Energy Sources	6.00	23
Blue Growth acquired:	Home Furnishings	4.00	12
Blue Growth acquired:	Chemicals	1.60	13
Blue Growth acquired:	Automobiles & Components	1.33	21
Blue Growth acquired:	Food and Beverage	1.14	45
Blue Growth was a target:	Aerospace & Defense	1.20	16
Blue Growth was a target:	Chemicals	1.00	42
Blue Growth was a target:	Automobiles & Components	1.90	29
Blue Growth was a target:	Other Real Estate	1.67	16
Blue Growth was a target:	Metals & Mining	1.42	46
Blue Growth was a target:	Building/Construction & Engineering	1.05	131
Captured through joint ventures and alliances (reflecting trends in strategic business activities often with an international character):			
Blue Growth	Natural Gas Transmission	3.00	5
Blue Growth	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical Systems and Instruments	3.00	5
Blue Growth	Steam, Gas, and Hydraulic Turbines, and Turbine Generator Set Units	1.33	10
Blue Growth	Trucking, Except Local (household goods moving)	1.00	15
Blue Growth	Arrangement of Transportation of Freight and Cargo (except freight rate auditors and tariff consultants)	0.45	27

Note: Detailed calculations and data are available in the industry reports that were prepared as part of this study. They are available at http://ec.europa.eu/growth/smes/cluster/observatory/cluster-mapping-services/trend-report/index_en.htm

An important observation stemming from both the empirical analysis and the literature review is that the value chain of Blue Growth industries has not experienced an emergence of completely new industries in the context of the existing industrial classifications. Within the established industries linked to Blue Growth industries, however, there are products/services emerging, which are typically bundled together within an existing sub-category. There are also weaker links such as those related to digital communication, computer technology and organic fine chemistry, which have basically appeared only

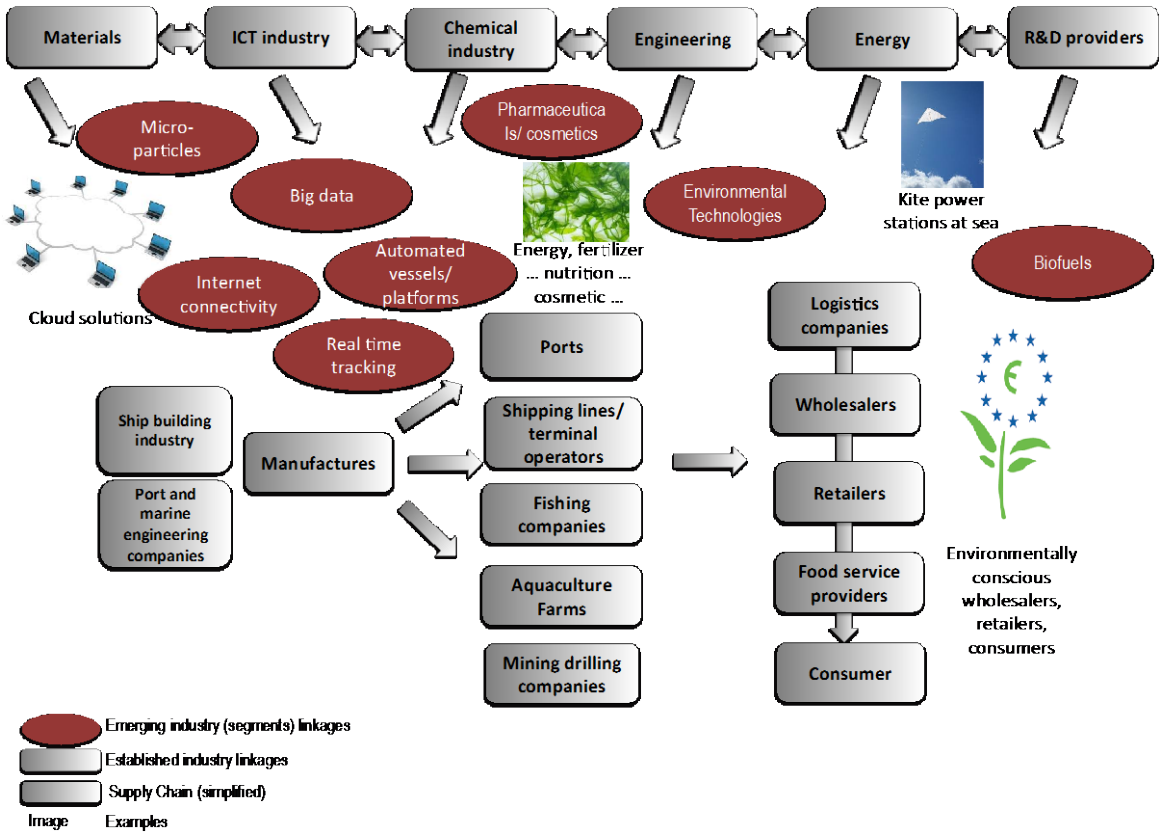
during the most recent period. In addition, there are established industries that have increased the intensity of their involvement with Blue Growth industries.

The empirical analysis confirms the ICT/Telecommunications crossovers. In patenting, 'IT methods for management' and 'Computer technology' can be found amongst the areas recording the highest growth. In M&As, 'Telecommunications' is among the most frequently encountered industries that Blue Growth industries merge with, or acquire. In JVAs, there is 'Information retrieval services' and amongst the industries with the highest growth 'Search, detection, navigation, guidance systems' appear.

The empirical analysis confirms the environmental technologies crossovers. The areas of most prominent patenting activities include 'mechanical elements' and 'engines pumps and turbines'. In M&As 'Industrials' and 'Energy and Power' are to be found and these are, in fact, also among the cross sectoral linkages recording the highest growth between the two periods investigated. In JVAs, there is 'Internal combustion engines' while, 'Steam gas and hydraulic turbines' are among the industries linked to Blue Growth industries that record the highest growth. Also in patenting, and predominantly at the upstream research level, there is a notable growth in a crossover with 'Micro structural and nano-technology' that has applications, which may be relevant for industrial and purification processes.

Crossovers with 'Pharmaceuticals', 'Organic fine chemistry' whose main consumers are the pharmaceutical, agrochemical and food & feed industries, 'Analysis of biological materials' and 'Micro structural and nano-technology' are confirmed by patenting trends in terms of being high growth crossover areas. Those may partly still represent more upstream research that is adding value to technology rather than large scale downstream developments of commercial products with a notable use in Blue Growth industries. Figure 5 depicts these cross-sectoral trends along the value chain of the Blue Growth industries.

Figure 5: Blue Growth industries – Value chain

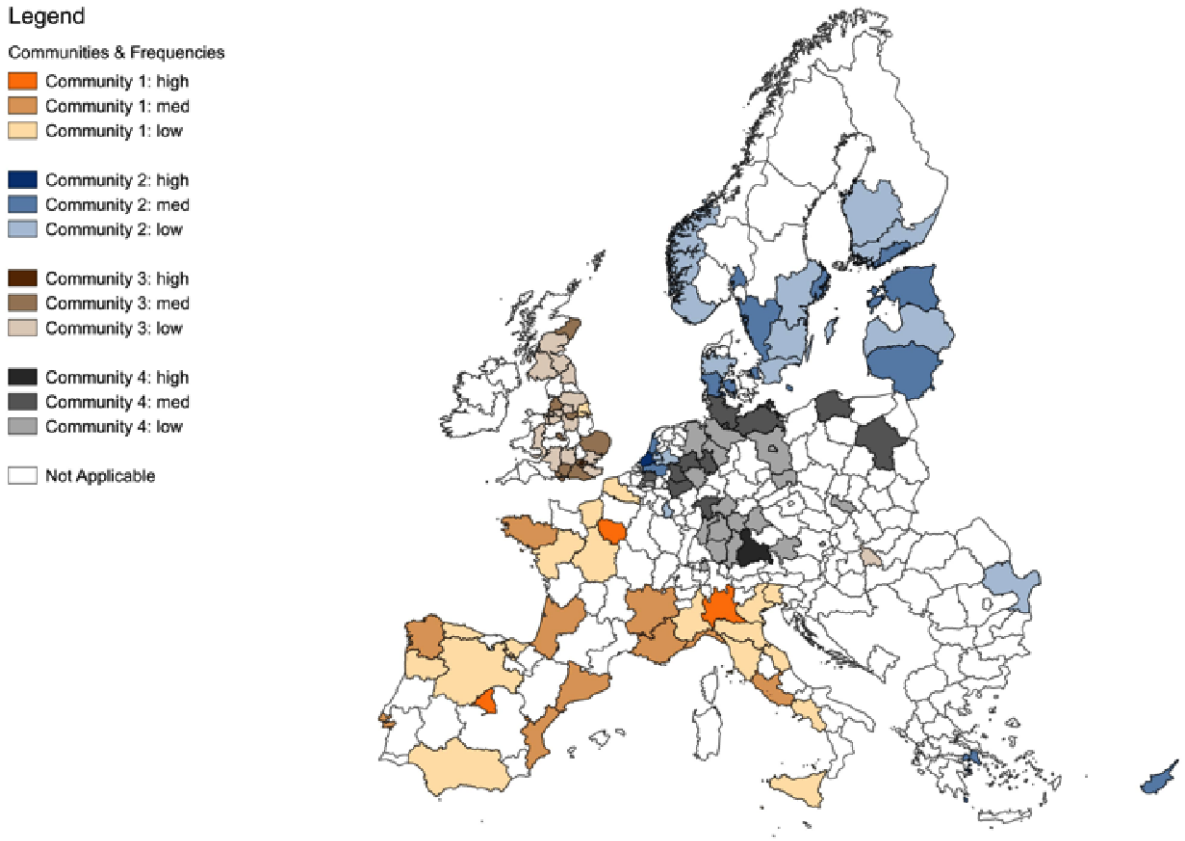


The most dynamics regional hot spots were found in Île de France, London (UK), Upper Bavaria, Schleswig-Holstein and Hamburg (Germany), South Holland, Comunidad de Madrid and Cataluna (Spain), Lombardia (Italy), Helsinki-Uusimaa (Finland) and Copenhagen (Denmark).

The highest number of linkages indicates regions with high cross-sectoral activity, whilst the results of a social network analysis can shed additional light on the connections that exist across geographic borders. The social network analysis identified four communities of regions that were the most closely connected through cross-sectoral linkages. These communities are centred round specific node regions that are not always the same as the regions with the highest number of linkages. Five **communities** have been detected, namely:

- Community 1 – IIe de France (France);
- Community 2 – South Holland (Netherlands);
- Community 3 – Inner London (UK);
- Community 4 – Düsseldorf (Germany);
- Community 5 – Other with no specific central actor

Figure 6: Regions and communities with dynamic cross-sectoral patterns in Blue Growth industries



Source: Technopolis group prepared with QGIS and based on Patstat and Thomson One data

Notes: based on 2010 NUTS codes. Frequency refers to the level of cross-sectoral dynamics present in the specific region based on the three indicators applied. The colours of the map reflect different communities (C1-C5) that belong together and represent one larger area where cross-sectoral spill-overs happen. The intensity of the colours represents the overall frequency and the most intense colours correspond to the regions with the highest frequencies. In particular: high represents the top 15 regions with cumulative frequency; medium represents regions with cumulative frequency of approximately 60%; and low represents the regions above the median but below the medium group. Colourless regions represent those regions where there is no cross sectoral activity in terms of patents, M&As and JVAs taking place or the frequency of cross sectoral activity is below the median (median=22).

2.1.4 The Creative Industries

The creative sector has its specific characteristics and differs to a large extent from traditional industrial sectors. In addition, Creative industries have individual branches that are very heterogeneous in terms of company structures, turnover, employment, markets, distribution channels and business models. Common to the creative industries is the fact that the economic relevance of micro enterprises is much higher than in other industry sectors.

Creative industries are very much customer and service oriented, which helps them to access the internal innovation processes of suppliers and clients. This promotes spill-overs to other branches within the creative industries and to other industrial sectors. However, this potential is not always harnessed as many small companies often have only limited contact with traditional industries. Creative industries were found to show the most dynamic cross-sectoral linkages, summarised in the table below, that relate to the following industries.

Table 8: Dynamic cross-sectoral linkages related to the Creative industries

Core industry under analysis	Links to other industries showing positive dynamics related to the core industry	Growth over periods (percentage change)	Total number of cross-sectoral linkages
Captured through mergers and acquisitions (reflecting trends in downstream activities such as production and services):			
Creative industries acquired:	E-commerce/B2B	4.40	87
Creative industries acquired:	Travel Services	3.00	12
Creative industries acquired:	Internet and Catalogue Retailing	2.30	40
Creative industries acquired:	Educational Services	1.90	44
Creative industries were a target of:	E-commerce/B2B	4.80	23
Creative industries were a target of:	Textiles & Apparel	1.80	11
Creative industries were a target of:	Home Furnishing	1.40	12
Creative industries were a target of:	Building/Construction & Engineering	1.10	60
Captured through joint ventures and alliances (reflecting trends in strategic business activities often with an international character):			
Creative industries	Radiotelephone communications	0.91	21

Note: Detailed calculations and data is available are the industry reports that were prepared as part of this study. They are available at http://ec.europa.eu/growth/smes/cluster/observatory/cluster-mapping-services/trend-report/index_en.htm

The important role of related service industries, in terms of total numbers as well as in terms of trends should be noted. The results of the quantitative analyses of M&A and JVA revealed strong and increasing linkages with sectors from Digital Services. The trends which had been identified through desk research also predominantly referred to the digitalisation of Creative industries and, therefore, confirm this observation. In addition, in recent years industries producing consumer goods such as furnishing and textiles have increasingly been involved in cross-sectoral M&A activities. The developing importance of travel and educational services also reinforces the role that creative services can play within the 'experience economy.'

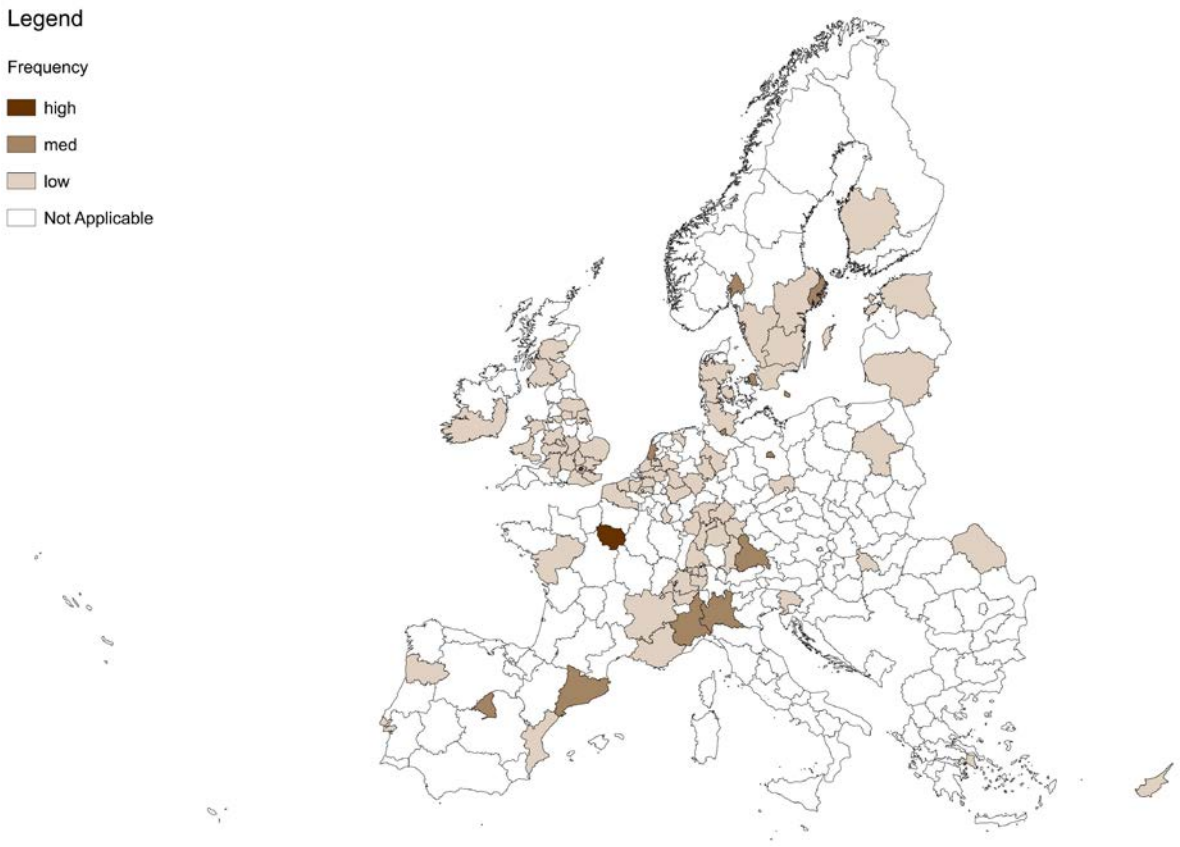
Because of the variety of industries within the overall framework of the creative industries, there is no single value chain model which fits all of them. Generally, value is created through an interactive process between creative service providers and their customers. These interactive processes can take

place at different stages in the industrial value chain. Also, external creative inputs may enrich and inspire knowledge development and innovation processes or help to upgrade existing products aesthetically, in terms of their appearance or design.

The most dynamic hotspots for the Creative industries are spread across several European countries. London stands out with approximately 85% more cross sectoral linkages than the second highest ranked region of Île de France (Paris), which has 33% more than the third ranked region of Oberbayern (Munich). In addition to these regions, especially regions in, or surrounding, national capitals and European creative centres like Stockholm, North Holland (Amsterdam), South Finland (Helsinki), Lombardia (Milan), Hamburg and Madrid are amongst the top15 hotspots.

The intensity of the different colours indicates the relevance of the hot spots in terms of frequency of cross sectoral linkages. In theory, this means that the regions are not necessarily strong in Creative industries but may have other industries that have intensive linkages to the Creative industry sector. Practically, all of hotspots identified belong to the European regions that are the leading regions in terms of the Creative industries. Given the profile of the industry, no social network analysis was performed in the case of Creative industries.

Figure 7: Regional hotspot of cross-sectoral activities in the Creative industries



Source: Technopolis group prepared with QGIS and based on Patstat and Thomson One data

Notes: Based on 2010 NUTS codes. Frequency refers to the level of cross-sectoral dynamics present in the specific region based on the three indicators applied. The intensity of the colours represents the overall frequency and the most intense colours correspond to the regions with the highest frequencies. Colourless regions represent those regions where only very limited cross sectoral activity in terms of M&A and JVA is taking place (frequency<9).

2.1.5 Digital-based Industries

The core of Digital industries comprises services related to information technologies, as well as the manufacturing of modern computer hardware and devices for various application contexts. Services especially include the programming and publishing of software, the provision of digital communication infrastructure, as well as computer-related consultancy services. In the digital sector, there is a noticeable shift from hardware to software, and within the software area a similar sort of shift from product to service.

When looking at the different indicators reflecting trends at specific stages of the industrial value chain, digital industries showed the most dynamic cross-sectoral linkages related to the following other industries and technological areas in the table below. In all the three data samples, the focus was on identifying industry linkages that indicated a growth in numbers. These trends are summarised in Table 9.

Table 9: Dynamic cross-sectoral linkages related to Digital Industries

Core industry under analysis	Links to other industries showing positive dynamics related to the core industry	Growth over periods (percentage change)	Total number of cross-sectoral linkages
Captured through patenting (reflecting trends in upstream activities such as research and technology):			
Digital industries	Transport	2.07	2586
Digital industries	Medical technology	1.75	6477
Digital industries	Analysis of biological materials	1.49	3270
Digital industries	Biotechnology	1.49	1701
Captured through mergers and acquisitions (reflecting trends in downstream activities such as production and services):			
Digital industries acquired:	Aerospace & Defence	3.00	28
Digital industries acquired:	Oil & Gas	2.90	27
Digital industries acquired:	E-commerce/B2B	2.00	77
Digital industries acquired:	Power	1.90	17
Digital industries acquired:	Healthcare Providers & Services	1.80	22
Digital industries were a target of:	E-commerce/B2B	2.00	73
Digital industries were a target of:	Other industries	1.80	81
Digital industries were a target of:	Real estate management & development	1.80	22
Digital industries were a target of:	Cable	1.60	79
Digital industries were a target of:	Semiconductors	1.50	37
Captured through joint ventures and alliances (reflecting trends in strategic business activities often with an international character):			
Digital industries	Advertising	2.00	12
Digital industries	Amusement and recreation	1.00	18
Digital industries	Accounting, auditing and bookkeeping services	0.91	21

Note: Detailed calculations and data are available in the industry reports that were prepared as part of this study. They are available at http://ec.europa.eu/growth/smes/cluster/observatory/cluster-mapping-services/trend-report/index_en.htm

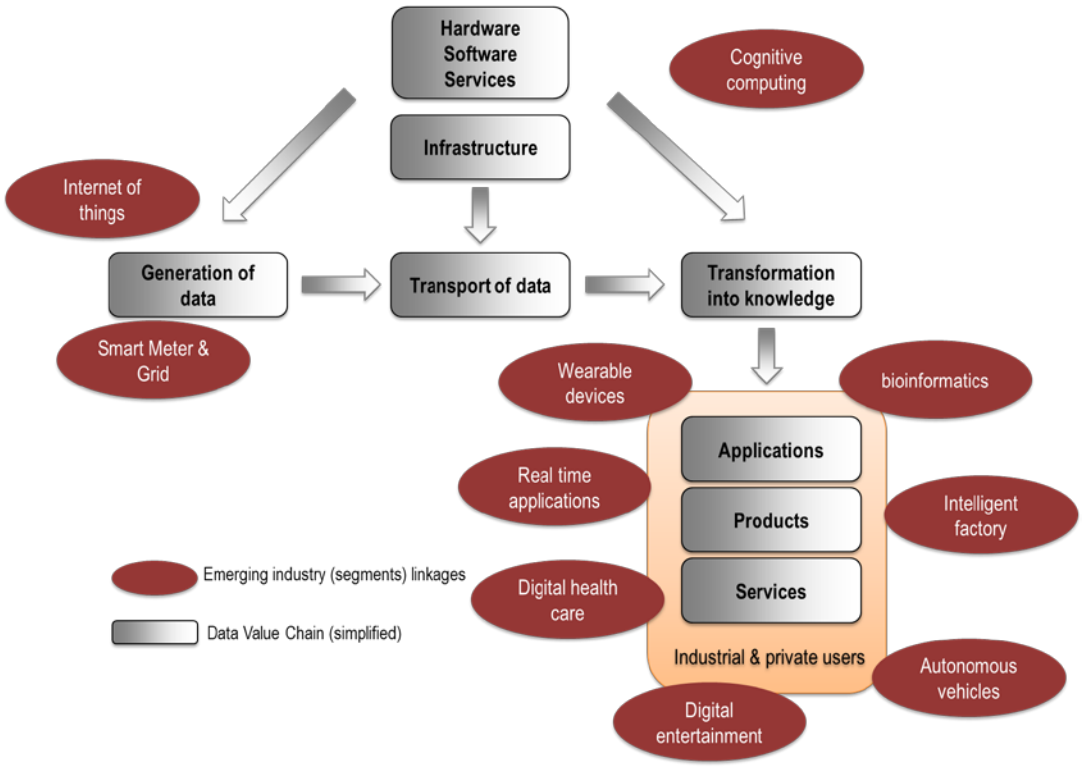
As both the data analysis and the literature review showed, **linkages to other industries occur predominantly when these other industries are users of information technology** and they employ this technology to enhance their existing, and even to create new, processes and products. This means cross-industry linkages and new trends are mainly related to downstream activities. The data analysis specifically highlights dynamics related to transport/aerospace and defence, medical technology/healthcare providers and other industrials. Vehicles have become more and more computerised over recent years. As the literature review also confirms, **autonomous vehicles** are the next step in this development and these are computer-controlled vehicles with coordinated acceleration, braking and steering. **Bioinformatics** are the application of information technologies to the field of biology that help to promote an understanding of biological processes. Specific examples include the analysis of DNA and protein sequences with the help of ICT. It has also to be noted that these solutions pose new challenges in terms of the storage of data and running powerful analysis. Under the label **Digital Healthcare**, a new cross-sectoral field is evolving which uses information and communication technologies to support sustainable healthcare systems. Facing the challenges of demographic change and the inevitable, increasing demand for health services, digitalisation of the health services is intended to increase the efficiency of the health sector.

As the desk research revealed**, intelligent manufacturing,** especially features connected to software intensive embedded sub-systems of production. In perspective, connected machines constitute intelligent networks and control each other autonomously through self-configuration, self-diagnosis and self-optimisation. Digital industries contribute by providing tools and applications for the measurement and generation of digital data and the atomisation of real-time analysis.

As a consequence of digitalisation, the entertainment industries are changing. **Digital music distribution**, video on demand services or online games are all markets that are growing very quickly. Digitalisation, combined with the increasing distribution of stationary and mobile devices, provides the permanent availability of, and access to, digital offers.

The application of information technology also makes a contribution to ensuring a reliable and efficient power supply. A **smart grid** is an electrical grid in which the supplier, grid operator and consumer constantly interact by using digital information and communication technologies. Figure 8 depicts these cross-sectoral trends along the value chain of Digital industries.

Figure 8: Data value chain and emerging cross-sectoral links in Digital industries



In the last step of the analysis, the geographical pattern of the most dynamic cross-sectoral linkages was investigated. The highest number of linkages indicates regions with high cross-sectoral activity, whilst the results of a social network analysis can shed additional light on the connections that exist across geographic borders. The social network analysis identified six communities of regions that were the most closely connected through cross-sectoral linkages. These communities are centred round specific node regions that are not always the same as the regions that have the highest number of linkages.

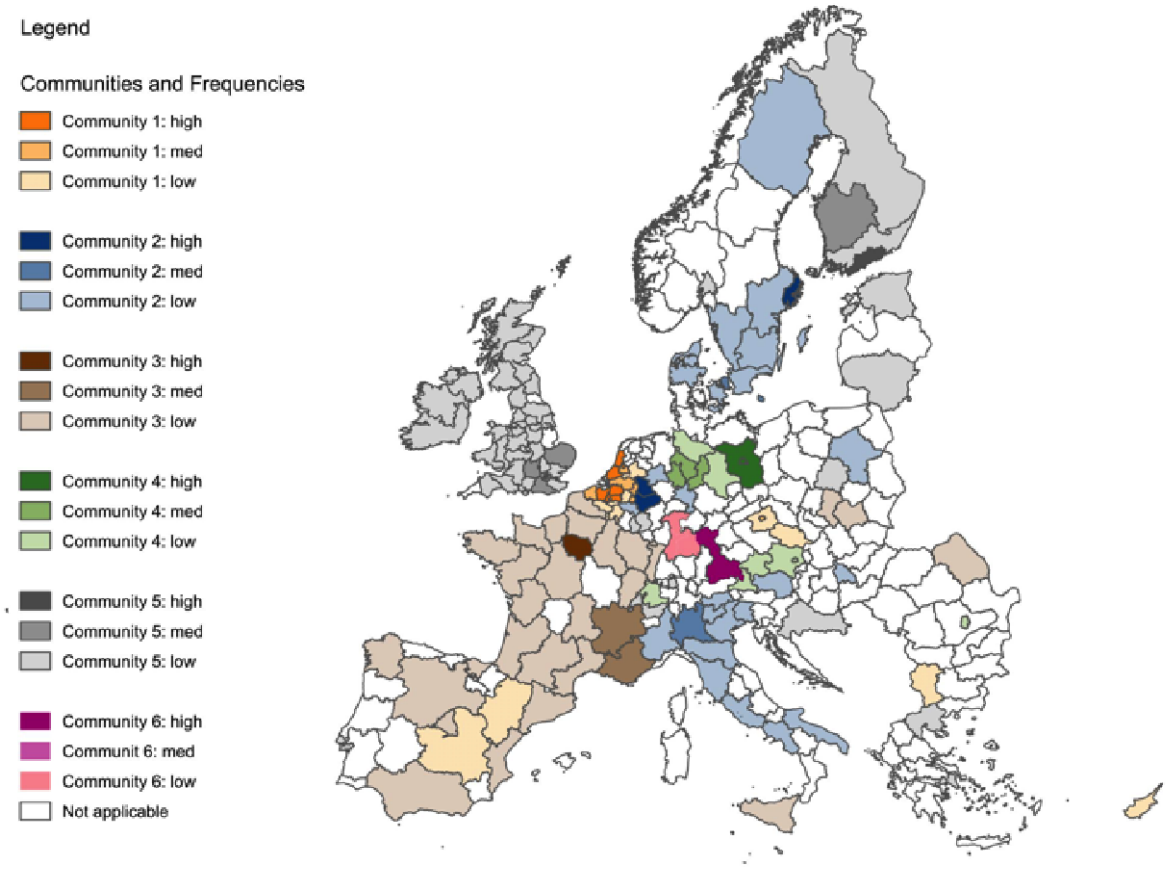
The most dynamic hotspots are spread across European countries with a focus on Germany. Within the top 20 regions, there are 11 German regions and Upper Bavaria leads in terms of the number of cross-sectoral linkages. Close behind follow Île de France, Inner London and Helsinki that are all in the top 10 hot spots, whilst Stockholm and Lombardia are in the top 20.

With the exception of Inner London and Helsinki, all top 10 regions in terms of frequency cross-sectoral linkages are also among the 10 most central regions in the entire Digital Industries network. The two other regions within the 10 most central regions are Lower Bavaria and Schwaben that are both in Bavaria.

Six **communities** have been detected using the spin glass community detection algorithm. Figure 9 depicts these communities in different colours and the regional hot spots in darker colours. They are:

- Community 1 – North-Holland (Netherlands);
- Community 2 – Düsseldorf (Germany);
- Community 3 – Île de France (France);
- Community 4 – Berlin (Germany);
- Community 5 – Inner London (UK);
- Community 6 – Upper Bavaria (Germany).

Figure 9: Regions and communities with dynamic cross-sectoral patterns in Digital industries



Source: Technopolis group prepared with QGIS and based on Patstat and Thomson One data

Notes: based on 2010 NUTS codes. Frequency refers to the level of cross-sectoral dynamics present in the specific region based on the three indicators applied. The colours of the map reflect different communities (C1-C6) that belong together and represent one larger area where cross-sectoral spill-overs happen. The intensity of the colours represents the overall frequency and the most intense colours correspond to the regions with the highest frequencies. In particular: high represents the top 15 regions with cumulative frequency; medium represents regions with cumulative frequency of approximately 60%; and low represents the regions above the median but below the medium group. Colourless regions represent those regions where there is no cross sectoral activity in terms of patents, M&As and JVAs taking place or the frequency of cross sectoral activity is below the median (median=28).

2.1.6 Environmental Industries

Environmental industries encompass all economic activities that decrease the environmental pressure of human activity. This is expected to result from the more efficient use of natural resources and from the reduction of harmful emissions across the industrial lifecycle. Environmental industries include a range of products, services, technologies and processes that serve many different economic sectors. This area is highly interdisciplinary and has considerable growth potential. On the one hand, Environmental industries include traditional vertical economic sectors such as the production of renewable energy. On the other hand, the area includes the dimension of services, technologies and processes that can assist, or create value for, any industrial sector and, in particular, for material and energy efficiency services, as environmental industries have to rely on cross-sectoral collaboration to achieve many of their objectives.

When looking at different indicators reflecting trends at specific stages of the industrial value chain, Environmental industries showed the most dynamic cross-sectoral linkages related to the other indus-

tries and technological areas in the table below. In all the three data samples, the focus was on identifying industry linkages that showed a growing patent, M&A or JVA count. These trends are summarised in the Table 10.

Table 10: Dynamic cross-sectoral linkages related to Environmental Industries

Core industry under analysis	Links to other industries showing positive dynamics related to the core industry	Growth over periods (percentage change)	Total number of cross-sectoral linkages
Captured through patenting (reflecting trends in upstream activities such as research and technology):			
Recycling	Semiconductors	1.50	15
Recycling	Audio-visual technology and Recycling	1.44	22
Recycling	Pharmaceuticals	1.25	45
Alternative energy	Micro-structural and nano-technology	4.32	3703
Alternative energy	Electrical machinery, apparatus	2.86	105987
Alternative energy	Digital communication	2.63	6100
Captured through mergers and acquisitions (reflecting trends in downstream activities such as production and services):			
Environmental industries acquired:	Semiconductors	3.01	229
Environmental industries acquired:	Electronics	2.57	427
Environmental industries acquired:	Biotechnology	2.31	54
Environmental industries acquired:	Household & Personal Products	1.95	68
Environmental industries were a target of:	Petrochemicals	3.45	133
Environmental industries were a target of:	Textiles & Apparel	3.41	108
Environmental industries were a target of:	Food & Beverage	3.00	179
Environmental Industries were a target of:	Transportation & Infrastructure	1.51	398
Captured through joint ventures and alliances (reflecting trends in strategic business activities often with an international character):			
Environmental industries	Oil and gas	2.22	58
Environmental industries	Electronics	2.09	127
Environmental industries	Construction	1.97	217
Environmental industries	Food and kindred products	1.73	68

Note: Detailed calculations and data are available in the industry reports that were prepared as part of this study. They are available at http://ec.europa.eu/growth/smes/cluster/observatory/cluster-mapping-services/trend-report/index_en.htm

In terms of linkages, alternative energy has been the sector that has been most strongly linked to **Biotechnology; Organic fine chemistry, Pharmaceuticals and Chemical engineering** in both periods. However, these linkages do not exhibit any growth over the periods that were analysed, which might suggest that they are established links.

Recycling patents have been closely linked to **Chemicals** and 'Chemical engineering' and 'Basic materials chemistry', but less linked and with a lower intensity to other technology areas in more recent years.

The data analysis, in particular, revealed the dynamic trends related to nano-technology and digital technologies that are gaining ground in the areas of alternative energy and recycling.

Since Environmental industries embrace many sub-activities and are ubiquitous across manufacturing industries, two cases were selected and explored in greater detail.

Off-shore wind energy

Off-shore wind energy is produced by the generation of electricity using arrays of wind turbines deployed in bodies of water either in-land or out at sea. Compared to on-shore wind power, wind speeds are higher offering a better yield and the yield is further reinforced by the possibility of using much larger windmills.

Whereas the overall design of a wind turbine is relatively mature, there are two key technological developments that have an impact on the profile of wind turbine manufacturing. These are firstly, that the **scale continuously increases** and, secondly, the increasing challenges of integrating intermittent power sources into the overall electricity grid necessitated the development of **smart grids**.

The related cross-sectoral trends are as follows:

- **Materials (carbon fibres):** The size increases have spurred the development of new material applications in the offshore wind sector, as the need for stronger materials to cope with the increasingly higher forces and the need for lighter materials to reduce transport costs both become greater;
- **Financing**: The new wind parks require increasingly large, upfront capital investments. These capital requirements have led to closer co-operation between the finance sector and the offshore wind developers;
- **Ports and offshore maintenance services:** The increasing size of wind turbines has significant implications for the ports and offshore maintenance services sector in terms of the design and introduction of larger installation and maintenance vessels in the offshore sector and also the design, planning and operation of ports due to a geo-concentration effect.

Plastic recycling

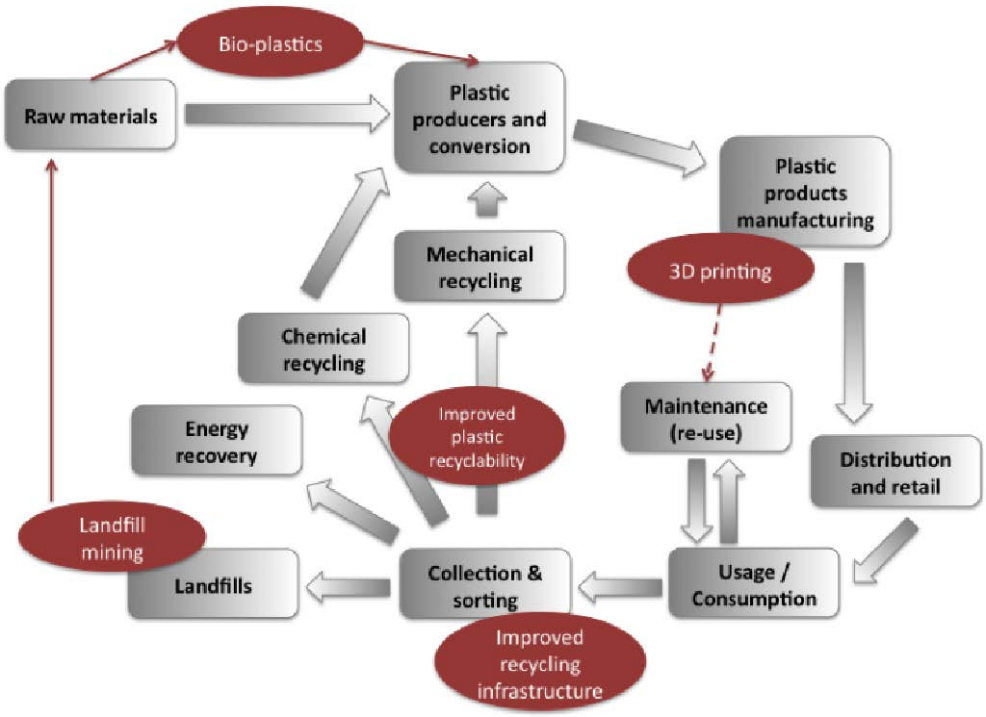
The majority of plastics currently in use are non-biodegradable. Therefore, simply sending them to landfills is not a suitable solution from an environmental point of view. Additionally, resource scarcity and the increasing prices of energy also help to make industry recognise plastic as a valuable material and so plastic waste is increasingly being recycled.

On one hand, established industrial linkages are those that have built a longstanding tradition of using plastic products, such as the **packaging, electronics and automotive industries**. The **construction and agriculture sectors** are, however, taking over an increasing share of plastics use around Europe, thanks to recycled plastics and the increased versatility of new plastic products.

On the other hand, there are emerging industrial sectors, such as **bio-plastic formulators and manufacturers and the 3d-printing industry**. These industries will not only interact with the traditional plastics manufacturers, but have an increased impact on the end industries themselves.

In the last step of the analysis, the geographical pattern of the most dynamic cross-sectoral linkages was investigated. The objective was to highlight the regional hot spots and secondly, the communities of regions that were the most closely connected through these cross-sectoral linkages. A social network analysis was also performed on the regions that appeared to have the most dynamic cross-sectoral linkages related to Environmental industries. Figure 10 depicts these cross-sectoral trends along the value chain of the plastics recycling sector.

Figure 10: Value chain of the Plastics Recycling sector in relation to emerging trends and sectors



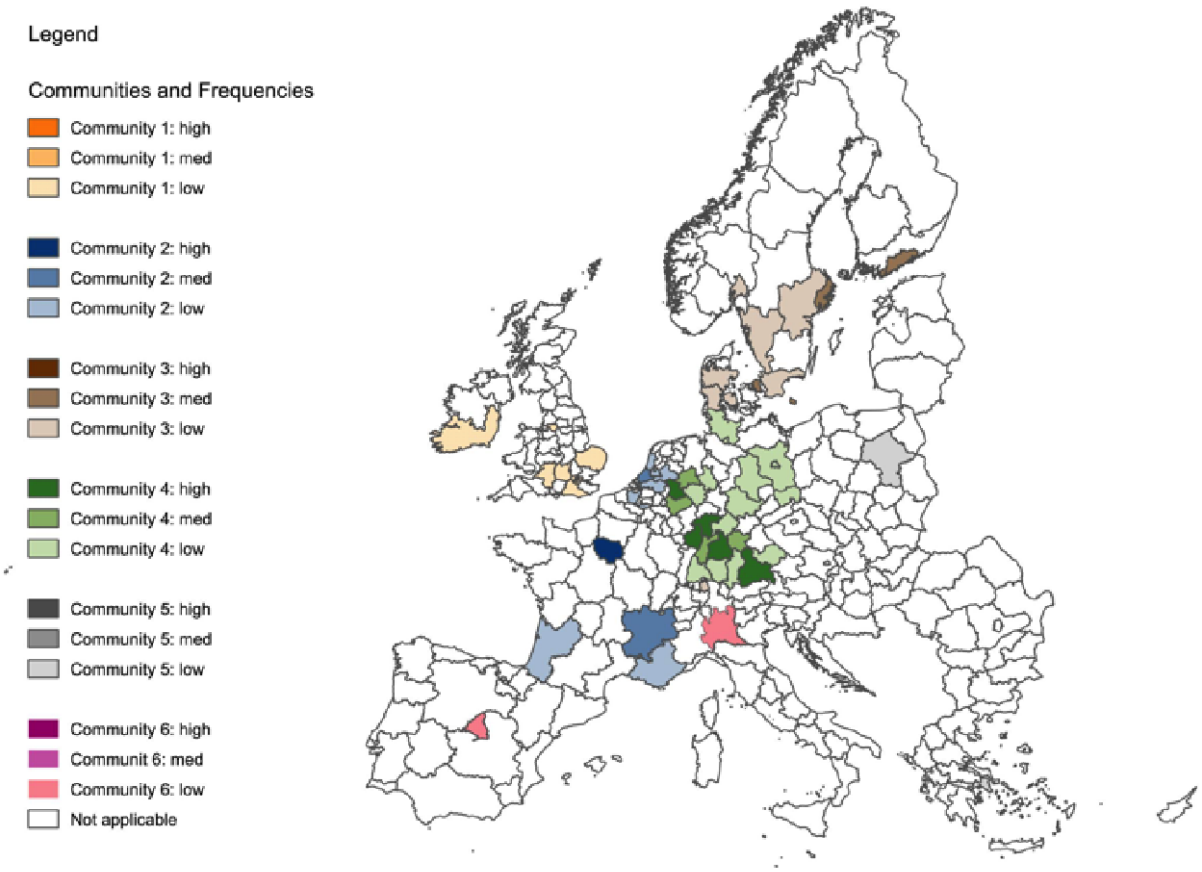
Source: Technopolis Group

When analysing geographical patterns, two outliers emerged, these being the Île de France and Darmstadt, as organisations in these regions appear more than 1000 times in cross-sectoral linkage pairing. Other regions that show most cross-sectoral activity related to environmental industries are Dusseldorf and Rheinhessen Pfalz (Germany), London (UK), Madrid (Spain), Stockholm (Sweden) and Lombardia (Italy), as all had a frequency of above 400.

The highest number of linkages indicates regions with high cross-sectoral activity, whilst the results of a social network analysis can shed additional light on the connections that exist across geographic borders. The social network analysis identified six communities of regions that were the most closely connected through cross-sectoral linkages. These communities are centred round specific node regions that are not always the same as the regions with the highest number of linkages. They are:

- Community 1 – Berkshire, Buckinghamshire and Oxfordshire concentrates geographically on UK and Irish regions;
- Community 2 – Île de France connects regions in France, Belgium, Netherlands and Switzerland;
- Community 3 – Zurich, Stockholm, Finland connects with Nordic regions;
- Community 4 – Upper Bavaria is mainly focused on German and Austrian regions;
- Community 5 – London is interestingly connected with several Central-Eastern European regions such as those in Poland, Hungary, Czech Republic and Romania;
- Community 6 – Lombardia relates to several Southern European countries.

Figure 11: Regions and communities with dynamic cross-sectoral patterns in Environmental industries



Source: Technopolis group prepared with QGIS and based on Patstat and Thomson One data

Notes: based on 2010 NUTS codes. Frequency refers to the level of cross-sectoral dynamics present in the specific region based on the three indicators applied. The colours of the map reflect different communities (C1-C6) that belong together and represent one larger area where cross-sectoral spill-overs happen; The intensity of the colours represents the overall frequency and the most intense colours correspond to the regions with the highest frequencies. In particular: high represents the top 15 regions with cumulative frequency; medium represents regions with cumulative frequency of approximately 60%; and low represents the regions above the median but below the medium group. Colourless regions represent those regions where there is no cross sectoral activity in terms of patents, M&As and JVAs taking place or the frequency of cross sectoral activity is below the median (median=99).

2.1.7 Experience Industries

The Experience Economy has been described by B. Joseph Pine and James H. Gilmore (1999) as the 'next economy,' following the industrial economy and the most recent service economy. In this economy, 'the experience' is in the focus of the product or service such as entertainment, edutainment and the cultural values embodied in the making and marketing of new consumer products. For the purposes of this report, Experience industries are understood as comprising the following six sub-sectors: Accommodation and tours; Food and drink services (restaurants, caterers etc.); Gambling; Museums and parks; Sports and leisure; and Arts.

The analysis showed that in terms of the highest number of cross-industrial Mergers and Acquisitions, the Experience industries had the strongest links to the following industries in both periods and as acquirers and targets of other industries: Professional services; Food and Beverage; Internet & Software Services; Other Consumer Products; Transportation & Infrastructure. These trends are summarised in the table below.

Table 11: Dynamic cross-sectoral linkages related to the Experience Industries

Core industry under analysis	Links to other industry showing positive dynamics related to the core industry	Growth over periods (percentage change)	Total number of cross-sectoral linkages
Captured through mergers and acquisitions (reflecting trends in downstream activities such as production and services):			
Experience industries acquired:	Transportation & Infrastructure	1.30	30
Experience industries acquired:	Food & Beverage	1.22	49
Experience industries acquired:	Computers and Electronics Retailing	10.00	10
Experience industries were a target:	Software	2.00	30
Experience industries were a target:	Professional services	1.25	108
Experience industries were a target:	Automobiles & Components	1.40	24
Experience industries were a target:	Other consumer products	1.30	53
Captured through joint ventures and alliances (reflecting trends in strategic business activities often with an international character):			
Experience industries	Information Retrieval Services; Data Processing Services	3.60	61
Experience industries	Telephone and Radiotelephone Communications	3.00	23

Note: Detailed calculations and data are available in the industry reports that were prepared as part of this study. They are available at http://ec.europa.eu/growth/smes/cluster/observatory/cluster-mapping-services/trend-report/index_en.htm

Experience industries are strongly driven by technological advancements especially in the field of ICT, online media, electronics and telecommunications, as was also seen in the analysis of mergers and acquisitions and joint ventures and alliances.

Emerging niches and new business models that rely on cross-sectoral spill-overs were found that were related to the following areas:

Online support for hotels and museums – crossovers of the Experience industry including accommodation, sports and museums and Internet and social media: The speedy developments in the Internet bubble, as well as in the social media networks have originated new ways of travelling, playing and watching sports. Also, crossovers between the experience industries and the Internet have led to the emergence of online platforms and websites, which inter alia, enable the automation of services in many areas such as accommodation and tours;

Technological upgrade of experience – crossovers of the experience industry including museums and gambling and electronics: New technological breakthroughs have come in to provide support for the experience industry, from museums to retailers and gamblers. The latest technologies are deployed in museums to develop 3D visualisation and applications that enable viewing invisible objects or comparing past and current times in living historical scenes. Electronics have also made multi-sensory experiences possible within museums by adding sounds and perfumes that lead to an augmented reality;

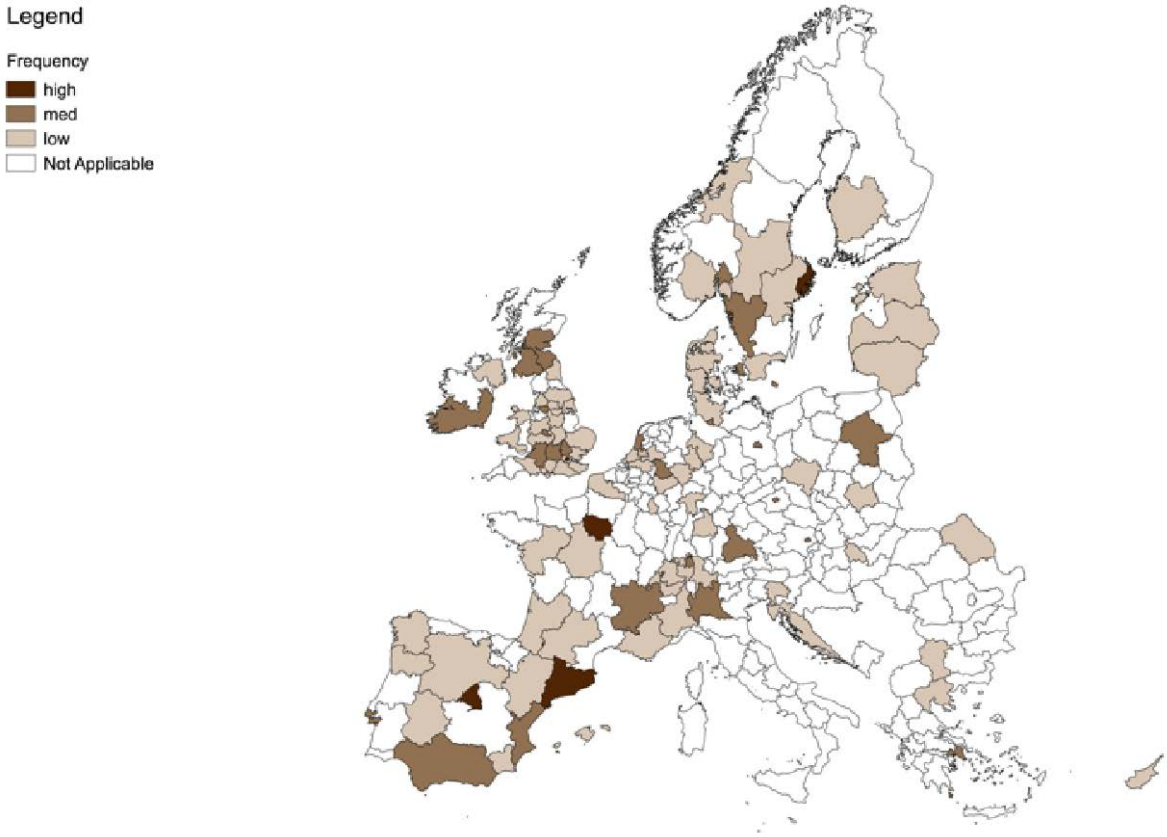
Big Data – crossovers with the Experience industry in sports and accommodation with database management systems: New trends in capturing, storing, analysing and visualising data have expanded their applications to various fields. Sport teams have started using big data to support coaches in player recruitment and to develop game strategies. In addition camera systems installed in

stadia provide insights into the ball's and players' movements, leading to an accumulation of data on players' performances. From this perspective, a new innovative dimension of sports is appearing, where game strategies depend as much on data analytics as on players' performance (Standford Business, 2014);

From biomechanics to adapted healthy nutrition in food and beverage and sports – crossovers between the experience industry and healthcare and medical technologies: New types of foods and beverages designed for specific intolerances, have found their place onto our grocery stores' shelves. Now, people can not only find adapted food but also restaurants that cater for their lactose or gluten intolerances.

In the last step of the analysis, the geographical pattern of the most dynamic cross-sectoral linkages were investigated. Given the scarce quantitative data and the profile of the industry, no social network analysis was performed In the case of Experience industries. The regional data available on mergers and acquisitions and joint ventures was consolidated and Figure 12 depicts the results and shows the regions, which were active in cross-sectoral links related to the Experience industries.

Figure 12: Regions with dynamic cross-sectoral patterns related to the Experience industries



Source: Technopolis group prepared with QGIS and based on Thomson One data

Notes: based on 2010 NUTS codes. Frequency refers to the level of cross-sectoral dynamics present in the specific region based on the three indicators applied. Only frequencies of cross sectoral activity are displayed. The intensity of the colours represents the overall frequency and the most intense colours correspond to the regions with the highest frequencies. In particular: high represents the top 15 regions with cumulative frequency; medium represents regions with cumulative frequency of approximately 60%; and low represents the regions above the median but below the medium group. Colourless regions represent those regions where there is no cross sectoral activity in terms of patents, M&As and JVAs taking place or the frequency of cross sectoral activity is below the median (median=7).

2.1.8 Logistical Services

The European Cluster Panorama (2014) defined the emerging Logistical Services industry in a broad sense as covering the management of the flow of goods or people and the actual process of transport between a starting point and a specific destination. In addition, auxiliary services which contribute to the smooth operation of transport and the provision of carriers or vehicles are considered to be part of Logistical Services. This includes, on the one hand, the logistics operation provision, whether terrestrial or via satellite, and, on the other hand, the development and provision of IT systems for logistics planning, organisation and management. Hence, logistics is about the provision of goods in the quality and quantity required, at the right time, in the desired location and, preferably, at low costs.

When looking at different indicators, reflecting trends at specific stages of the industrial value chain, Logistical Services was found to show the most dynamic cross-sectoral linkages related to the other industries and technological areas in the table below. In all the three data samples, the focus was on identifying those industry linkages that demonstrated a growth. These trends are summarised in the Table 12.

Table 12: Dynamic cross-sectoral linkages related to Logistical Services

Core industry under analysis	Links to other industries showing positive dynamics related to the core industry	Growth over periods (percentage change)	Total number of cross-sectoral linkages
Captured through patenting (reflecting trends in upstream activities such as research and technology):			
Logistics	Handling and Transport	1.80	28
Logistics	IT methods and Computer technology	1.71	19
Logistics	IT methods and Control	1.57	18
Logistics	Handling and other special machines	2.50	14
Captured through mergers and acquisitions (reflecting trends in downstream activities such as production and services):			
Logistics acquired:	Other retailing	1.30	16
Logistics acquired:	E-commerce/B2B	1.30	9
Logistics acquired:	Internet and catalogue retailing	1.20	11
Logistics acquired:	Petrochemicals	7.00	7
Logistics acquired:	Legal services	6.00	6
Logistics was a target of:	Agriculture & Livestock	3.30	13
Logistics was a target of:	Water and waste management	2.50	14
Logistics was a target of:	Publishing	2.00	30
Logistics was a target of:	Oil & Gas	1.70	35
Captured through joint ventures and alliances (reflecting trends in strategic business activities often with an international character):			
Logistics	Hotels and motels	1.50	10
Logistics	Towing and tugboat services	1.25	9
Logistics	Natural gas transmission	4.50	11

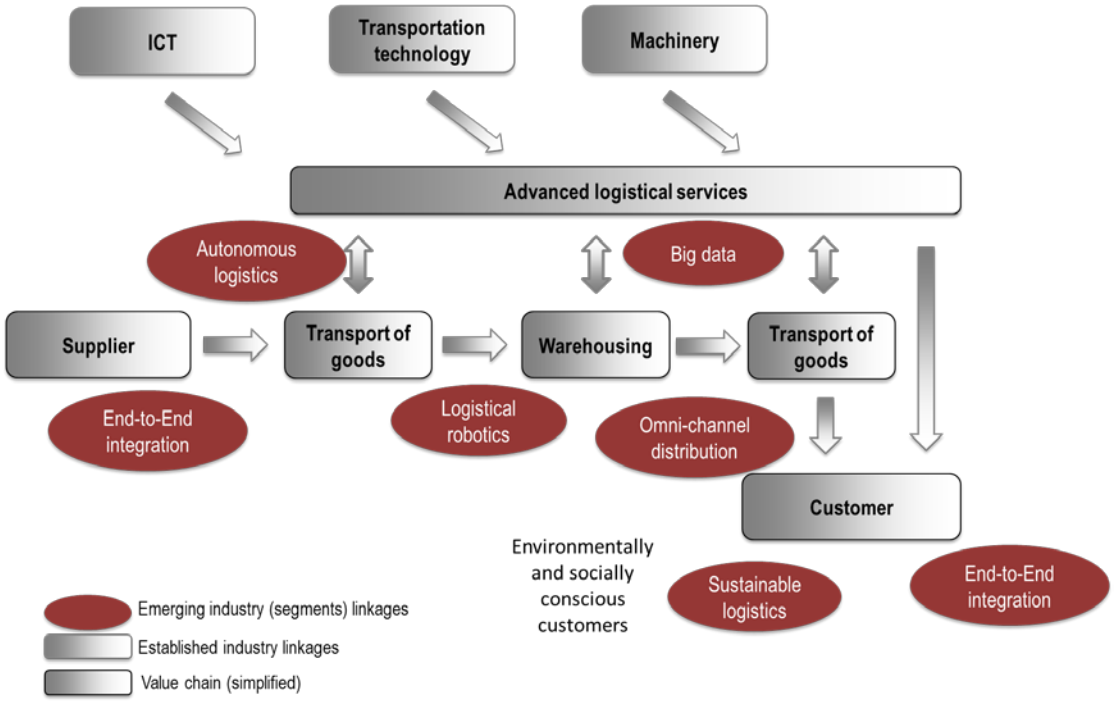
Note: Detailed calculations and data are available in the industry reports that were prepared as part of this study. They are available at http://ec.europa.eu/growth/smes/cluster/observatory/cluster-mapping-services/trend-report/index_en.htm

Central to the value chain in logistical services is the transport of goods from a starting point A – the supplier - to a destination B – the customer - within a given time frame. This usually includes warehousing as part of the distribution process. Logistical Services are used by nearly all industries and so there is a huge variety of possible suppliers and customers. In the case of logistical services related to retailing, consumers appear as customers in the logistical services value chain. In addition, suppliers and customers are not necessarily different companies, as intra-firm logistics often are operated by external logistics service providers.

In recent decades, logistics service providers have broadened their service portfolios by entering addition areas of the logistics value chain. These Third Party Logistics Service Providers (3PL) have taken over logistics activities which were previously performed in-house by manufacturers, wholesalers or retailers. These new activities are not only related to the execution of logistics but also to the control of the logistical process as a whole. These activities involve, in particular, higher added value services. Examples of such advanced logistical services are order fulfilment, inventory management and after-sale customer services. Important enabling industries for advances in logistical services are ICT, transportation technologies and machinery.

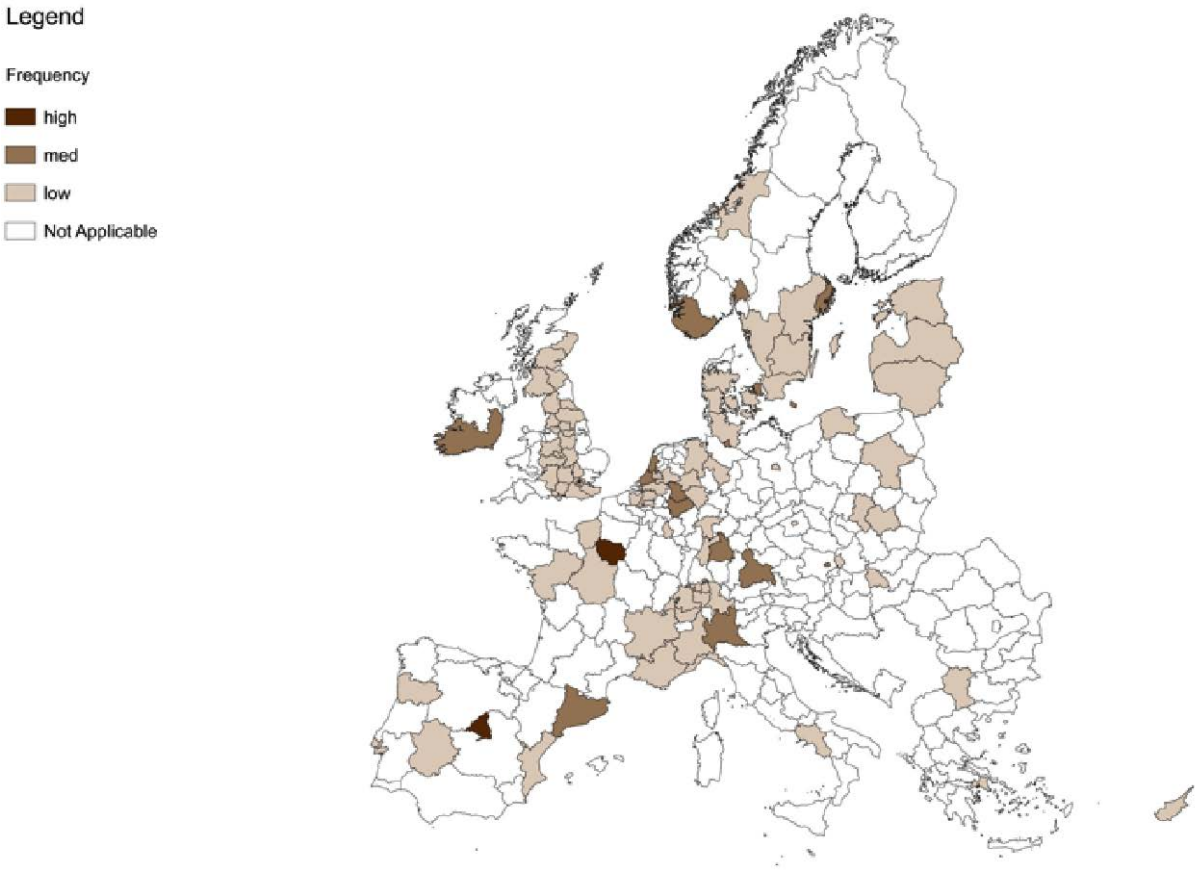
Two general trends can be observed in the logistics value chain - specialisation and integration. Specialisation relates to the higher expectations of customers of receiving high quality customised services. As the demands of different industries can vary significantly, this results in specialisation such as the emergence of smaller and medium sized logistics service providers, which focus on selected customer industries. Striving for higher efficiency and advances in information technologies often results in a greater integration of logistical processes along the supply and value chains. On the one hand, such integrated processes are often organised by large services providers on the global stage. On the other hand, the Logistical Services industry has become more interconnected to enable it to provide for such integrated chains. These developments in logistics also lead to a changing perception of logistical services. Logistics are no longer only considered to involve simply ‘transport costs’. Instead, recent trends have transformed logistics into an advanced service industry which will gain further prominence in a world with more and more interconnected economies.

Figure 13: Value chain and cross-sectoral linkages in Logistical Services (simplified)



When investigating geographical patterns, the most dynamic hotspots were found to be spread across several European countries. Île de France and London stand out with around 50% more cross sectoral linkages compared to the third ranked region of Madrid. In addition to these three, larger coastal cities such as Oslo, Stockholm and Hamburg and important logistics hubs like the North and South Holland and the Helsinki region in South Finland, are amongst the top15 dynamic hotspots. Given the scarce quantitative data and the profile of the industry, no social network analysis had been performed in the case of Logistical Services. The available regional data for mergers and acquisitions and joint ventures had been consolidated and Figure 14 depicts the results and shows the regions, which were active in cross-sectoral links related to Logistical Services.

Figure 14: Regions with dynamic cross-sectoral patterns related to Logistical Services



Source: Technopolis Group prepared with QGIS and based on Patstat and Thomson One data

Notes: based on 2010 NUTS codes; Frequency refers to the level of cross-sectoral dynamics present in the specific region based on the three indicators applied. Only frequencies of cross sectoral activity are displayed; The intensity of the colours represents the overall frequency and the most intense colours correspond to the regions with the highest frequencies. In particular high represents the top 3 regions with cumulative frequency ca. 20%, med represents regions with cumulative frequency ca. 50% and low the regions above the median and below med; Colourless regions represent those regions where no cross sectoral activity in terms of patents, M&As and JVAs is taking place or the frequency of cross sectoral activity is below the median (median=5.5).

2.1.9 Medical Devices

The Medical Devices industry is defined as the industrial sector that manufactures products which are generally based on biomedical engineering. These are developed through mechanical, electrical and/or materials engineering, leading to products that permanently, or temporarily, replace or support a function of the body. When looking at different indicators reflecting trends at specific stages of the industrial value chain, the Medical Devices industry was found to exhibit the most dynamic cross-sectoral linkages related to the other industries and technological areas in the table below. In all the three data samples, the focus was on identifying industry linkages that showed a growing patent/M&A/JVA count. These trends are summarised in the Table 13.

Table 13: Dynamic cross-sectoral linkages related to Medical Devices

Core industry under analysis	Links to other industries showing positive dynamics related to the core industry	Growth over periods (percentage change)	Total number of cross-sectoral linkages
Captured through patenting (reflecting trends in upstream activities such as research and technology):			
Medical devices	Computer technology	1.55	5351
Medical Devices	Transport	1.49	1403
Medical Devices	Thermal processes and apparatus	1.48	748
Medical Devices	Control including systems, checking devices, 'traffic' control systems, and demonstration appliances	1.32	1679
Medical Devices	Mechanical engineering including handling and devices which apply lifting, packaging and robotics	1.31	4485
Captured through mergers and acquisitions (reflecting trends in downstream activities such as production and services):			
Medical Devices acquired:	Automobiles & Components	2.00	12
Medical Devices acquired:	IT Consulting & Services	1.80	14
Medical Devices acquired:	Water and Waste Management	1.66	8
Medical Devices acquired:	Professional services	1.45	242
Medical Devices was a target of:	Electronics	1.61	55
Medical Devices was a target of:	Professional services	1.45	243
Medical Devices was a target of:	Other consumer products	1.40	60
Medical Devices was a target of:	Household & personal products	1.22	20
Captured through joint ventures and alliances (reflecting trends in strategic business activities often with an international character):			
Medical Devices	Computer Programming, Data Processing, and Other Computer Related Services	1.18	83
Medical Devices	Electronic and Other Electrical Equipment and Components, except Computer Equipment	1.35	33
Medical Devices	Communication Equipment	3.40	22

Note: Detailed calculations and data are available in the industry reports that were prepared as part of this study. They are available at http://ec.europa.eu/growth/smes/cluster/observatory/cluster-mapping-services/trend-report/index_en.htm

The review of industrial trends shows that new cross-sectoral configurations seem to be concentrated in the phases of research, development and design of medical devices, on the upstream side of the value chain. New developments are very much technology driven. Promoted by the new era of personalised healthcare, exploiting cross-sectoral solutions appears, however, to be closer to the patient on the downstream side, although it seems that there is still a relatively unexplored field in new service offerings and business models. The high level of linkages related to professional services in the data of mergers and acquisitions might reflect this trend as well.

Both the data and the literature review points to the trend in **e-health** since the 2000s, which has resulted from the convergence area of ICT and health care. This area has a sub-area including the integration of information-communication technologies into medical devices. Linked also to ICT, **wireless medical technology** enables the creation of new solutions by applying telecommunications to medical, health and wellness products and combining wireless and medical product design.

The trends in patenting highlight that **mechanical engineering** is a technological field related to Medical Devices**.** This field is becoming even more relevant in the era of cost-conscious, value-based healthcare, in which medical device companies are under intense cost pressures and have to find new ways of manufacturing their products more efficiently. Within this area, the convergence of technologies is located such as the convergence of sensors or robotics with medical technologies.

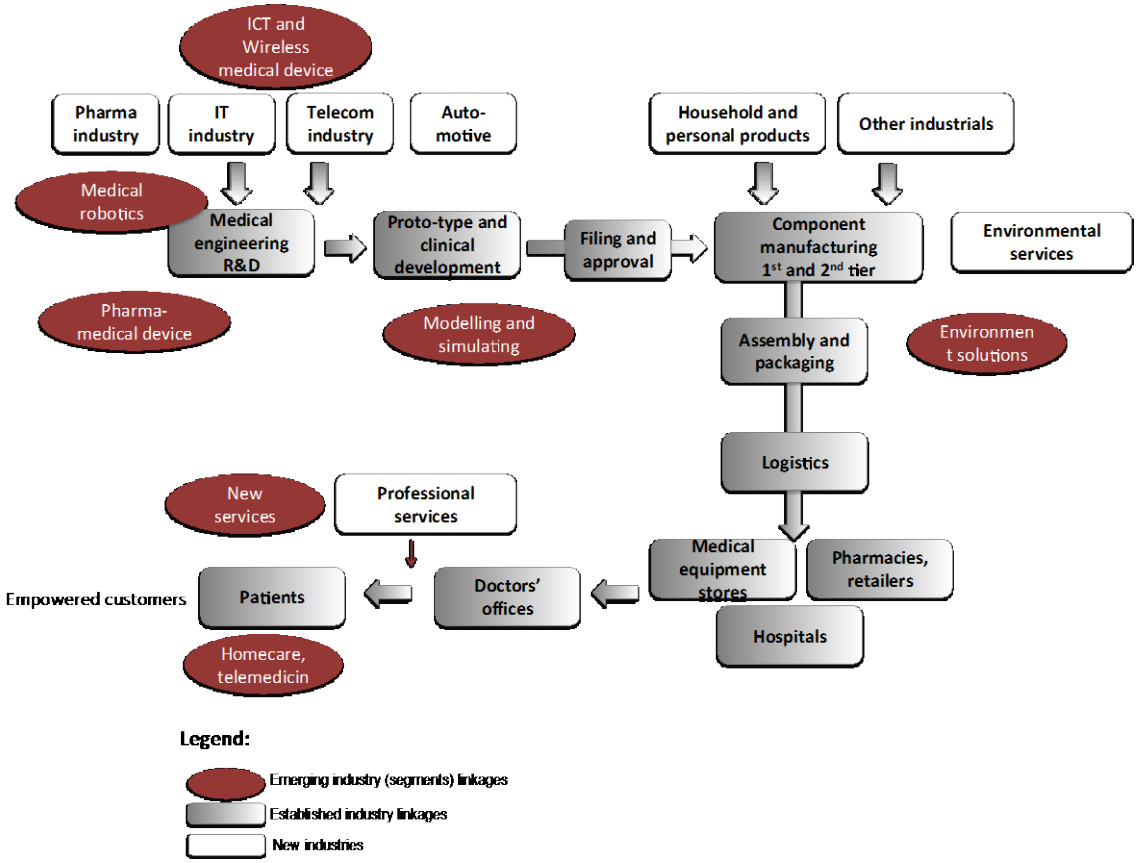
Automotive is an apparent trend in cross-sectoral partnerships of medical devices firms as the analyses of both M&A and JVA have shown. In addition, the patent analysis also identified a trend in medical devices technologies to link with control system technologies that include, for instance, checking devices and 'traffic' control systems.

Surprisingly, medical devices industries also show a **dynamic relation with Environmental industries**. With more stringent environmental regulations, a trend can be observed in which medical devices companies are increasingly linked to water and waste management firms in order to ensure the appropriate treatment of discarded, and often dangerous, medical device equipment.

Telemedicine enables patients to stay at home and still be monitored and treated by their doctors through remote diagnostics and computerised health assessment devices that transmit data to the hospital.

Figure 15 below depicts the industrial value chain and reflects the on-going changes that influence the industry at different points. The picture shows that both on the upstream and the downstream sides of the chain, transformations are taking place, although the upstream side is more active given the research and technology driven nature of this industry.

Figure 15: Value chain of the Medical Devices industry: established and emerging actors



Source: Technopolis Group

Notes: The grey chain of boxes represents the traditional value chain of medical devices industries. Industries illustrated by graphics represent new actors. Red circles refer to new niches and areas of developments related to medical devices.

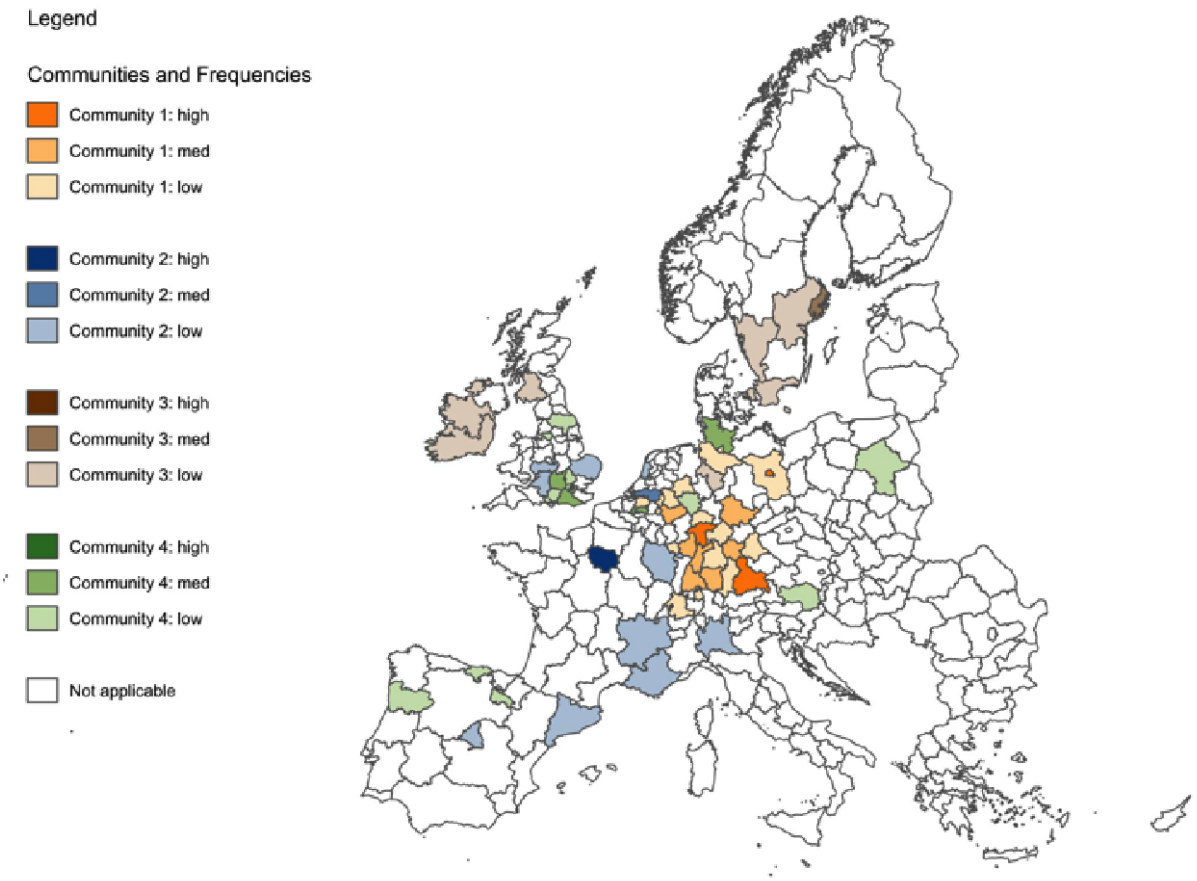
The geographic analysis identified the most dynamic hotspots in:

- Upper Bavaria, Darmstadt, Berlin, Koln and Freiburg;
- UK: London, Surrey and Berkshire, Buckinghamshire and Oxfordshire;
- France: Île de France and Rhône-Alpes;
- Sweden: Stockholm; Belgium: Flemish-Brabant;
- Netherlands: North-Brabant and Limburg;
- Italy: Lombardy;
- Poland: Mazovia.

The highest number of linkages indicates regions with high cross-sectoral activity, whilst the results of a social network analysis can shed additional light on the connections that exist across geographic borders. The social network analysis identified four communities of regions that were the closest connected through cross-sectoral linkages. These communities are centred round specific node regions that are not always the same as the regions with the highest number of linkages. Figure 16 depicts these communities (in different colours) and the regional hot spots (in darker colours). The communities are:

- Community 1 – Upper Bavaria (Germany);
- Community 2 – Île de France (France);
- Community 3 – Stockholm (Sweden);
- Community 4 – London (UK).

Figure 16: Regions and communities with dynamic cross-sectoral patterns in the Medical Devices Industry



Source: Technopolis group prepared with QGIS and based on Patstat and Thomson One data

Notes: based on 2010 NUTS codes. Frequency refers to the level of cross-sectoral dynamics present in the specific region based on the three indicators applied. The colours of the map reflect different communities (C1-C4) that belong together and represent one larger area where cross-sectoral spill-overs happen. The intensity of the colours represents the overall frequency and the most intense colours correspond to the regions with the highest frequencies. In particular: high represents the top 15 regions with cumulative frequency; medium represents regions with cumulative frequency of approximately 60%; and low represents the regions above the median but below the medium group. Colourless regions represent those regions where there is no cross sectoral activity in terms of patents, M&As and JVAs taking place or the frequency of cross sectoral activity is below the median (median=10).

2.1.10 Mobility Technologies

The purpose of **Mobility Technologies** is to move people and goods and hence, they are engaged in the manufacturing of transport vehicles, the construction of transport infrastructures and the operation of transport services. Mobility Technologies, in this report, include manufacturers of transport vehicles and their first and second tier suppliers of components together with service providers of passenger transport.

When looking at different indicators, reflecting trends at specific stages of the industrial value chain, Mobility Technologies were found to show the most dynamic cross-sectoral linkages related to the other industries and technological areas in the table below. In all the three data samples, the focus was on identifying industry linkages that demonstrated a growth. These trends are summarised in the Table 14.

Table 14: Dynamic cross-sectoral linkages related to Mobility Technologies

Core industry under analysis	Links to other industries showing positive dynamics related to the core	Growth over periods (percentage change)	Total number of cross-sectoral linkages
Captured through patenting (reflecting trends in upstream activities such as research and technology):			
Mobility Technologies	IT methods for management	1.03	224
Mobility Technologies	Computer technology	1.03	1973
Mobility Technologies	Biotechnology	0.94	47
Mobility Technologies	Medical technology	0.91	1009
Mobility Technologies	Semiconductors	0.73	374
Mobility Technologies	Digital communication	0.73	1354
Captured through mergers and acquisitions (reflecting trends in downstream activities such as production and services):			
Mobility acquired:	Real estate	10.00	12
Mobility acquired:	Industrials (transportation & Infrastructure)	7.11	82
Mobility acquired:	Educational Services	3.50	11
Mobility acquired:	Oil & Gas	3.50	11
Mobility acquired:	Semiconductors	3.25	21
Mobility acquired:	Other Materials	2.00	12
Mobility acquired:	Construction Materials	1.88	31
Mobility acquired:	Travel Services	1.75	15
Mobility acquired:	Containers & Packaging	1.50	14
Mobility acquired:	Building/Construction & Engineering	1.28	141
Mobility acquired:	Professional Services	1.07	86
Mobility was a target of:	Travel Services	10.00	12
Mobility was a target of:	Industrials (transportation & Infrastructure)	4.92	90
Mobility was a target of:	National Agency	3.50	11
Mobility was a target of:	Oil & Gas	3.00	10
Mobility was a target of:	Electronics	2.80	24
Mobility was a target of:	Textiles & Apparel	2.67	14
Mobility was a target of:	Other Consumer Products	2.10	41
Mobility was a target of:	Home Furnishings	2.00	20
Mobility was a target	Containers & Packaging	1.33	10

Core industry under analysis	Links to other industries showing positive dynamics related to the core	Growth over periods (percentage change)	Total number of cross-sectoral linkages
of:			
Mobility was a target of:	Building/Construction & Engineering	1.28	141
Mobility was a target of:	Professional Services	1.23	84
Captured through joint ventures and alliances (reflecting trends in strategic business activities often with an international character):			
Mobility Technologies	Internal Combustion Engines, NEC (except stationary engine radiators)	4.00*	4
Mobility Technologies	Metals Service Centers and Offices	3.00*	3
Mobility Technologies	Petroleum Refining	3.00*	3
Mobility Technologies	Plastics Products, (except plastics pipe fittings and plastics sausage casings)	4.00*	4
Mobility Technologies	Relays and Industrial Controls	4.00*	4

Note: Detailed calculations and data are available in the industry reports that were prepared as part of this study. They are available at http://ec.europa.eu/growth/smes/cluster/observatory/cluster-mapping-services/trend-report/index_en.htm

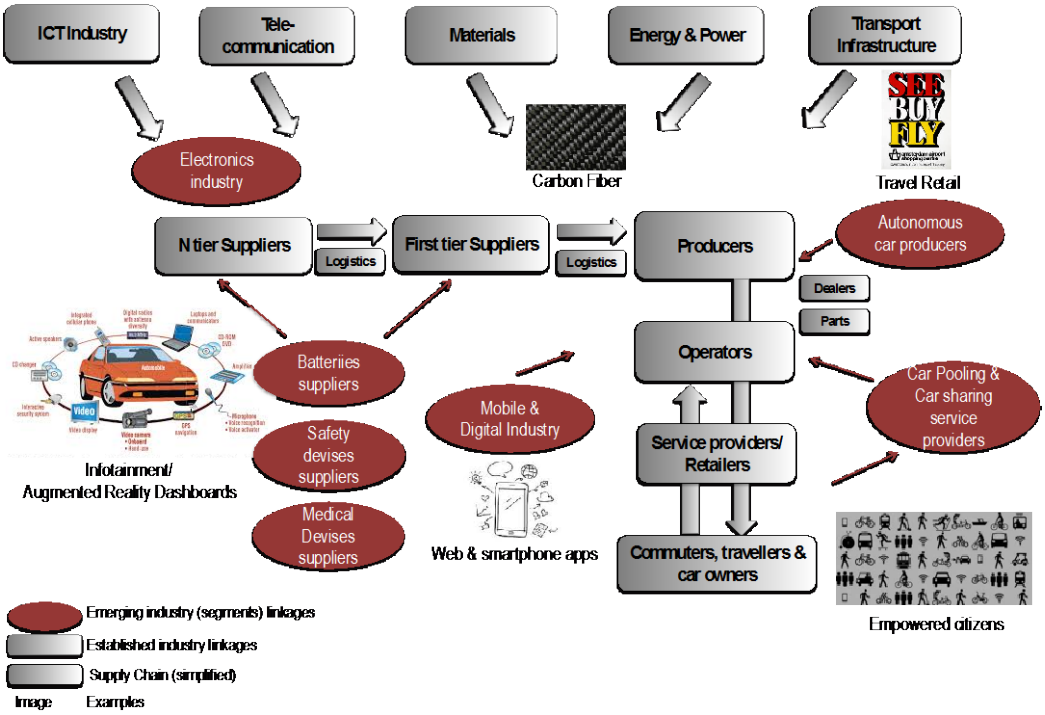
In Joint Ventures and Alliances that reflect trends in strategic business activities often with an international character, there are no particular insights revealed apart from the links with Radio and Television Broadcasting and Communications Equipment.

In patenting, amongst the areas recording the highest growth are 'IT methods for management' and 'Computer technology'. In M&As amongst the most frequent industries that the Mobility Technologies industry merge with or acquire are 'High Technology' industries like 'Electronics, Software' and 'Telecommunications,' although the latter is less prominent. In JVAs 'Communications Equipment' and 'Electronic Components' are amongst the most frequently occurring cross-sectoral JVAs. These trends have been also confirmed by the empirical analysis.

The empirical analysis also confirms the environmental technologies crossovers. In patenting, the most prominent patenting areas include 'Electrical machinery, apparatus, energy'. In M&As, 'Materials' and 'Energy and Power' are among the cross sectoral linkages that recording the highest growth between the two periods that were investigated. In JVAs, 'Electric Services' and, in particular, 'Other electric power generation' can be found. It should be noted that JVAs contain predominantly manufacturing industries covering a wide range of activities and including 'internal Combustion Engines', 'Chemical and Chemical Preparations' and 'Steel Works' industries and crossovers with such industries may involve joint ventures to tackle environmental issues.

The automotive industry is a very consolidated industry' that has emerged through M&As of automotive manufactures and is characterised by both in-house R&D and the extensive and increasing in importance of first, second, …'nth' tier of supplier networks. JVAs have recently become more critically important to car manufacturers in helping them to comply with environmental and safety regulatory requirements and also market demand. Figure 17 depicts cross-sectoral patterns along the industrial value chain.

Figure 17: Mobility Technologies Industry – Value chain approach



Source: Technopolis Group

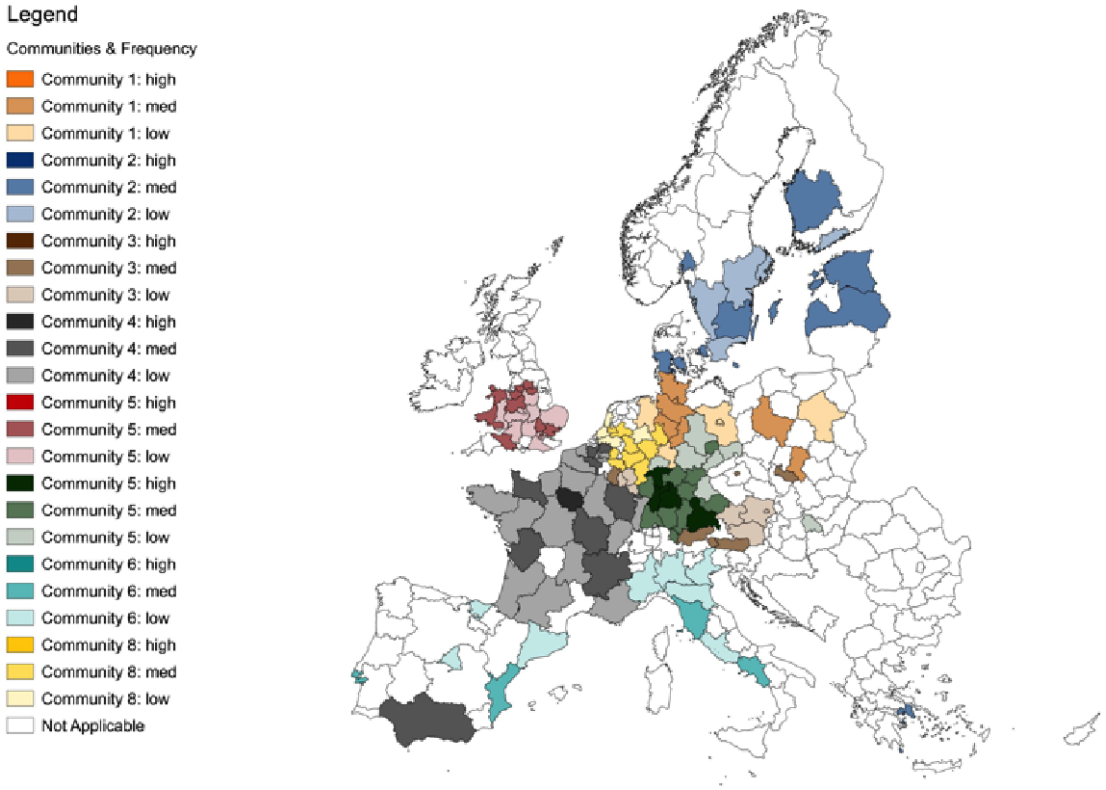
The geographic analysis identified the most dynamic hotspots in the following regions:

- Germany: Stuttgart, Oberbayern, Darmstadt, Karlsruhe, Köln, Rheinhessen-Pfalz, Düsseldorf, Tübingen, Unterfranken, Mittelfranken, Braunschweig, Detmold, Hannover, Arnsberg, Schwaben, Oberfranken, Schleswig-Holstein, Hamburg, Lüneburg, Koblenz, Freiburg and Niederbayern;
- France: Île de France and Rhône-Alpes;
- UK: Inner London.

The highest number of linkages indicates regions with high cross-sectoral activity, whilst the results of a social network analysis can shed additional light on the connections that exist across geographic borders. The social network analysis identified five communities of regions that were most closely connected through cross-sectoral linkages. These communities are centred round specific node regions that are not always the same as the regions with the highest number of linkages. Figure 18 depicts these communities (in different colours) and the regional hot spots (in darker colours). The Communities are:

- Community 1 – Hannover (Germany);
- Community 2 – West Sweden (Sweden);
- Community 3 – Vienna (Austria);
- Community 4 – Île de France (France) ;
- Community 5 – London (UK);
- Community 6 – Stuttgart (Germany);
- Community 7 – Catalonia (Spain);
- Community 8 – Köln (DE);
- Community 9 – Other.

Figure 18: Regions and communities with dynamic cross-sectoral patterns in Mobility Technologies



Source: Technopolis group prepared with QGIS and based on Patstat and Thomson One data

Notes: based on 2010 NUTS codes. Frequency refers to the level of cross-sectoral dynamics present in the specific region based on the three indicators applied. The colours of the map reflect eight different communities (C1-C8) that belong together and represent one larger area where cross-sectoral spill-overs happen. The intensity of the colours represents the overall frequency and the most intense colours correspond to the regions with the highest frequencies. In particular: high represents the top 15 regions with cumulative frequency; medium represents regions with cumulative frequency of approximately 60%; and low represents the regions above the median but below the medium group. Colourless regions represent those regions where there is no cross sectoral activity in terms of patents, M&As and JVAs taking place or the frequency of cross sectoral activity is below the median (median=22).

3. Internationalisation of Clusters

This third Chapter further analyses the ten emerging industries in terms of their internationalisation patterns.

Clusters act as real "springboards" for firms, especially small and medium enterprises (SMEs) to help them increasing their competitiveness and thus supporting them in getting access to global value chains and new markets (Meier zu Kocker et al, 2007). Cluster participants can benefit from specialised business support services of cluster organisations stimulating and organizing these actions. In particular, if firms have to increasingly integrate their activities into global value chains in order to become and remain competitive, being part of a cluster is supportive. This is, especially the case in emerging industries considered in this report.

Clusters in emerging industries face the needs for internationalisation as transformation processes within value chains urge clusters to think global and internationalise accordingly. Internationalisation may no longer be understood as export promotion or initiating publicly funded international R&D projects. Furthermore, the prevailing reason for considering an international scope is to keep their lead in technological development, identify upcoming market needs, properly reacting to transformation processes and to strengthen their own position on markets worldwide. Furthermore, the expectation to improve the access to identified new niches and target markets, in order to take advantage of the cooperation more easily and efficiently, is a common motive.

Consequently, cluster managers are more and more taking over the responsibility to initiate internationalisation of their cluster members (Zombori, 2012). The cluster participants and mainly SMEs often lack time, resources, know-how, information or budgets to successfully realise internationalisation processes. There are many other reasons why SMEs are reluctant to go international[7]. This is the rationale why cluster organisations can provide customised supporting measures and tools to the cluster participants on their paths towards internationalisation, as they usually have more resources at their disposal and are more experienced in internationalisation matters. A common understanding within clusters, a sophisticated internationalisation strategy and a consequent implementation of related actions are the prevailing key success factors for internationalisation of clusters (Greenhalgh, 2012). However, this requires specific cluster manager internationalisation skills for building long-term transnational and cross-sectoral cluster partnerships.

In the following a closer look is given how and to what extend clusters within these different emerging industries varies in terms of

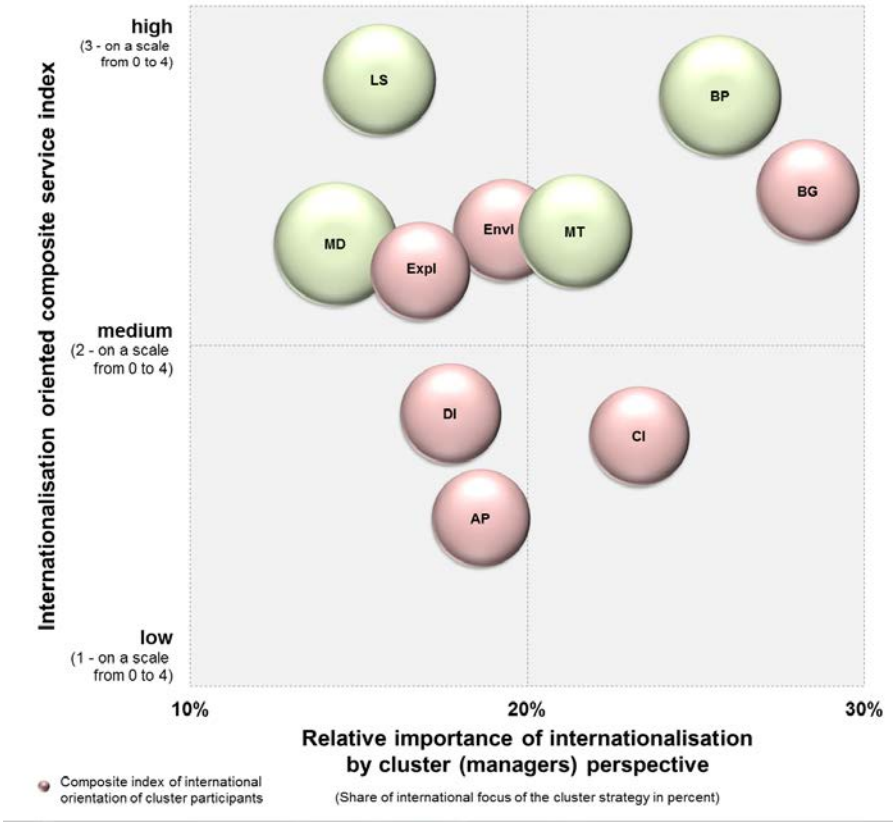
- international orientation of the cluster participants by specific emerging industries;
- importance of international cooperation along value chains;
- prevailing framework conditions for internationalisation;
- business support services offered by cluster organisations to support cluster participants to cooperate internationally.

This study makes use of the comprehensive data pool of the European Secretariat for Cluster Analysis (ESCA). The here used extracts of the overall cluster benchmarking data consist of data of 154 cluster organisations, only clearly belonging to the selected ten Emerging Industries and being assessed in the period from July 2012 to June 2014. Thus, a large up-to-date data set on internationalisation aspects of various European organisations is available allowing the identification of current trends: from

companies, also from SMEs, R&D organisations, and all kinds of education/training providers, all active in clusters dealing with the selected Emerging Industries.

Aggregating the existing data on a very high level allows comparing the strategic orientation of clusters in each of the Emerging Industries with their spectrum and intensity of services available aiming to support internationalisation. Clusters, in this context, are used to represent their industrial sectors as such. Figure 19 demonstrates that strategic importance of internationalisation as well as the spectrum and intensity of services regarding internationalisation offered by cluster organisations vary quite significantly between the different emerging industries.

Figure 19: Portfolio analysis of selected internationalisation aspects of European Clusters in the different Emerging Industries[8]



Notes: LS=logistical services; BP=biopharmaceuticals; MD=medical devices; Expl=experience industries; Envi=environmental industries; DI=digital based industries; AP=advanced packaging; CI=creative industries; BG=blue growth; MT=mobility technologies; Source: VDI/VDE-IT

The allocation of the different industries within this portfolio "strategic importance" versus "related services" furthermore has to be seen in the context of the status or degree of internationalisation of all the stakeholders within this sector. If the status of internationalisation is (very) high, within clusters, the issue of internationalisation does not necessarily need to be specifically addressed, as it is omnipresent. Even though the assessed internationalisation status of cluster participants in all emerging industries was higher than average (compared to all >600 clusters of which data is available in the ESCA database), there are some differences: The size of the "bubble" represents the status of internationalisation, for four of the emerging industries (green colour) a slightly higher status was assessed than for the rest.

[8] *See also Table 22*

Cluster organisations in the field of Blue Growth, Biopharmaceuticals, Environmental and Mobility Industries offer quite an intensity of international support services for their cluster participants, since the importance to act internationally is considered to be high (upper right square). In these cases, the services spectrum is often considered as a dedicated demand due to the high importance. Consequently, less and fewer services are offered in the field of Digital Industries and Advanced Packaging, as the importance for internationalisation is considered to be comparably low.

However, Figure 19 also displays that for cluster participants in the field of Creative Industries, there seems to be a mismatch between strategic importance for internationalisation (which is high) and a comparably low amount of services for internationalisation. But practice has shown that firms being active in this field tend to be reluctant to accept internationalisation support services, even if cluster organisations offer such services in sufficient quality, and even if the cluster firms do know that internationalisation is of high importance. Since firms in this industry are often very small and do neither have experiences and capacities to go international nor do they have the financial capability, they do often not become internationally active although they should do so. Creative Industries firms, often consist only of some individual artists, which are usually trying to serve their home markets rather than going international. Summarizing the adsorptive capacity of many firms in Creative Industries, the ability to internationalise is limited. Cluster organisations in the field of Logistical Services, whose cluster participants are already quite internationalised (comparably big-sized bubble in Figure 19), still offer a lot of support services (like match-making, strategic partnerships, etc.), although the strategic importance of internationalisation is considered to be decreasing. The respective services offered by cluster organisations have created, according to the explanations of many cluster participants, quite high, positive impacts and helped them to go international. Since these services still have a positive impact on international business, cluster participants appreciate to make further use of them. However, since cluster participants are more and more internationalised, the importance from the cluster participant side is decreasing. Another explanation is that four out of twelve areas of strong mutual interdependencies between global mega trends and emerging industries (see Table 20) can be grouped even to Logistical Services, meaning that cluster participants have to act very globally to follow these hot spots. Thus, it is expected that the importance of internationalisation, following these global transformation trends, might rise in the future.

Cluster participants from industries like Medical Devices or Biopharmaceuticals seem to be more internationalised already than cluster participants from Advanced Packaging or Experience or Creative Industries. Reasons for this might be that Medical Devices or Biopharmaceuticals are quite well established and international R&D and business cooperation are state-of-the-art, whereas Advanced Packaging is a quite young and small sector, not yet much dominated by international R&D or business cooperation. However, it seems to be quite interesting that cluster participants from Digital Industries and Environmental Industries are comparably less internationalised.

When only considering the axis of abscissae in Figure 19, this compares the order of current degree of internationalisation of cluster participants in the respective ten emerging industries with the strategic importance of internationalisation. It is interesting to see that for Biopharmaceuticals and Mobility Technologies, the status of internationalisation of the cluster participants is high as well as that the future importance of internationalisation within the respective clusters remains high as well - meaning cluster participants are considering internationalisation as still of high strategic importance. When it comes to Medical Devices and Logistical Services, the cluster participants are quite well internationalised, but the importance of internationalisation is decreasing. As already mentioned, the reasons might be that due to the high level of internationalisation of the cluster participants, international cooperation is state of the art, and much further attention is given to this topic. However, it is interesting to see that the three of the four Emerging Industries (Biopharmaceuticals, Medical Devises, Logistical Services as well as Mobility Technologies) of which cluster participants are most internationalised, seven out of twelve AOSI (Areas of strong interdependencies) of strong mutual interdependencies between global

mega trends and emerging industries can be grouped. It is no surprise that especially these AOSI are dedicated targets of global competition and cooperation. The reason for this is not only due to the fact that these industries are per se internationally positioned. This applies both, for their value chains and their markets and customers. If the reactions to external stimuli such as mega trends shall create long-term positive results in these mentioned industries, they must cover the entire "reaction room" of these industries, what means that they would have to be internationally active in every case. This awareness seems to be already implemented in a comprehensive manner in these emerging industries. Biopharmaceuticals shows the peculiarity that both, the degree of internationalisation and the recognition of the importance of such activities are quite high, which is evident from the portfolio positioning (in the fourth quadrant).

This industry has been faced already longer with the challenges of internationalisation and has already been in the duty to use several options to generate solutions – for example due to its origin story As a result, the dynamics of regional development in the Biopharmaceuticals sector will be slightly less than in industries that are currently meeting increasing challenges of internationalisation and that have to react accordingly (Medical Devises, Logistical Services as well as Mobility Technologies).

Clusters in emerging industries like Blue Growth and Environmental Industries seem to become the future drivers for internationalisation, since the cluster participants are not yet fully internationalised, but there is common sense that internationalisation is gaining strategic importance. Here, cluster managers shall be motivated to increase their efforts to support their cluster participants to internationalise. Since the demand to internationalise is fully understood, there might be a high openness of the cluster participants to support the cluster managements. However, dedicated business services have to be created, taking the specific needs into account. Roadmapping, defining a common internationalisation strategy, identifying strategic partnerships as well as technology and market scouting shall be preparatory actions before taking dedicated actions. The understanding of the transformation process within the both respected Emerging Industries appears to be of high importance. Furthermore, cross-sectoral cooperation, when going international, can be considered as an additional success factor.

3.1 Trans-Regional Collaboration Paths of European Clusters in Emerging Industries

Traditionally, internationalisation by exporting has been considered as a way to increase the growth of firms. Often, cluster organisation focus on activities to promote export possibilities for their cluster participants rather than striving for other aspects of internationalisation. The export of goods still remains significant, but during the studies conducted by the ESCA expert pool over the past, some interesting changes could be identified. Many firms within the investigated clusters have re-directed their focus on business activities of internationalisation besides export and are considering these to be important to achieve sustainable competitive advantages. Cross-border partnerships with foreign companies, foreign investments and cross-border networking have become increasingly important as opportunities to facilitate the exchange of technology and knowledge, which enable also SMEs to formulate international business concepts.

In the following, it is further investigated, in which intensity and in which geographical directions regions tend to cooperate. The expected differences as well as similarities will be shortly explained. Selected examples shall help to illustrate types and peculiarities of cluster cooperation between regions. For the following analyses, geographic regions were defined (Table 15):

Table 15: Defined geographic regions for the investigation of trans-regional Collaboration of European Clusters in Emerging Industries

Northern Europe	Northwest Europe	Central Western Europe	Southwest Europe	Southeast Europe	Central Eastern Europe
Denmark Faroe Islands	England	Austria	France	Albania	Czech Republic
Faroe Islands	Ireland	Belgium	Portugal	Balkan	East Europe
Finland	Shetlands	Germany	Southern Europe	Bosnia/Herzegovina	Hungary
Greenland	UK	The Netherlands	Spain	Romania	Poland
Iceland		Switzerland	Italy	Turkey	Slovakia
Nordic Countries[9]				Croatia	Baltic Sea Region
Norway				Greece	Estonia
Sweden				Macedonia	Latvia
				Montenegro	Lithuania
				Cyprus	Belarus
				Slovenia	Moldavia
				Bulgaria	Russia
					Ukraine

North America	South America	Eastern Asia	Africa	Oceania	Arabian Peninsula
Canada	Argentina	China	Africa	Australia	Qatar
Mexico	Brazil	India	Namibia	New Zealand	UAE
North America	Cameron	Japan	Ruanda		Israel
Panama	Chile	Korea	Senegal		
USA	Colombia	Malaysia	Zambia		
	Peru	Singapore	Algeria		
	Uruguay	South East Asia	Libya		
		Taiwan	Morocco		
		Thailand	Tunisia		
		Vietnam			

For each of the investigated Emerging Industries, from a pool of more than 50 representative clusters, those clusters were selected for analysis of their intensity and target regions of international cooperation, which were with their measured parameters inside the range of standard deviation. Thus, statistical outliers could be avoided, and the results give an image of the clusters' behaviour[10]. In order to get a complete picture, cooperation regarding commercial and business activity was distinguished from cooperation regarding R&D. All figures demonstrating intensity and geographic priorities of the cooperation can be found in the full report on Internationalisation also published under the European Cluster Observatory. Some selected examples are discussed in the following with focus in business cooperation between clusters.

Figure 20 shows the typical image of the international orientation of an economically quite strong region like Northern Europe. International business cooperation is state-of-the art, value chains are developed across these regions. The reasons for this are manifold: The intensity of cooperation is at

[9] *This type of subsumption is used, when they were named by the interviewees instead of single countries. To avoid statistical distortions, only those subsumptions have been used which are assignable to the selected partitioning of the regions.*

[10] *Only data of clusters representing values inside the standard deviation were used, in order to give a representative overview and to exclude singularities.*

least medium or even higher with other strong regions within Europe (Northwest Europe, Central Europe or Southwest Europe). Weaker cooperation exists with emerging markets (Eastern Asia, but also Central Eastern Europe). Africa, South America, Australia are virtually hidden. Weak industrialised regions therefore induce consequently only a weak response in terms of cooperation or of the ability to cooperate.

Figure 20: Target Cooperation Regions: Business cooperation – Northern Europe

Some selected examples will illustrate the types of cooperation, the drivers and the expected directions of development. It can be expected that many ongoing industrial transformation processes will further strengthen this trend. The Scandinavian countries are traditionally strong in the sectors mobility and transportation. Here, a large R&D competence is concentrated, both in the university and in the industrial sector. The region around Gothenburg particularly stands out[11]. The institutes (e.g. SP Technical Research Institute of Sweden, SWEREA, Chalmers) and industrial research departments (Volvo, Scania, Autoliv, Here (Nokia)) are best known to provide innovative solutions for more competitive environments in application fields such as active and passive driving safety, future traffic concepts, road safety, Heavy Duty Transportation or Telematics and Navigation. Also the manufacturers based in the region, especially in the mentioned areas, achieve outstanding research and development results. Not least, therefore, the chairman of the Working Group R&D of the European Association of Automotive Suppliers (CLEPA) comes from Autoliv, the world's largest automotive safety supplier. Autoliv is a Scandinavian company with sales to all of the leading car manufacturers in the world.

However, the industrial exploitation of these R&D results in the region is based on only a few, though powerful, but very focused OEMs such as Volvo and Scania. The establishment of co-operations for

[11] *One of the five strong clusters in West Sweden: Urban future, the marine environment and the maritime sector, transport solutions, green chemistry and bio-based products, and life science.*

the extension of the application areas, and thus to the conquering of markets, therefore seems be obvious. Because of the concentration of both, as well as powerful suppliers along the entire value chain and also innovative OEMs, the goal for these cooperation activities with Central Europe is obvious. German OEMs, which are strong in car manufacturing, significantly extended cooperation with partners in the Skane region (Sweden). The reason is that know-how and capabilities in car communication is still seen as a future key success factor (please refer also to chapter 2.1.10). One of the centres of competences of mobile communications in Scandinavia is located in the Skane region, where Ericsson once manufactured mobile phones. Central European OEMs and suppliers identified these trends in the Mobile Technology sector and initiated respective cooperation with Northern Europe. This is a good example to demonstrate how new value chains have been created and why trans-national cooperation in this field is a must.

Other remarkable examples are: For the development of competitive, road-based freight transport solutions, Volvo leads, together European expertise, in a research centre in Lyon. This centre has grown out of a long-term cooperation with Renault in the truck sector.

The cooperation in the field of intelligent transportation systems (ITS)[12] brings together excellent Scandinavian navigational expertise, which emerged from the mobile tradition, with the system knowledge of German and French TIER 1 supplier for the development of a European Open Telematics Platform for street and rail traffic (HERE, Valeo, Continental, Bosch, Siemens).

Close research collaboration between the regions of Northern and Central Europe join the Scandinavian know-how in the field of heavy goods vehicles and alternative transport solutions together with the system knowledge of leading German system suppliers to develop marketable, eco-friendly and sustainable solutions for the road-based transport of goods. Examples are wired traffics[13], [14] or Induction Power Transfer solutions for mid- and long ranges (Volvo, Siemens, and Daimler).

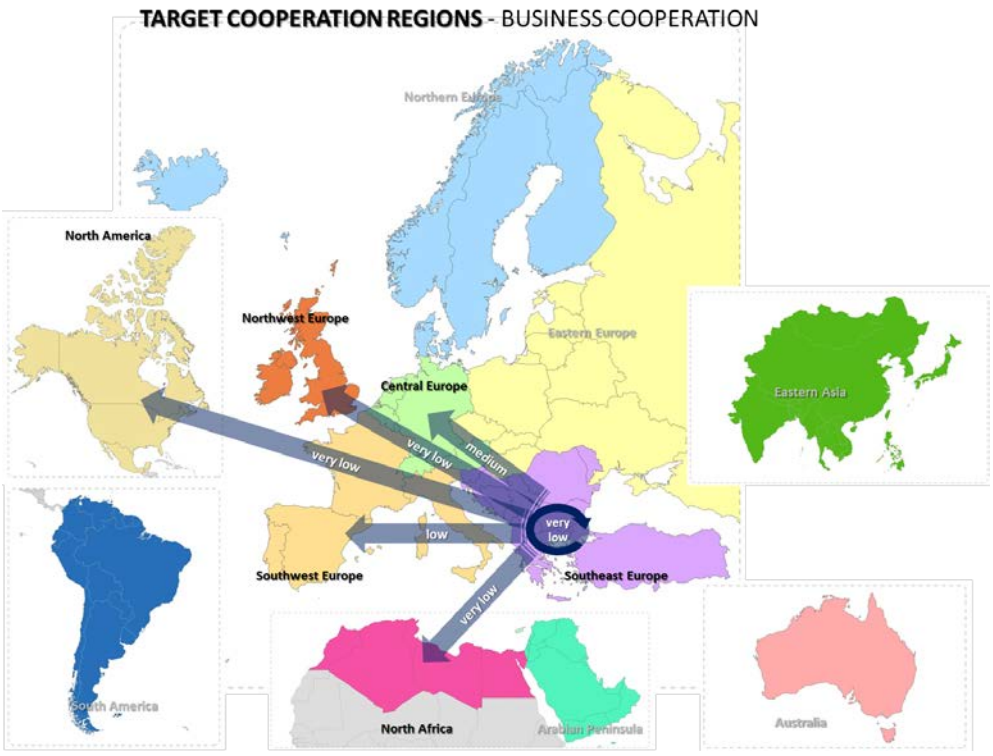
Figure 21 shows another, but no less typical picture: Cluster participants from a less strong economy tend to be less able to initiate business cooperation with other cluster participants from other regions. Even within the own region, cross-border cooperation is comparably weak. However, there is transnational cooperation between South-eastern European cluster participants and other regions, but only on a low level.

[12] *(Commission, 2010) defines ITS as systems in information and communication technologies which are applied in the field of road transport, Including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport.*

[13] See also: http://www.metro.net/projects/i-710-corridor-project/

[14] (Siemens AG, 2014)

Figure 21: Target Cooperation Regions: Business Cooperation – Southeast Europe



The internationalisation efforts of cluster participants in Southwest Europe have, in contrast to most of the previously studied examples, the peculiarity that both - in the own region as well as with other regions - no strong cooperation but only comparably weak links can be observed. One reason for this may be due to the lack of a larger number of competitive stakeholders in the region who are striving for international excellence (or could do this). Their activities focus on regions where a broader community of suitable partners and related opportunities can most likely be found (cooperation within Southwest Europe and with Central Europe). Likewise, there are activities in regions with traditional ties (the Americas).

Table 16: Cluster-driven trans-regional cooperation matrix in the field of emerging industries with focus on Business Cooperation

	Northern Europe	Northwest Europe	Central Western Europe	Southwest Europe	Central Eastern Europe	Southeast Europe
Northern Europe		o	++	+	-	-
Northwest Europe	o		o	-	-	-
Central Western Europe	++	o		++	o	o
Southwest Europe	+	-	++		-	-
Central Eastern Europe	-	-	o	-		-
Southeast Europe	-	-	o	-	-	

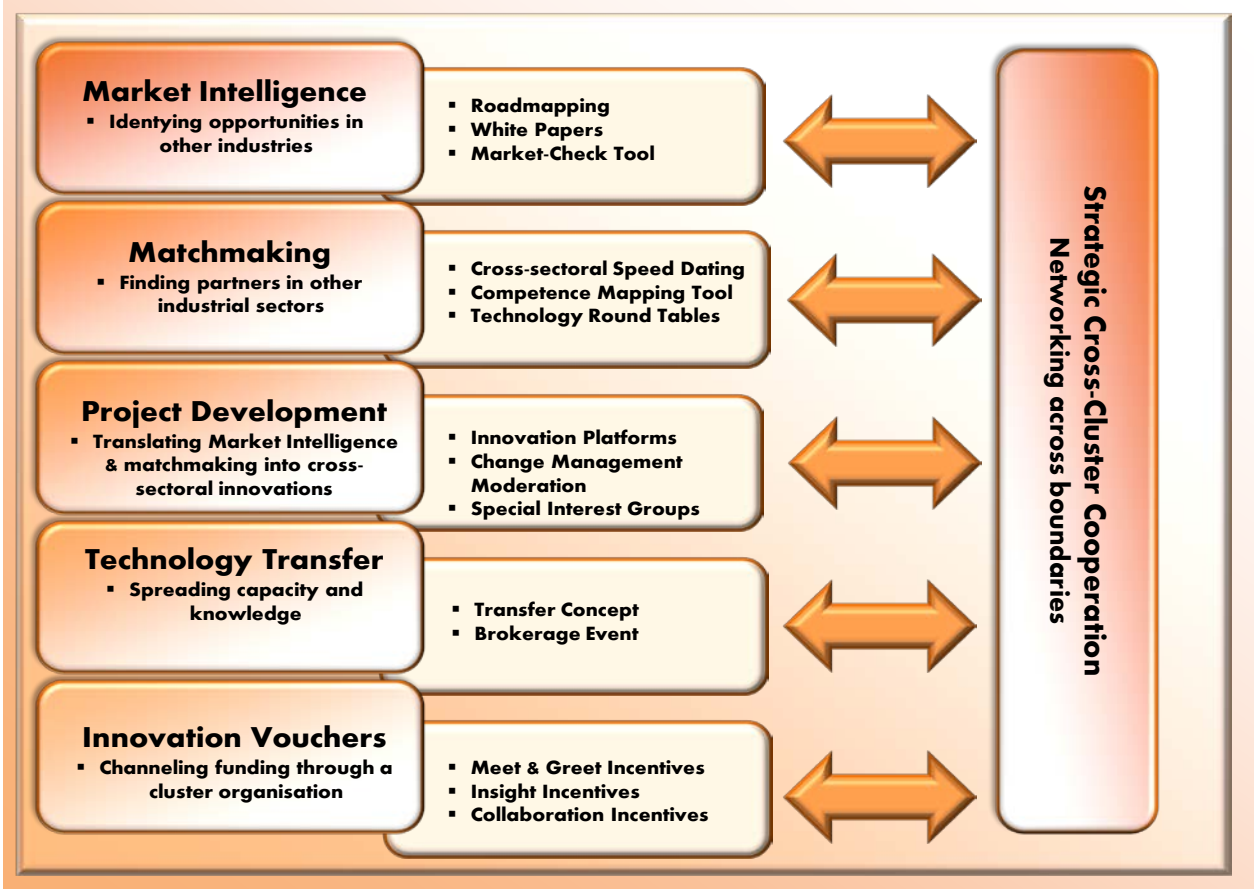
++ very strong cooperation, + strong cooperation, o medium strong, - weak cooperation

Table 16 shows a summary of the cluster-driven trans-regional cooperation with focus on business cooperation.

Cluster services, meaning specific, tailor-made services provided by cluster organisations to their cluster participants are important tools for cluster organisations, especially in the field of internationalisation. Practice has shown that cluster organisations can play a decisive role for the development of new industrial value chains and emerging industries, notably through creating a favourable environment. An appropriate strategy, mandate to internationalise and appropriate service spectrum, adapted to the transformation trends and needs of the cluster participants are the key to succeed.

However, the analyses also revealed that there is not a singular service offered by cluster organisations really contributing to the internationalisation success of cluster participants rather than a well-integrated, holistic approach of several complementary activities. When deciding to go international to tackle new value chains or emerging industry starts with the observation that there is an opportunity (= "market intelligence services"), then partners are needed to develop ideas on how to take advantage of these opportunities (= "matchmaking services"); once ideas are born, they need to be translated into projects/measures (= "project development services"); new knowledge might be worth to be shared with others and funding is required (= "innovation vouchers").

Figure 22: Service spectrum to promote international cross-cluster cooperation[15]



[15] *Cluster Collaboration and Business Support Tools to Facilitate Entrepreneurship, Cross-sectoral Collaboration and Growth, European Commission, Brussels, , 2014 available at: http://ec.europa.eu/enterprise/initiatives/cluster/observatory/2014-10-10-eco-report-d4.1.pdf*

4. Dimensions of Collaboration Spanning through Emerging Industries

The final task in analysing the linkages between related industries included the identification of three 'so-called' cross-sectoral collaboration spaces. These collaboration spaces are expected to span most of the emerging industries and to provide a basis for cooperation and development between a wider range and type of clusters.

The purpose of identifying three cross-cutting areas is also to highlight the cross-sectoral linkages from which important innovations and increased entrepreneurship are most likely to emerge, namely those spaces that provide a particular opportunity for unexpected or unplanned, but still positive, events to happen. These collaboration spaces also represent communities of industrial linkages that are currently the most dynamic and, hence, involve most of the narrow industries in Europe.

In order to identify collaboration spaces that cut across industries, it was decided to follow a quantitative, data-driven approach and the method of social network analysis was applied. The basis for the social network analysis was the identified industry linkages of cross-technological patenting, cross-sectoral mergers and acquisitions (M&A) and joint ventures and alliances (JVA) per emerging industry that has been presented in Section 1.1. The key criteria for the selection of industry linkages for a social network analysis were the followings:

- The top 20 other 'technological areas' and the top 15 other 'narrow industries' have been included per each emerging industry that had been the strongest connections in terms of number of patenting or number of mergers and acquisitions in the most recent period of analysis, notably 2002-2012 for patents and 2007-2014 for mergers and acquisitions;
- The other industries have been consolidated in case they belonged to an emerging industry as defined during the cross-sectoral trend analysis;
- Each technological or industry linkage also included a weighting reflecting the strength of the linkage in terms of its frequency during the period selected.

The introduction of the distinction between the two data files of patenting and M&A/JVA was intended to assist the exploration of collaboration spaces that happen either at the research and technology development stage of the value chain, or those that are more linked to industrial production and service provision.

Analytical methods from Social Network Analysis (SNA) have been used to identify the three collaboration spaces. SNA is useful in analysing patterns of relationships between units that can be people, organisations or cells. It can explore the social structure and interdependencies of individuals or organisations, from which it can then depict the informal social network. In order to mine deeper into the structural characteristics of these networks, community detection algorithms were used.

Communities have been uncovered amongst the industry linkages in a two-step process. Firstly, communities were calculated using the Infomap community detection algorithm, in order to make an approximation of the highest number of communities emerging from the network. In a second step, the Spinglass community detection algorithm was used to identify a pre-defined number of communities within the main component of the collaboration network. Spin Glass is an approach from statistical physics, based on the 'so-called' Potts model. In this model, each vertex or node can be in one of c spin states, and the interactions between the edges, namely the links, specify which pairs of vertices or nodes would prefer to stay in the same spin state and which would prefer to move to different spin states. The model is then simulated for a given number of steps and, in the end, the spin states of the particles define the communities.

4.1 Collaboration Spaces driven by Research and Development

The social network analysis and the Spin Glass community detection approach were applied to the data table of the cross-technological patent industry pairs within each of the ten emerging industries. The type of linkages between emerging industries and other industries can help to reveal if there are any common patterns that drive collaboration and if there are any larger communities that span across the borders of the individual emerging industry. The number of these communities was restricted to three.

The first community is centred round **Biotechnology** and includes the analysis of biological materials, biopharmaceuticals, food chemistry and chemicals. This group is a relatively tailored group and focuses on the emerging industry of Biopharmaceuticals reaching out to other industries such as chemicals, food, manufacturing or even packaging.

Table 17: Composition of the first technological community (result of the Spin Glass analysis)

ID	Technological area	Centrality main component	Infomap	Spin Glass
8	**Biotechnology**	**0.283**	**1**	**1**
3	Analysis of biological materials	0.156	1	1
7	Biopharmaceuticals*	0.0774	1	1
19	Food chemistry	0.0416	1	1
24	Macromolecular chemistry	0.0545	1	1
26	Measurement	0.1815	1	1
1	Advanced Packaging*	0.02184	1	1

** The use of red type indicates that this is one of the ten emerging industries that are the focus of the report*

The second community is centred round **Environmental technology**. It is a relatively wide group with connections to a range of other technological areas such as chemistry, biotechnology, electrical machinery, materials, thermal processes and apparatus or micro-structural nano-technology. This might reflect the trend towards more resource-efficient thinking in terms of production processes with developments mainly in the area of chemical, material and engineering technologies.

Table 18: Composition of the second technological community (result of the Spin Glass analysis)

ID	Technological area	Centrality main component	Infomap	Spin Glass
18	**Environmental technology**	**1**	**1**	**2**
33	Organic fine chemistry	0.4007	1	2
10	Chemical engineering	0.2919	1	2
36	Pharmaceuticals	0.291	1	2
16	Electrical machinery	0.236	1	2
2	Environmental industries/Alternative energy	0.2222	1	2

ID	Technological area	Centrality main component	Infomap	Spin Glass
37	Semiconductors	0.2030	1	2
6	Basic materials chemistry	0.1753	1	2
41	Thermal processes and apparatus	0.1624	1	2
25	Materials and metallurgy	0.1487	1	2
35	Other special machines	0.1186	1	2
17	Engines pumps turbines	0.0894	1	2
11	Civil engineering	0.0660	1	2
30	Micro-structural and nano-technology	0.0083	1	2
9	Blue growth industries	0.00124	1	2

** The use of red type indicates that this is one of the ten emerging industries that are the focus of the report*

Interestingly, the third community is centred round **Surface technology** and it includes a range of other technological areas like transport and medical technologies. As surface technologies are instrumental in prolonging the life of products and their components, this might reflect a trend toward advanced materials and advanced manufacturing. In this group, Digital Industries can be found together with technologies linked to this topic such as digital communication and IT methods for management.

Table 19: Composition of the third technological community (result of the Spin Glass analysis)

ID	Technological area	Centrality main component	Infomap	Spin Glass
38	**Surface technology**	**0.09316**	**1**	**3**
42	Transport	0.05367	1	3
32	Optics	0.0457	1	3
4	Audio-visual technology	0.04513	2	3
27	Mechanical elements	0.0436	1	3
23	Machine tools	0.0336	1	3
29	Medical technology	0.02610	1	3
39	Telecommunications	0.02395	2	3
14	Digital industries	0.02250	2	3
40	Textile and paper machines	0.02186	1	3
28	Medical Devices	0.02107	1	3
34	Other consumer goods	0.0177	1	3

12	Computer technology	0.0177	1	3
31	Mobility Technologies	0.0169	1	3
13	Control	0.0166	2	3
21	Handling	0.01661	1	3
15	Digital communication	0.01567	2	3
20	Furniture and games	0.00932	1	3
5	Basic communication processes	0.00511	2	3
22	IT methods for management	0.0037	1	3
42	Logistical Services	0,00142	1	3

** The use of red type indicates that this is one of the ten emerging industries that are the focus of the report*

In summary, the network analysis of cross-technology pairs revealed three communities of technological areas that the most frequently connect the emerging industries, namely:

- **Biotechnology** that might reflect the move towards a bio-based economy;
- **Environmental technologies** that might reflect the importance of resource efficient technologies;
- **Surface technologies** that might reflect trends towards multi-functional coatings, advanced manufacturing that relies on smart coatings and the impact of digitalisation on manufacturing industries.

4.2 Collaboration Spaces in the Phases of Industrial Production and Service Provision

A social network analysis and the Spin Glass community detection approach have been applied to the joined data table of the cross-sectoral M&A and JVA within each of the ten emerging industries. The top 15 cross-sectoral industry pairs from the emerging industries, for example, a pairing of Biopharmaceuticals with Computers & Peripherals, have been compiled into a single data table. The industrial classification of the Thomson One Business Classification has been used and this refers to narrower industry groups than the ten emerging industries that always represent always a combination of sectors or industries, as outlined in Section 1.1. The type of linkages between emerging industries and other industries can reveal if there are any common patterns that drive collaboration and if there are any larger communities that extend beyond the borders of the emerging industry in question.

The selection of communities was restricted to three and the following communities were identified:

1. Computers and Peripherals;
2. Environmental Industries;
3. Healthcare.

The first community centred on **Computers and Peripherals** connects the following emerging industries: ‘Experience industries’; ‘Mobility Technologies’; ‘Digital industries’; ‘Logistical Services’; ‘Creative industries’; and ‘Advanced Packaging’. Table 20 provides a detailed overview of the composition of this community.

Table 20: Composition of the first community (result of the Spin Glass analysis)

ID	Industry	Centrality full graph	Infomap	Spin Glass
8	Computers & Peripherals	3.93965748467562e-05	9	1
35	Professional Services	0.64751917341341	3	1
16	Experience industries	0.510543610558549	2	1
27	Mobility Technologies	0.295642834685842	6	1
11	Digital industries	0.228225334097344	8	1
29	Other Consumer Products	0.11937914171143	10	1
23	Logistical Services	0.117154118244418	3	1
12	E-commerce/B2B	0.0774744654892614	2	1
10	Creative industries	0.0404541124003228	4	1
38	Textiles & Apparel	0.0379088765052841	2	1
1	Advanced Packaging	0.0260571074287911	9	1
37	Telecommunications Services	0.0211008909665753	8	1
32	Other Real Estate	0.0146662373326183	2	1
36	Telecommunications Equipment	0.00299053029981502	8	1
2	Aerospace & Defence	0.00193165653723464	4	1
39	Wireless	0.00184032633834771	8	1
9	Construction Materials	0.0017134688185561	4	1
13	Educational Services	0.00112133757141777	4	1
21	Home Furnishings	0.00111747966427572	4	1
17	Food & Beverage Retailing	0.00021407353636158	4	1

The second community centred on **Environmental Industries** specifically connects 'Environmental industries' and 'Blue Growth industries', although the review of each emerging industries in Section 1 shows that environmental services are increasingly important to Medical Devices, Mobility Technologies and Advanced Packaging. Table 21 provides a detailed overview of the composition of this community.

Table 21: Composition of the second community (result of the Spin Glass analysis)

ID	Sector	Centrality full graph	Infomap	Spin Glass
15	Environmental industries	1	1	2
6	Building/Construction & Engineering	0.556613875469728	5	2
24	Machinery	0.383261973024145	9	2
34	Power	0.354049753732549	5	2
30	Other Industrials	0.254544369760885	6	2
26	Metals & Mining	0.226675634192253	4	2
7	Chemicals	0.206905708574268	7	2
28	Oil & Gas	0.182470800031149	1	2
31	Other Materials	0.0995264809618704	9	2
5	Blue Growth industries	0.0518382163799522	5	2

The third community is centred on **Healthcare,** with electronics as a common connection and driving factor. It connects with the emerging industries of 'Medical Devices' and 'Biopharmaceuticals', although there are also connections to Digital industries, Advanced Packaging and Experience industries as revealed by the literature review in Section 1.1. Table 22 provides a detailed overview of the composition of this community.

Table 22: Composition of the third community (result of the Spin Glass analysis)

ID	Sector	Centrality full graph	Infomap	Spin Glass
14	Electronics	0.089904520168754	4	3
25	Medical Devices	0.0660669530043743	10	3
4	Biopharmaceuticals	0.0465007105420381	7	3
19	Healthcare Equipment & Supplies	0.00264818938298336	7	3
33	Other Retailing	0.00156269781010052	4	3
18	Food and Beverage	0.0011787938173977	5	3
22	Household & Personal Products	0.00059578438320416	9	3
20	Healthcare Providers & Services (HMOs)	0.000234353042741893	7	3
3	Agriculture & Livestock	0.000140611825645133	7	3

In summary, the results of the network analysis reveal a similar picture to that of patenting and point to the existence of the following three cross-industry communities, each centred round a common theme:

- **Computers and peripherals** connecting the emerging industries of 'Experience Industries', 'Mobility Technologies', 'Digital Industries', 'Logistical Services', 'Creative Industries', and 'Advanced Packaging';
- **Environmental industries** connecting 'Environmental Industries' and 'Blue Growth Industries', and also being related to Medical Devices, Mobility Devices and Advanced Packaging;
- **Electronics connecting healthcare related industries** such as 'Medical Devices' and 'Biopharmaceuticals' and also the food industry and household and personal product manufacturing with their links to Digital Industries, Advanced Packaging and Experience Industries.

Interestingly, the results of the network analysis in cross-technological patenting and cross-sectoral M&A and JVAs exhibit some common patterns, with the most obvious being in the area of environmental industries. The cross-cutting collaboration spaces identified seem to represent important hubs for the connections with several other emerging and other 'traditional' industries.

Related to technology-driven connections between the ten emerging industries, biotechnology, environmental technologies and surface technologies seem to be the common denominators and also the strongholds, particularly, in terms of the numbers of patents.

However, in industrial production, the emerging industries seem to be mostly driven by different service-based business activities such as computers and related services, environmental services and healthcare related services.

5. Cluster Foresight – Results of the Expert Workshop

This Chapter summarises the results of a Foresight Workshop of the European Cluster Observatory that was held in Berlin on 23rd of January 2015.

The goal of the foresight workshop was to define the most promising and dynamic areas of future change in industrial transformation and cluster-development, collaboration and value creation. During the workshop, three expert groups (23 cluster experts from 15 European countries) developed roadmaps covering three thematic trends[16] relevant for a variety of industrial sectors:

- Smart Everything
- Personalisation of Products and Services
- Resource Efficiency

To facilitate, structure and streamline the roadmaps, the Visual Road-Mapping method was applied to outline possible development paths for cross-cluster collaboration. The VRM is akin to mind-mapping in that it helps to visually organise different types of information about complex problems. The visual representation of concepts, developments, drivers etc. allows to relate these phenomena to each other and to analyse them in a systematic way. The VRM is a roadmap matrix combining a time line and 4 thematic domains: framework conditions, technological developments, resulting products and services, outcomes and impacts. The participants of the workshop were divided into three groups. Each group prepared a roadmap by collecting ideas, arranging them in the matrix and discussing possible path-ways. Subsequently, each group was invited to analyse, discuss and comment the other roadmaps in a world café walk over. This feedback was followed by a plenary discussion focusing on possible con-sequences of the findings for SMEs, clusters and policy makers.

The resulting three roadmaps will serve as a framework for the horizon scanning exercise to be exe-cuted as the next step in the foresight analysis. Horizon scanning is part of the foresight methodology and aims at identifying weak and diffuse signals for the developments charted in the maps. Based on the identified weak signals, the key drivers and other relevant aspects, as well as cause-and-effect-relationships the project team will draft a number of scenarios about possible futures of cluster devel-opment. They will serve as a source to discuss future cluster opportunities and challenges, to spell out their implications, to identify weak signals that would indicate a development in the direction of a spe-cific scenario and to foster dialogue between relevant actors in the field.

The remainder of this report is structured as follows: the following three sections present the roadmaps ‘Smart Everything’, ‘Personalisation of Products and Services’ and ‘Resource Efficiency’ respectively. In each case different pathways of how the development might unfold, will be presented. The discus-sion also entails and visual representation of the analysis of the maps prepared during the workshop and the subsequent comments and analysis. The report finishes by pointing to cross-cutting themes and by drawing a number of preliminary conclusions.

5.1 Roadmap ‘Smart Everything’

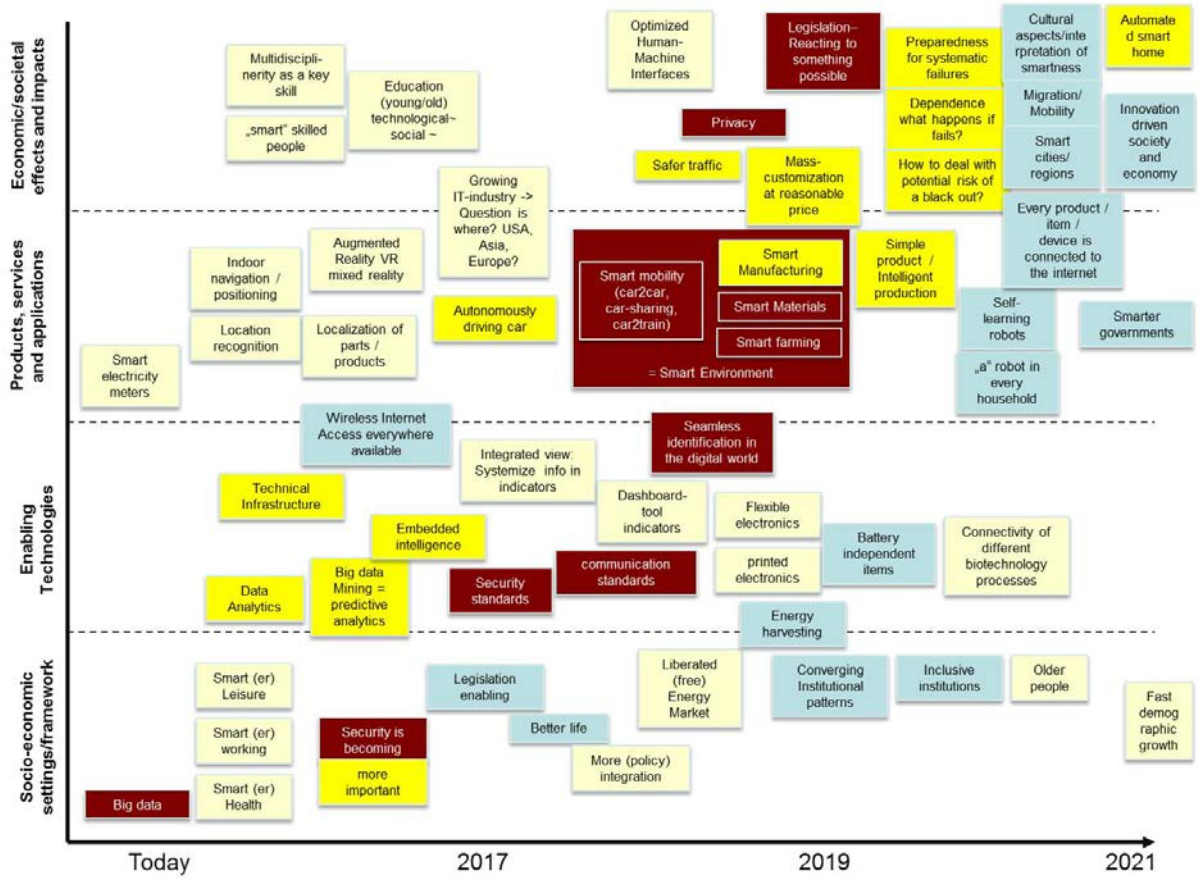
In the context of this work ‘Smart Everything’ describes a comprehensive digitalisation of all spheres of life, such as the convergence of technologies driven by smart home, internet of things, or e-mobility. Especially sensors, software and hardware required to generate, transfer and process vast amounts of

[16] The selection of these trends resulted from expert interviews, a survey amongst cluster managers and output from other work strands of the European Cluster Observatory.

data, are becoming smaller and more powerful every day. Users are moving through a connected world and with the evolution of mobile technology not only single devices but all objects are becoming smart. The trend covers a variety of areas, like living (Smart Home, Smart City etc.), mobility (Smart Cars), infrastructure (Smart Grids) and production (Smart Manufacturing) as well as many other areas of life (Smart Health, Smart Work, Smart Leisure). Thus 'smart' is related e.g. to connectivity, efficiency, resilience, autonomy, adaptation, self-learning and self-awareness.

Within the trend of 'Smart Everything' three pathways were identified during the workshop. They can be dubbed as 'Security and Privacy', 'Inclusiveness', and as 'Resilience and Dependence'.

Figure 23: Roadmap 'Smart Everything'



Source: European Cluster Observatory, prepared by VDI/VDE-IT and Technopolis

The first pathway '**Security and Privacy**' (highlighted in dark red) is placed in a specific socio-economic context containing aspects such as big data and concerns about security. Technological developments along this pathway concern standards for data and information security, as well as communication. A seamless identification in the digital world is identified as a key aspect when people are moving through smart environments. These developments might in turn change the value of privacy both on an individual level, as well as a societal level and influence legislation to react to new requirements regarding the protection of privacy. Essentially the pathway can be viewed as a feedback loop, where new legislative decisions result from technological developments. In turn, these legislative changes facilitate changes within the socio-economic setting. Changed socio-economic circumstances might lead to new technological developments that again influence legislative actions.

The second pathway '**Inclusiveness**' (highlighted in pale blue) starts similar to the first pathway in a very specific set of present institutional patterns. These patterns are a holistic view of the rules and

regulations that influence the socio-economic framework e.g. national laws, standards, values and norms and thus the understanding of inclusiveness. The main questions influencing developments along this path concern whether or not 'Smart Everything' should or could include anybody and if so, how this goal can be achieved. Specific enabling technologies include access to wireless internet anywhere, the necessary energy to operate all kinds of connected objects and devices and predictive data analytics. The development of these technologies might lead to a future where every household has at least one robot with environments where every object is connected to the internet. These enclosed environments make up smart cities and finally smart regions, where mobility, logistics and work settings are all connected. A possible outcome of these developments might be change in migration patterns: in a connected reality, where work and leisure and all aspects of a smart environment are available for anyone, there might no longer be a need to move between regions. In answering the question whether or not these technology-driven developments should include everyone, one has to consider cultural aspects that influence the interpretation of what 'smart everything' actually means. Cultural aspects are influencing the socio-economic framework as well as being influenced and changed by technological and social developments. A proposed endpoint for this pathway would be an innovation driven society and economy.

The third pathway '**Resilience and Dependence**' (highlighted in bright yellow) concerns aspects regarding the vulnerability and interdependence within and between connected systems. The main question in this case is: what happens if the system (energy, internet etc.) breaks down? In an interconnected world a need for redundant or back-up systems has to be met in order to deal with potential risks resulting from system failures. This pathway is again based in very specific socio-economic framework, where security concerns are an important issue. This can mean both individual security as well as societal security. Security can be guaranteed by creating a technical infrastructure that addresses potential threats. Within this infrastructure, intelligent systems measure and evaluate warning signs and automate appropriate responses. One example would be the recent developments regarding autonomously or self-driving cars as a step stone towards smart mobility solutions. The benefit in this particular case is improving traffic safety. Separated but not unrelated other intelligent systems might include smart assembly lines and materials enabling smart manufacturing. Within all these complex and connected systems, the risks of failure need to be addressed. This can happen on a legislative level as well as a societal level through regulations and norms. Similar to the feedback loop described above, these new regulations and norms change the socio-economic framework over time and influence the realization of improvements to the technical infrastructure.

While the three pathways have been presented here as separate ways to the future, they are **interconnected** as the following examples illustrate:

- The effects of demographic change influence all three pathways.
- The three pathways also share a common group of impacts concerning the role of education and qualification, as multidisciplinary knowledge and constant development of skills are seen as key prerequisites for adapting to a complex and dynamic world.

Based on the rather abstract discussion, the experts formulated two **hypotheses**:

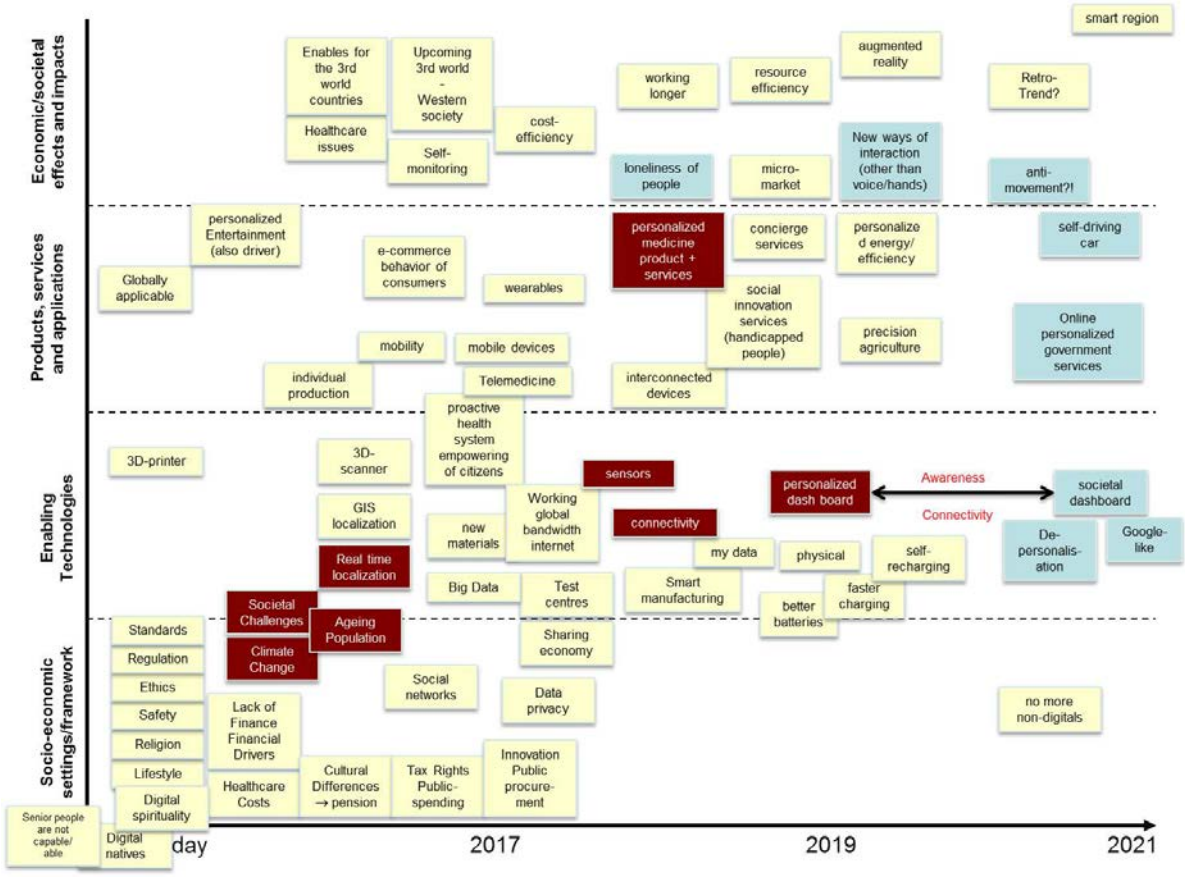
- Smart is not a goal, but a means to improve the quality of life. In connection with the remarks regarding inclusiveness, this hypothesis illustrates an important question: whether or not technological developments that might lead to the realization of 'Smart Everything' should be available for everyone and if so, how the needs of those included can be incorporated during the development phase.
- Smart should be human-centred. When centring smart developments on humans and their needs, the first step is formulating those needs and ways to meet them. It is a less technology-driven approach.

5.2 Roadmap 'Personalisation of Products and Services'

Personalisation of products and services refers in this context to all innovations that allow firms to provide tailored products and services, relative to personal demand and taste. Examples for personalised products and services are wearable technologies, smart meters, concierge services (such as Uber in the transportation sector) as well as personalised medicine.

Participants see two pathways in the development of personalised products and services: The creation of an 'individual dashboard of personalised products and services' and an 'aggregated societal dashboard'. The following figure highlights the two pathways (red and blue in the figure below) among the overall socio-economic context, enabling technologies, products and services as well as the economic/societal effects and impacts.

Figure 24: Roadmap 'Personalisation of products and services'



Source: European Cluster Observatory, prepared by VDI/VDE-IT and Technopolis

The first pathway (marked in red) implies the development of an **individual dashboard of personalised products and services**. Departing from societal challenges, such as the ageing of the population or climate change; products, services and applications could feed into a sort of dashboard that each individual would own. Using enabling technologies such as sensors, real time localisation and data-driven technologies, the dashboard would instantly provide access to a multitude of products, services and applications that could be accessed at the individual's 'fingertips'. For instance, such a dashboard could be used to manage interconnected products (e.g. smart homes, smart manufacturing, smart health) as well as services (e.g. personalised mobility services, e-commerce). The need for the dashboard results out of the aforementioned societal challenges, such as the ageing population. Because people will have longer expectation of life, they will also work for a longer period of their lives,

implying a higher cost of healthcare. As other societal challenges such as climate change could increase the need for overall cost-efficiency, people will face increased pressure to engage in self-monitoring of their health, in order to allow for the most (cost-)efficient provision of health care. Thus, the long-term perspective of personalised health care services (that already exist today, to a certain extent) could require individuals to control many more factors with implications to their health, such as nutrition, fitness or medication. The dashboard on an individual basis will further allow bringing together other products and services that result out of the need to address societal challenges mentioned above. The underlying enabling technologies of the dashboard are sensors, which facilitate the automated connectivity of the range of personalised products and services (automatically sending a self-driving car when you need it). Finally, the dashboard is to be understood as a service (e.g. cloud-based) and could potentially entail a physical device to manage the dashboard, such as a tablet. The timeframe for this pathway was considered to be 2019 i.e. in four to five years.

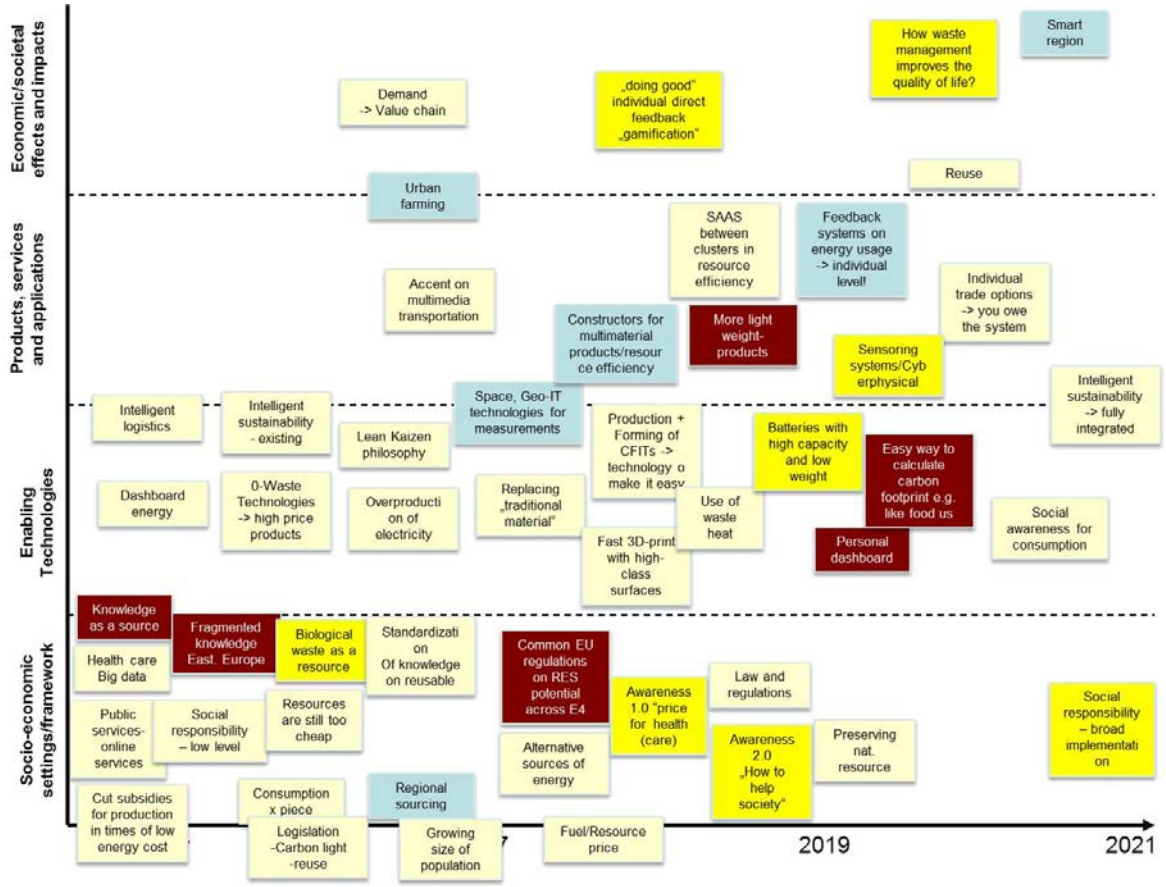
The second pathway – the '**aggregated societal dashboard**' – is marked in blue colour above and could develop out of the individual dashboard of personalised products and services of the first stage. This societal dashboard would aggregate all the personalised dashboards on the individual level with the purpose of creating a basic tool for policy making. The user of the aggregated societal dashboard (i.e. the government) might integrate the whole range of usage of personalised products and services that people manage with their individual dashboards. For instance, health data that was gathered through sensors and self-monitoring in the framework of the individual dashboard could be compiled for the whole society. Using its societal dashboard, a government would be able to adapt its health policies in real time. If, for example, the individual dashboards of people in a certain region indicate unusual body temperatures, the government could conclude that a flu epidemic is on the rise and therefore take measures accordingly, such as increasing vaccination in neighbouring regions. Certainly, privacy issues would arise out of such an aggregated societal dashboard. The connotation of an almighty 'Big Brother' government that would be capable of knowing everything about its citizens comes to mind, when the abilities and functions of an aggregated societal dashboard are described. However, the dashboard could even have much broader implications for people besides the privacy issues. The complete personalisation of products and services as well as – to a certain extent – of governance could entail a feeling of de-personalisation that could have in turn implications for the well being of people as well as on their perception of society, ethics and religion. As the dashboards make communal institutions (such as churches as places of gathering) less relevant, a kind of digital spirituality could emerge out of it. Furthermore, as the individual gains autonomy from its dependence on communities and the society because of the new ability of managing everything (from health to mobility and even production) with a dashboard, people could develop an increased feeling of loneliness. Especially with an ageing population, alienation of the individual from society could develop into a serious problem. Because of these issues, it could be possible that a sort of movement is founded against the aggregation of individual dashboards of personalised products and services.

Finally, looking at the individual and aggregated societal dashboard in which the trend of personalised products and services might unfold, the experts brought up the **hypothesis** of increased importance of clusters in their regional contexts. In their view, the personalisation trend reflects the convergence of global applicability of clusters and smart regions, meaning that clusters gain importance as 'horizontal enablers' of government policy. Instead of only being a subject of regional development policy, those clusters could actively pursue economic policy in domains such as ICT, Healthcare, Biotech and creative industries: Cluster will serve as laboratories and incubators for future policies concerning economic cooperation structures and smart regions.

5.3 Roadmap 'Resource Efficiency'

Resource efficiency is understood here in a rather broad way. It encompasses not only energy and material but also process efficiency.[17] The trend of resource efficiency will unfold along three basic pathways: 'Codify & Spread the Gospel', 'Region is at the Heart' and 'Enable Choice'. The following Figure 25 presents all three pathways in different colours on the roadmap.

Figure 25: Roadmap 'Resource efficiency'



Source: European Cluster Observatory, prepared by VDI/VDE-IT and Technopolis

The first pathway '**Codify & Spread the Gospel**' (path marked in dark red) takes its starting point from a socio-economic context that can be characterised by a fragmentation of knowledge about resource efficiency. There are considerable gaps between the knowledge about fostering a resource efficient way of production and living of people living in different regions in Europe. The gaps concern expertise at individual level, e.g. what is good to do or not do when separating waste, at institutional level, e.g. codified knowledge in standards about measuring energy efficiency, at organisational level, e.g. when a company uses less-efficient production processes, and at national level, where e.g. regulation and legislation can put incentives for resource efficient behaviour into place. To promote a resource efficient way of life knowledge should be 'harvested' and disseminated, which could e.g. be done through the standardisation of knowledge or in common EU regulations. The latter is of particular importance

[17] *The efficient use of resources can e.g. be manifested in the design of administrative procedures, if they are digitalised and virtual rather than material and face-to-face. The efficient design of processes will, in turn, lead to less use of natural, material, or energetic resources.*

for some new member states, as it creates incentives to adjust national, regional and local policy frameworks. Enabling technologies for such a development would by 2019 e.g. be simple technologies to calculate the carbon footprint of a process or a product. In combination with a 'personal dashboard' it could inform citizens, entrepreneurs and managers about the effects of their decision-making. In parallel the market would start providing an increasing number of lightweight products and products made of reusable or recyclable materials. This would, in turn, meet a growing demand for this type of products driven by consumers who increasingly value products and services that can be re-used and are in this sense resource efficient. The time frame for this development is assumed to be five years.

A second pathway – '**Region is at the Heart**' – (pale blue) could develop out of two contextual factors: a trend towards emphasising the region as a source for materials, products and services. Space-based technologies (satellites, remote sensing etc.) – available by 2017 – would support the monitoring, measurement and management of water, land, forest, and agricultural resources would help to increase productivity even in regions with high cost of labour. Moreover, these systems would be used to provide a direct feedback to citizens, as well as management, about the impact of their decisions at home and in organisations respectively. Through a 'personal dashboard' would every individual know about the effects that she causes with her behaviour. This information could be linked to earning 'brownie points' (or miles for that matter), heralding an increasing trend of the 'gamification' of business relations. Traditional material would be replaced by intelligent and lightweight materials. Such a development would meet an increasing demand for urban farming, a phenomenon that addresses the wish for fresh and locally produced produce that is not transported around the globe. Finally, intelligent logistics would make smooth and highly efficient transportation available, connecting the different partners of the value chain. The timeframe for this development was considered to be rather short i.e. in two to three years.

A third pathway, marked in bright yellow, – '**Enable Choice**' – builds on the aforementioned technologies that provide real-time and individualised information about the impact of all buying (and production) decisions. The information transmitted through personal dashboards allows individuals to combine their efforts to lead a resource efficient life with playfulness. By 2017 citizens would be increasingly aware of the price of resources (experts see the price of oil to bounce back to $100 per barrel within the next two years) and conscious of the price of resource inefficiency. The latter exceeds the purely monetary dimension and includes the price for health (care) and safety measures that have to be adapted to balance the effects of a resource-inefficient lifestyle. Alternative sources of energy (e.g. burning waste, which is of particular interest in Eastern Europe, while in Northern Europe some waste incineration facilities require supplies from other countries) combined with high-capacity-low-weight batteries would allow for a wide range of choices among different energy sources. Cyber-physical sensing systems would provide a wealth of data about the value-creation processes by 2019 and allow for individualised feedback about the resource balance of a person's lifestyle. Every individual could have a personal account of resources, granted by the time a person is born, that is diminishing or increasing in dependence of his/her lifestyle. In addition, individuals might be allowed to trade 'brownie points' (or miles for that matter), which would be linked to certain privileges or access to scare resources. This would not only meet with a value of playfulness / gamification mentioned above but also lead to what can be called 'Awareness 2.0': awareness about the resource efficient lifestyle of community, a group of people, a house or a company. 'Personal dashboards' would be complemented by 'community dashboards' that would provide the information for individuals to think about ways to help society to become more resource-efficient.

Looking at the three pathways in which the trend of resource efficiency might unfold, the experts formulated a number of **hypotheses**:

- The trend towards higher resources efficiency is mainly a demand-side driven trend. Changes of the ethical values of consumers and citizens make resource efficiency a factor that companies will not be able to ignore in the future.
- The trend goes hand in glove with a strong regional identity and a care for the wellbeing of the immediate environment in which people live. It is for their region that people are ready to take action, to get involved, to share their creativity (or to pay a premium). It is also regional sources that people tend to trust and where to seek solutions for the issues at hand.
- Codification of knowledge be it through benchmarking, best practice case studies, standards or regulation, will help to spread good practices of resource efficient ways of production and life.
- Especially in the beginning a number of paradoxes will have to be overcome such as the falling oil price (less of an incentive to be resource efficient) and the need for high investments, e.g. in renewable or alternative sources of energy.
- Luxury products and services are likely to play a pivotal role in brining about a more resource efficient lifestyle. The reasons for their importance is that they secure suppliers of resource efficient products and services a higher margin and, thereby, room to experiment, to innovate and to manoeuvre through dire phases until mass markets provide for the necessary scale, as well as the fact that luxury carries an allure for a lifestyle that might later be imitated by other strata.

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Appendix A: Results of the Spin-Glass Community Analysis

Table 23: Result of the Spin Glass social network analysis

ID	Sector	Centrality full graph	Info-map	Spin Glass	Centrality Main Component
1	Advanced Packaging	0.0260571074287911	9	1	0.0260571074287911
2	Aerospace & Defence	0.00193165653723464	4	1	0.00193165653723461
3	Agriculture & Livestock	0.000140611825645133	7	3	0.00014061182564513
4	Biopharma	0.0465007105420381	7	3	0.046500710542038
5	Blue Growth industries	0.0518382163799522	5	2	0.0518382163799519
6	Building/Construction & Engineering	0.556613875469728	5	2	0.556613875469728
7	Chemicals	0.206905708574268	7	2	0.206905708574269
8	Computers & Peripherals	3.93965748467562e-05	9	1	3.93965748467364e-05
9	Construction Materials	0.0017134688185561	4	1	0.00171346881855608
10	Creative industries	0.0404541124003228	4	1	0.040454112400323
11	Digital industries	0.228225334097344	8	1	0.228225334097344
12	E-commerce/B2B	0.0774744654892614	2	1	0.0774744654892615
13	Educational Services	0.00112133757141777	4	1	0.00112133757141776
14	Electronics	0.089904520168754	4	3	0.089904520168754
15	Environmental industries	1	1	2	1
16	Experience industries	0.510543610558549	2	1	0.510543610558549
17	Food & Beverage Retailing	0.00021407353636158	4	1	0.000214073536361563
18	Food and Beverage	0.0011787938173977	5	3	0.00117879381739765
19	Healthcare Equipment & Supplies	0.00264818938298336	7	3	0.00264818938298334
20	Healthcare Providers & Services	0.000234353042741893	7	3	0.000234353042741876
21	Home Furnishings	0.00111747966427572	4	1	0.00111747966427571
22	Household & Personal Products	0.00059578438320416	9	3	0.000595784383204149
23	Logistical Services	0.117154118244418	3	1	0.117154118244418
24	Machinery	0.383261973024145	9	2	0.383261973024145
25	Medical Devices	0.0660669530043743	10	3	0.0660669530043742
26	Metals & Mining	0.226675634192253	4	2	0.226675634192253
27	Mobility Technologies	0.295642834685842	6	1	0.295642834685842
28	Oil & Gas	0.182470800031149	1	2	0.182470800031149

ID	Sector	Centrality full graph	Info-map	Spin Glass	Centrality Main Component
29	Other Consumer Products	0.11937914171143	10	1	0.11937914171143
30	Other Industrials	0.254544369760885	6	2	0.254544369760885
31	Other Materials	0.0995264809618704	9	2	0.0995264809618704
32	Other Real Estate	0.0146662373326183	2	1	0.0146662373326183
33	Other Retailing	0.00156269781010052	4	3	0.00156269781010051
34	Power	0.354049753732549	5	2	0.354049753732549
35	Professional Services	0.64751917341341	3	1	0.647519173413411
36	Telecommunications Equipment	0.00299053029981502	8	1	0.00299053029981501
37	Telecommunications Services	0.0211008909665753	8	1	0.0211008909665752
38	Textiles & Apparel	0.0379088765052841	2	1	0.037908876505284
39	Wireless	0.00184032633834771	8	1	0.00184032633834769

Appendix B: Abbreviations

Table 24: List of used abbreviations

Emerging Industries	Abbreviation
Advanced Packaging	AP
Biopharmaceuticals	BP
Blue Growth Industries	BG
Creative Industries	CI
Digital Industries	DI
Environmental Industries	EnvI
Experience Industries	ExpI
Logistical Services	LS
Medical Devices	MD
Mobility Technologies	MT

For further information, please consult the European Cluster Observatory Website:

http://ec.europa.eu/growth/smes/cluster/observatory/

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