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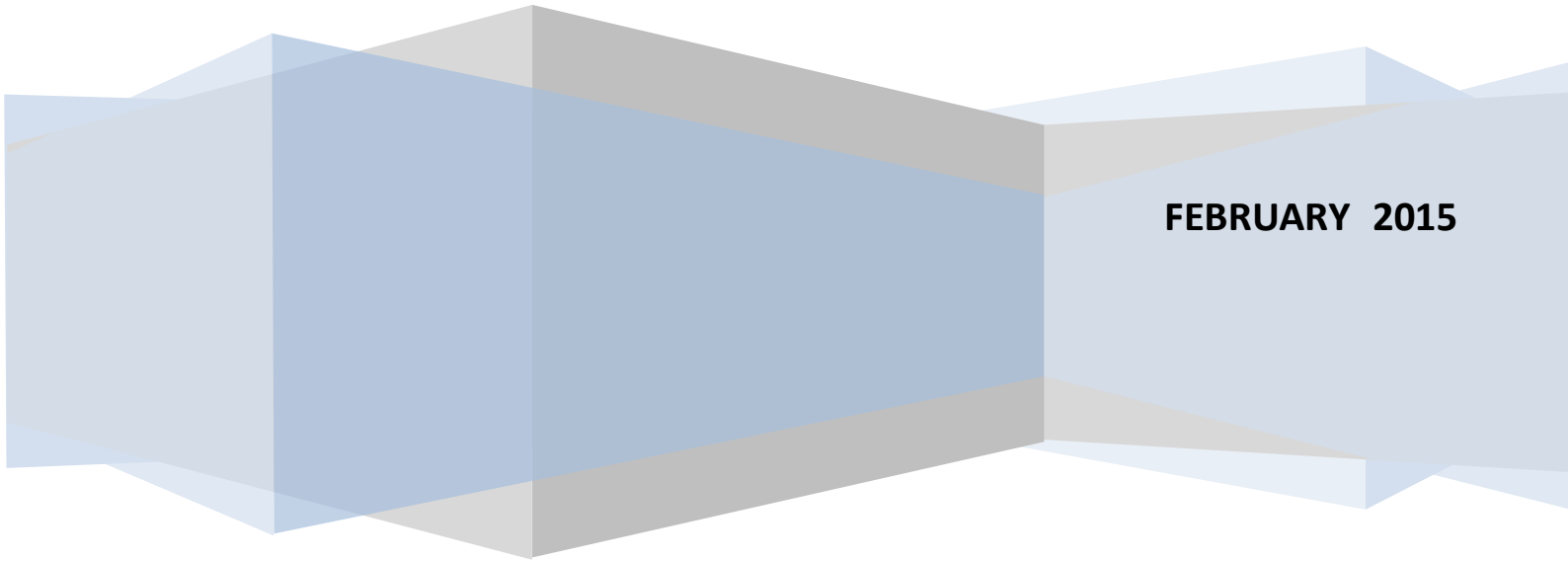
Innovation Clusters' Formation in new "High-Tech" Industries



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Abstract

The purpose of this dissertation is the understanding of new high-tech industry innovation clusters' formation and further strengthening processes. Chapter 2 provides a literature review of cluster related issues, trying to understand the concept of clustering, the factors that are considered to affect cluster emergence and evolution, cluster participants and cluster life cycles. Examples of European innovative clusters in biotechnology and ICT are presented and analyzed in Chapter 3 focusing on successful policies and the characteristics and conditions of each region. A comparative analysis of the results is presented in Chapter 4, along the lines of the literature review in Chapter 2. Finally, in Chapter 5 the conclusions derived from the comparative analysis in Chapter 4 are presented with further research suggestions.

Keywords: *innovation cluster, high-tech industries, cluster policies, cluster's emergence, cluster strengthening process, ICT, biotechnology*

Περίληψη

Ο σκοπός της παρούσας διατριβής είναι η κατανόηση της διαδικασίας της συγκρότησης και ενδυνάμωσης υπαρχόντων καινοτομικών cluster επιχειρήσεων σε high-tech βιομηχανίες. Το κεφάλαιο 2 παρέχει μια βιβλιογραφική ανασκόπηση θεμάτων σχετικών με τα cluster, προσπαθώντας να αναλυθεί η έννοια του cluster,οι παράγοντες που επηρεάζουν την δημιουργία τους όσο και την εξέλιξη τους, καθώς και οι συμμετέχοντες σε αυτά και οι κύκλοι ζωής τους. Στο κεφάλαιο 3 παρουσιάζονται ευρωπαϊκά παραδείγματα καινοτομικών cluster βιοτεχνολογίας και ICT, προσπαθώντας να παρουσιαστούν επιτυχημένες πολιτικές καθώς και τα χαρακτηριστικά και οι συνθήκες των περιοχών που τα φιλοξενούν. Στο κεφάλαιο 4, επιχειρείται η συγκριτική ανάλυση των αποτελεσμάτων, σε συνάρτηση με τη βιβλιογραφική ανασκόπηση του κεφαλαίου 2. Τέλος, στο κεφάλαιο 5 παρουσιάζονται τα συμπεράσματα που προέκυψαν από τη συγκριτική ανάλυση του κεφαλαίου 4 και προτεινόμενα θέματα για περαιτέρω έρευνα.

Λέξεις κλειδιά: *cluster καινοτομίας, high-tech βιομηχανίες, πολιτικές των cluster, δημιουργία cluster, διαδικασίες ενδυνάμωσης cluster, ICT, βιοτεχνολογία*

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Chapter 1: Introduction

1.0 Introduction

Since the mid 90's, an increasing research effort has been devoted to the study of innovation clusters. Scholars from various fields have engaged in constant theoretical, conceptual, methodological or empirical investigations. One key common challenge of these research efforts has been to provide in-depth analyses of the spatial dimensions and mechanisms underlying the clustering phenomena in high-tech sectors such as biotechnology and ICT.

This academic interest in innovation clusters analysis has been encouraged by the rising conviction expressed since the late 90's by many governments and international organizations that national competitiveness in a global economy lie, as Porter (1998) puts it, in *"local things"*. Following this conviction, most governments in developed, emerging or developing countries have engaged in more or less active cluster policies, but with differentiated achievements and success. Along with these policies, national or regional governments and international organizations have supported and funded a large set of academic research in order to enlighten their choices and actions in favor of innovative sectors and regional development and competitiveness (Hamdouch, 2008).

Among the various research issues addressed in the literature, the analysis of the factors (scientific and technological, economic and financial, historical and institutional) underlying the emergence, the structuring and the evolution of innovative activities within clusters appears to be a core topic. In most works, the emphasis is either put on the nature and the intensity of the relationships between the actors involved in innovative activities such as universities and research labs, firms, funding organizations and public institutions or on the relevant spatial scaling of innovation clusters. Innovation clusters locate to specific areas, which is close to urban areas and places of higher education, but also to areas where other high-tech sectors are present.

This dissertation aims to contribute to the research on innovative clusters by analyzing innovation clusters' formation in new high-technology fields such as ICT and biotechnology. Specific issues to be addressed are the role of universities and research institutes, the tools and policy measures that lead to the formation of firms, policies that encourage the spill-over of research results and the institutional arrangements

heartening academia-industry co-operation. The distinct roles and functions performed by different actors within and around clusters are also being identified. The overall aim is to reach conclusions on the determinant factors of cluster development such as institutions, public administration, social and economic factors, path dependencies, innovation policies and also the initial conditions of a region such as educational infrastructure and local availability of financial engineering skills and the region's comparative advantages.

The paper is structured as follows: Chapter 2 provides a literature review of cluster related issues, trying to understand the concept of clustering, the factors that are considered to affect cluster's emergence and their further strengthening processes, cluster's participants and cluster's life cycles. The term cluster policy does not refer only to government actions, since according to the Triple Helix Model industry, academia and financial actors play critical roles. Chapter 3 provides an attempt of analyzing European examples of innovative clusters in biotechnology and ICT, trying to present successful policies and the characteristics and conditions of each region. Finally, Chapter 4 is a comparative analysis of the case studies presented in Chapter 3 and an attempt to better understand the cluster formation process in any case.

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Chapter 2: The Theoretical Approach

2.0 Introduction

The current chapter is an attempt of reviewing the cluster related literature, trying to understand the concept of clustering. The main question that is expected to be answered within this chapter is why clustering has turned into a significant issue for both researchers and policy makers. In order to understand the vague cluster concept the following issues will be analyzed:

Firstly, I will refer to the different cluster's definitions and the factors that are considered to facilitate cluster's emergence. Clustering can lead to significant advantages for firms. The most important of them is the enhancement of knowledge creation that derives from the locational advantages in addition to the increased levels of interrelations and interactions between the cluster's actors. So it is vital to analyze how this process is facilitated within the clustering framework the processes that lead to the creation of a common knowledge base. Then, I will focus on the consisting actors of a cluster and their role in innovative clusters and cluster's life cycles recognizing the interactions of the involved firms and institutions on each level. An issue of great significance is the connection between clusters and innovation and in what ways clusters are used as an innovation tool.

Finally, I will refer to cluster policy by analyzing the different definitions of the term. There will be an attempt of categorizing those cluster policies and the chapter will close with a special reference to European cluster policies as an interesting case of cluster policy creation and implementation.

2.1 Cluster Definitions

Industrial agglomeration is the spatial concentration of industries. It favours accumulation of human capital, productivity enhancements, reduction of transaction costs and spill over effects. Networks can be defined as alliances of organisations and people that work together towards a common goal, characterised by identifiable and stable relations. Clusters combine both dimensions geographic concentration and cooperation and are characterised by spatial proximity, linkages and socially embedded interactions. Clusters are associated with economic benefits which derive by co-locating firms, from vertical linkages in the value chain and horizontal

relationships, and the interaction with education, R&D and other organizations nearby.

Marshall (1920) was one of the first economists dealing with the concept of cluster, observing the formation of industrial districts. Marshall distinguished the importance of industrial localization by examinating English industrial regions of the 19th century. Although Marshall referred to the technological dynamism of those regions, he did not clearly distinguish between localization as a means of reducing production costs under conditions of market uncertainty and localization as a reinforcement of the technological trajectory of an industry. Czamanski and Ablas (1979) refer to clusters as "*a group of industries connected by important flows of goods and services*".

The geographic concentration as key characteristic in the definition of clusters appears later in Redman's(1994) work : "*a cluster is a pronounced geographic concentration of production chains for one product or a range of similar products, as well as linked institutions that influence the competitiveness of these concentrations (e.g. education, infrastructure and research programs)".*

Rosenfeld (1995) strengthened the conception of geographical concentration, identifying a cluster as "*a loose, geographically bounded agglomeration of similar, related firms that together are able to achieve synergy. Firms "self-select" into clusters based on their mutual interdependencies in order to increase economic activity and facilitate business transactions*".

Jacobs and DeMan (1996) based on Porter definitions of the vertical and horizontal industry clusters but expanded them in order to identify key dimensions to define clusters. Those key dimensions include the geographic or spatial clustering of economic activity; horizontal and vertical relationships among industry sectors; use of common technology; the existence of a central actor such as large firm or a research centre, and the quality of the firm network, or firm cooperation. They consider the existence of a central actor as a key feature for a cluster.

Rosenfeld (1997) uses further criteria in his definition including the size of the cluster, the economic or strategic importance of the cluster, the range of products produced or services used, and the use of common inputs. According to Rosenfeld (1997), an industry cluster is "*a geographically bounded concentration of similar, related or complementary businesses, with active channels for business transactions, communications and dialogue that share specialized infrastructure, labor markets and services, and that are faced with common opportunities and threats*". His

definition emphasizes the importance of social interaction and firm cooperation in determining the nature of a cluster and also the importance of specialized infrastructures in the establishment of a cluster.

The most widely used is Porter's definition: "*Clusters are geographically concentrated groups of interconnected companies, specialised suppliers, service providers, firms in related industries, and associated institutions (for example, universities, standards agencies, and trade associations) in particular fields that compete but also cooperate"*(Porter, 1998). Porter defines two types of clusters: vertical clusters and horizontal clusters. Vertical clusters consist of industries connected through buyer-seller relationships, while horizontal clusters include industries in which market, technology and labor force prevail. Geographic proximity emphasizes advantages of industrial clusters but is not a precondition to their identification.

Roelandt and den Hertog (1999) use a different definition: *"Clusters are often cross-sectoral (vertical and/or lateral) networks, made up of dissimilar and complementary firms specializing around a specific link or knowledge base in the value chain*." In that definition the notion of spatial proximity is completely absent. In contrast to Porter, their definition does not view clusters as agglomeration plus interrelations between actors but focuses only on their interrelations in the form of networking. Closely related to the difficulty of defining the cluster notion is the question of its spatial scale. Porter (1998) applies his cluster definition to all spatial scales: "*The geographic scope of a cluster can range from a single city or state to a country or even a network of neighboring countries"*. This vagueness invites a host of criticism (Martin and Sunley 2003).

According to Chiesa and Chiaroni (2005) the key features which play a key role in a cluster are the formal input-output relationships, the buyer-seller linkages, the geographic concentration of firms and the shared specialized infrastructures so their definition of cluster is the following: *"a geographical concentration of actors in vertical and horizontal relationships, showing a clear tendency of co-operating and of sharing their competences, all involved in a localized infrastructure of support".*

2.2 Cluster emergence

Clusters are not created but they tend to form themselves and evolve over time (Maxwell Stamp PLC, 2013). Clusters' evolution is a path-dependent process. It is often triggered by chance events or by a mixture of planning and chance. The availability of raw materials, particular soil or climatic conditions, the proximity to nearby markets and the know-how and experience in a particular area are other initial conditions for clusters' emergence. An example of the role of chance events in cluster evolution is the Swiss watch industry. According to Bumbacher (1995) its emergence was mostly influenced by Calvinist edicts against luxury and "*useless"* jewelry; the flight of Protestant Huguenots from prosecution in other European countries to Switzerland and the specialization of jewelers among them on watches.

Krugman (1991) demonstrates the role of chance in the case of the carpet manufacturing cluster of Dalton, Georgia, which began as a wedding gift that reintroduced a method uncommon at that time. Feldman (2001) regards cuts in public employment in the region around Washington D.C. as an important factor of the establishment of new enterprises in biotechnology and ICT. Even Silicon Valley, although influenced by the vision of Stanford University's manufacturing dean was formed by chance events. William Shockley's decision to found the semiconductor manufacturer Shockley Transistor in Palo Alto after returning from New Jersey may have been due to his familial ties within the region. These ties may have complemented Terman's encouragement for Shockley to settle there (Lécuyer, 2000).

However, chance events could occur in any region. Thus they cannot explain why some regions develop into clusters while others do not. Chance events, and sometimes also foresighted planning, can act as triggers for a path-dependent process that leads to the development of a cluster. Glückler (2007) defines path-dependence as "*a concept of cumulative causation in which a certain sequence of events creates unequal propensities for future events. Though path-dependent change allows for inferences from a present on future states of development, it is subject to contingency*." This means that the precise sequence of events leads to a certain regional trajectory that can result in a cluster.

Storper and Walker (1989) suggest that industries shape their environments instead of using them as given. In their words, *"the basic patterns of industry location and regional growth can be produced by processes endogenous to capitalist*

industrialization, rather than by the exogenous placement of resources and consumers. Industrial location patterns are created through the process of growth rather than through a process of efficient allocation of plants across a static economic landscape. That is, industries produce economic space rather than being hostage to the pre-existing spatial distribution of supplies and buyers". This model tries to explain why clusters of new industries emerge in locations distant from established industrial core regions, such as the case of the semiconductor industry Silicon Valley. However, while increasing returns lead to a path-dependent growth process of those locations that develop into clusters in the clustering phase, the model does not directly explain processes that lead to increasing returns. Thus it cannot predict which locations grow into clusters (Markusen, 1996).

The concept of regional branching (Frenken and Boschma, 2007) introduces product diversification as an explanation for localization. Diversification into new activities leads to regional branching when new industries come out of old ones or emerge through a recombination of existing industries' competences. Boschma and Frenken (2007) argue that "*when firms diversify (but not many will do so because of the risks involved), they will show a higher propensity to diversify into technologically related instead of unrelated industries, because of the firm-specific routines they have built over the years (e.g. reducing switching costs), and because of the opportunities the regional environment provides*." While companies tend to prefer diversification through innovation, radical innovations are more likely to be pursued through labor mobility and spin-off creation. Their commercialization can be started somewhere else because does not necessarily require the use of existing routines. Thus, the more radical an innovation is, the more open is the window of locational opportunity (Frenken and Boschma, 2007).

2.3 Cluster benefits

Clustering can lead to important advantages for firms. They can take advantage of the strong demand in the location, the large supply of high qualified and specialized manpower and the network of complementary strengths in neighboring firms. In high technology industries, geographical proximity plays a significant role in the early

stages of the life cycle of a product or technology, facilitating the use and transfer of tacit knowledge that is a key to successful development (Chiesa and Chiaroni, 2005).

Marshall (1920) stated two reasons together with technological spillover effects as the main advantages of clustering. A specialized labor force attracts both employers and workers to locate in the cluster, as co-location can alleviate the consequences of business cycles and thus reduce the risk of not finding labor or employment. If companies are not completely affected by business cycles, workers who lost their jobs during a cyclical downturn have a greater chance of finding employment somewhere else in the cluster. In contrast, during a cyclical upturn, employers have a better chance to find workers within the localized labor force (Krugman, 1991; Bathelt and Glückler, 2003). Specialized suppliers have an incentive to locate in a cluster if they encounter internal economies of scale in their own production process. Then they can capture the benefits of being close to the market and concentrating their production capacities at the same time by locating their entire production in the cluster (Krugman, 1991; Bathelt and Glückler, 2003).

Porter (1998) identifies three kinds of advantages in clustering:

1) Productivity advantages: due to the use of better and cheaper components and services. These come from minimal inventory requirements and lower transaction costs as for the low distance and for the establishment of high trust relations between companies within a cluster. Furthermore, mutual purchasing services or shared infrastructures may reduce fixed costs for existing companies and initial investments for new ventures.

2) *Innovation advantages*: proximity between customers and suppliers favors the transfer of tacit knowledge. Moreover, the proximity to knowledge centers offers a strong prospective of innovation, allowing critical mass to be gained, particularly for pre-competitive activities such as basic research. Finally, localized benchmarking among actors in the cluster and the availability of a qualified labor market can improve innovation capacity.

3) *New business advantages*: due to better transmission of information about market opportunities and potential, barriers and risks for new firms can be lower for the clear perception of unfilled needs.

Another analysis on the clustering phenomenon is presented by Swann et al (1998) in their book "*The dynamics of Industrial Clustering"*. The authors analyze both

advantages and disadvantages of clusters, assuming two perspectives: demand side and supply side. Table 1 shows the results of their analysis.

As far as the demand side is concerned the main advantages are the following:

• I*nput-output multipliers*: firms located in the same geographic area take advantage by a strong local demand and stimulate induced activities such as dedicated suppliers or services as well as the demand by other areas, thus creating a virtuous circle that sustains the cluster growth;

• *Hotelling*: the term refers to the theory by Harold Hotelling (1929) concerning spatial competition. His empirical evidence shows that the location of a new firm within a cluster allows increasing its market share thanks to the existence of incumbents;

	Demand Side	**Supply Side**
Advantages	• Input-output multipliers	• Technology spillovers
	• Hotelling	• Specialized labor
	• Search costs	• Infrastructures
	• Information externalities	
Disadvantages	•Congestion and competition in output markets	• Congestion and competition in input markets

Table 1: Advantages and disadvantages in clustering (source: Swann et al., 1998).

• *Search costs*: the existence of a firm in a cluster may increase its visibility to existent and potential customers allowing them to reduce searching costs;

• *Information externalities*: informal relationships favored by co-location may increase the transfer of tacit knowledge between people working in a cluster.

As far as the major disadvantages are concerned:

• *Congestion and competition in output markets*: a larger number of competitors in the same geographic area may reduce, according to microeconomic theories, per-firm sales, prices, profits and growth. These effects, however, actually start to dominate demand side advantages when congestion becomes intense, suggesting that there may be diminishing or even negative returns to locating in a cluster as it reaches its maturity phase.

On the supply side, major advantages are:

• *Technology spillovers*: from extensive transfer of tacit technology

• *Specialized labor*: the presence of high qualified labor within a cluster is mainly affected by two processes: the ability to generate resources "internally" favored by a strong scientific base and the ability to attract people from other geographic areas related to the visibility of the cluster itself and to the area attractiveness.

• *Infrastructures*: the opportunity to share common facilities, which according to Porter reduces costs for firms within a cluster.

Disadvantages refer to congestion and competition in input markets, whether it may be the cost of real estate or the cost of labor. Both contributions look at clustering as a *"spontaneous phenomenon".* Possible actions by public actors to increase perceived advantages or to reduce disadvantages are not taken into account.

Ketels (2003) summarizes clusters' benefits into four points.

1) Cluster is a critical engine in the overall economic make-up of a region or a country. Affecting the ability of the region to be more productive and innovative has many benefits for the economy at large.
2) Cluster is a more effective way to implement microeconomic policy. Firm-level interventions are too costly and tend to distort competition. On the contrary, policies directed at broad sectors or the whole economy will tend to have little effect and miss the levers critical for a specific cluster.
3) Cluster can help to find challenges in the business environment affecting the whole economy, and they can be the testing ground for specific remedies addressing them. The economy-wide perspective often is less effective in reaching level of granularity needed to achieve improvements in microeconomic factors.
4) Cluster can help both private and public sector to adopt a new approach of economic policy making, characterized by collaboration and joint action among a broad set of players.

2.4 Cluster Life Cycles

According to Lord Sainsbury (1999) cluster is dynamic and can be described as a cyclical process of four stages (figure 1)

Figure 1: Cluster Life Cycle (Source: Lord Sainsbury, 1999)

Embryonic: Cluster is on the early stage of growth. It is characterized by many new firms, rapid growth and frequent changes in firms and products. The emphasis at this stage is the creation and diffusion of knowledge.

Established: Cluster grows steadily and can facilitate further growth. This stage of the life cycle is characterized by the transformation of knowledge into products and processes.

Mature: Cluster's structure is stable. It is characterized by fewer new firms, slower development and fewer changes in products or services.

Declining: Cluster has reached its top and now is falling down. Sometimes the cluster can renovate and have a second-round cycle process. Cluster characteristics are declining employment growth, more firm deaths than firm births and few or none changes in products or services.

Sölvell (2009) uses the next figure (figure 2) to describe cluster life cycle

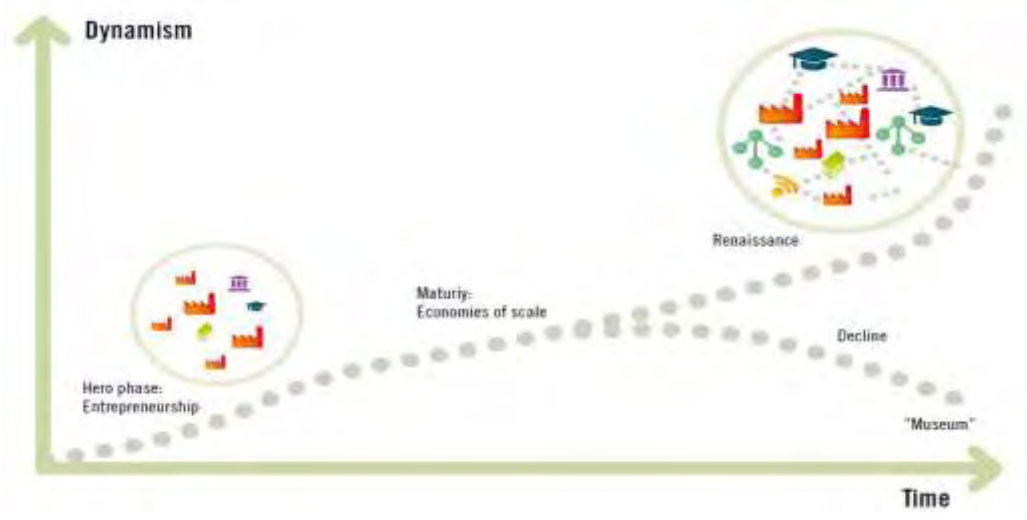

Figure 2: Cluster Life Cycle (Source: "*Clusters Balancing Evolutionary and Constructive Forces*", Sölvell, 2009)

Hero phase: It is the emergence of the cluster. Typical seeds of clusters include natural advantages such as ore deposits, transportation routes and climate or some particular demand or skill within the region. Another cluster seed is an entrepreneur who starts a particular industrial activity in a particular location. If the new venture is successful, with factor advantages supporting the business idea, a cluster can begin to grow and prosper. Some clusters will immediately take off and grow and others will remain small or disappear.

Maturity: Growing clusters enter into a process of international competition in both factor markets (attractiveness on new companies, people and capital) and final goods markets. The more successful clusters are built on a combination of superior internal dynamics; including rivalry and intensive new firm formation, and superior attraction on resources from the outside. Cluster growth takes place within a particular political setting. Regulations and political actions range from antitrust, regional policies, industry policies, and science and innovation policies, including patents. Those policies affect the overall attractiveness of a region to both people and companies.

Renaissance/Decline: Some clusters go into decline. This is because of excessive concentration, heavy government involvement, subsidizing companies, radical technological shifts coming from other regions, radical shifts in demand at other locations or war and other extreme circumstances. On the contrary there are some clusters which jump onto a new cycle and experience a renaissance based on new technologies and new firms.

2.5 Cluster participants

A cluster may consist of five different sets of actors, including firms, government, academia, intermediate institutions for collaboration (IFCs) and financial institutions (figure 3)

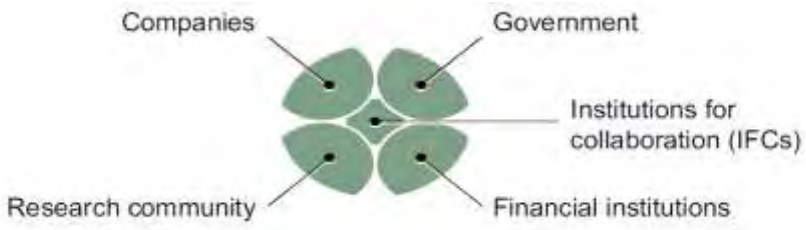

Figure 3: Cluster Participants
(Source: "*The Custer Initiative Green Book*", Sölvell, 2003)

Financial institutions: traditional banks, commercial banks, venture capital, private equity and angel networks.

Firms: large firms and SMEs. Private industry includes competitors, suppliers of goods and services, buyers, and firms in related technologies sharing common factors, such as labor skills or technologies.

Figure 4: Cluster Participants (Source: "*The Custer Initiative Green Book*", Sölvell, 2003)

Government:

- National ministries and agencies involved in:
    - Industry and economic development policy (e.g. SMEs, entrepreneurship, networking, cluster and investment attraction)
    - Regional policy (e.g. readjustment funds, infrastructure and cluster programs)
    - Science and technology policy (innovation, incubator, university-industry cooperation and technology transfer and technology cluster)
- Regional agencies and regional units of national bodies such as county administrative boards and regional public bodies based on federative initiatives from local communities.
- Local communities

Academia: universities and colleges, research institutes, technology transfer offices and science parks.

Private and public-private organizations for collaboration: NGOs, chambers of commerce, formal networks, cluster organizations

Sölvell (2009) considers media the sixth participant of a cluster. Media help into building a regional brand (figure 4)

2.6 Clusters and innovation

Over the last two decades, the connection between innovation and economic growth has caught the attention of many scholars. Porter (1990) argues that innovation activities will be improved in a cluster environment with firms and supporting institutions of the same field agglomerating in a particular place. Innovation is a process through which economic or social value is extracted from knowledge—through the creation, diffusion and transformation of ideas—to produce new or significantly improved products. There are two main sources of innovation: the scientific community and entrepreneurs. Both scientific world and entrepreneurs generate new knowledge, ideas and concepts. But this is only the first side of the coin. The other side is about bringing the new product into use and creation of commercial value. The size of an innovation is not depending on the idea but on how widely it is coming into use. So there are two sides to the coin, developing a new idea, product or service and bringing it to the market. Clusters are important mainly to the second half (Lindqvist & Sölvell, 2011). In their words: *"Clusters offer complementary skills, sophisticated users, access to education and research, and financial capital prepared to finance new ventures. Clusters offer the soil where ideas are turned into successful commercial service and products; clusters offer a soil for innovation".*

Figure 5: Clusters and innovation (Source: "*Clusnet Final Report*", Lindqvist & Sölvell, 2011)

According to Freeman (1991) innovation is based on a process of incremental reduction of technical and economic uncertainty, where new technologies typically

undergo a number of modifications models are adjusted accordingly. New particular knowledge and skills and business develop over time. Proximity favours such an evolutionary process. Tacit knowledge is based on personal skills and operational procedures. Innovation is based on a process of continuous interaction across organizations, building ties, specialized language, and social capital within the region. This process of exchange and creation of new knowledge is enhanced by face-to-face contacts. Some studies indicate that informal and oral information sources provide most key communications about the market opportunities and technological possibilities that lead to innovation. According to Utterback (1974), the unexpected, or unplanned, personal encounters often turn out to be most valuable. The costs and time associated with repeated exchange of knowledge and information in the development work will be lowered if taking place in the local context. Frequent interaction between buyers and suppliers involve sensitive information, and therefore require a high level of trust between the parties (Ludvall, 1992).

Some innovations are partly the outcome of a process of transferring technology and tacit skills through university education, apprenticeship training, specialized technology transfer offices and incubators, and regional public-private organizations that focus on networking and commercializing new discoveries. Proximity favours such transfers and co-learning, as research, technology and innovation are all involved simultaneously (Freeman, 1982).

Innovation is enhanced in environments where different resources can be rearranged at low cost, through mobility of skilled personnel and licensing. Various forms of product and technology sharing or sourcing also facilitate rearrangement of critical resources. Innovations do not find use where they first emerge, but only after migration will they find the right soil, a process that is highly influenced by information distance and density of networks. Clusters favour mobility of small streams with high transaction costs, while large flows of standardized information, materials, components and products are traded globally (Scott, 1998).

All of this can potentially take place at a global scale. However, innovation processes seem productive within proximate and networked environment surrounded by a common set of institutions and particular cultural and historical norms for reasons of efficiency, flexibility and openness, built on trust and social capital. Linkages can include joint R&D projects, joint product development, or the sharing of technology through licensing involving fees and patent transfers. These linkages can develop

between similar types of organizations such as firm to firm, or between different types of cluster actors such as public research organizations and firms.

2.6.1 Knowledge in innovation clusters

Knowledge flows are a critical element for identifying clusters (Wolfe and Gertler, 2004). Knowledge flows help to identify the interrelations among the actors of a cluster. Maskell has proposed a knowledge-based theory of the cluster suggesting that the main reason for the emergence of clusters is enhanced knowledge creation. Clusters gather extensive market, technical and competitive information, thereby enabling complete access to it by cluster members. Personal relationships and community ties foster trust and facilitate the flow of information among firms, making information more transferable within the cluster (Porter, 1998). Firms need to tap into knowledge flows that connect them to both the local community and the global context. Bathelt, Malmberg, and Maskell (2004) refer to these channels as local buzz and global pipelines.

According to Porter (1998) the competitive advantage for firms increasingly comes from access to knowledge. As a result, the new source of competitive advantage for regions may be linked more to their ability to capitalize on knowledge resources than on access to physical resources. For resource-based industries, in particular, this creates new challenges. Because of the necessity to locate near the resources, they must find ways to attract highly skilled labor and knowledge workers.

The key components of innovation framework are presented in figure 6:

Creation: Generating new knowledge or improving existing knowledge through activities such as researching, inventing and designing.

Diffusion: Sharing knowledge through activities including mentoring, networking, collaborating, training and publishing. Diffusion plays an important role in clusters contributing in their success or failure. It is often related to the concept of social capital. It involves trust, norms and reliable networks that have the capacity to accept new members—all factors that are generally considered to help keep the binding networks of clusters together (Fountain,1997).

Transformation: Developing new or improved products and processes and transforming knowledge through activities such as prototyping, testing, customizing, producing, and assembling.

Use: Implementing new or improved products or processes including activities such as selling, buying, installing and operating.

Value: Creating or enhancing economic or social value; improving organizational performance; improving profit, rising revenue, increasing productivity, increasing GDP, enhancing health outcomes and reducing environmental emissions. Value it is at the centre of the framework. Increased value is the result of successful interaction among all aspects of the framework. The creation of social and economic value also feeds back into the innovation environment itself, which then affects the ability of each of the other components of the system to function, both independently and co-operatively.

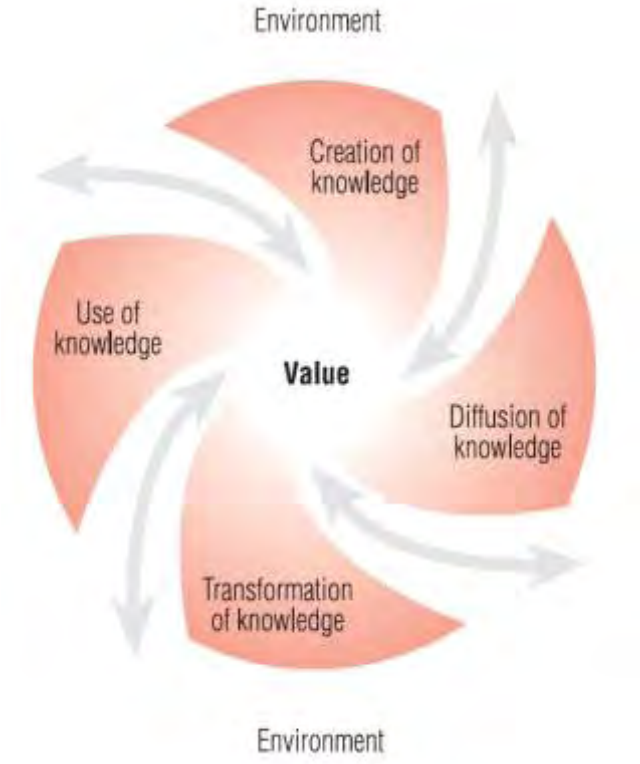

Figure 6: Innovation framework (Source: The Conference Board of Canada, Munn-Venn and Voyer, 2004)

Environment: Facilitating the overarching conditions that influence innovation; aligning inputs (environmental conditions include leadership, management, culture, brand recognition, entrepreneurship, governance, regulations, taxation, infrastructure, communication systems, market forces and the availability of skilled workers).

2.6.2 Triple Helix Model

Triple Helix refers to a spiral model of innovation, which is opposite to the linear model that captures multiple mutual relationships among institutional settings (public, private and academic) at different stages in the capitalization of knowledge (Rosselli, 2005). These three institutional spheres which formerly operated at arms' length in liberal capitalist societies are increasingly working together, with a spiral pattern of linkages emerging at various stages of the innovation process (Rosselli, 2005). The actors, according to roles and models of action which involve various and varied cultures, can be separated and belonging to the three systems: education system, economic system and political system. Innovation can be brought out by the collaboration between each actor.

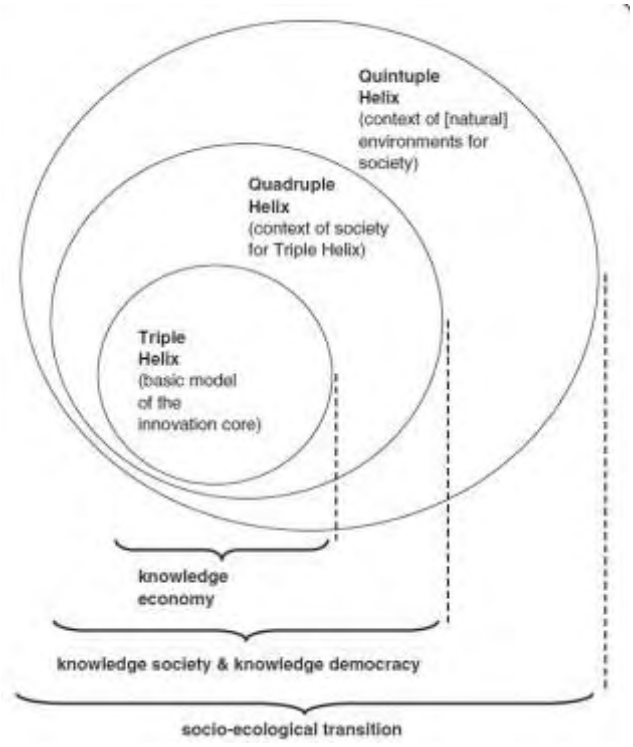

Figure 6: Knowledge production and innovation. (Source Campbell and Carayannis, 2012)

The education system: It consists of academia, universities, higher education systems and schools. In this helix, the required human capital (students, teachers, scientists, researchers and academic entrepreneurs) of a state is created by the diffusion and the research of knowledge.

The economic system: It consists of industries, firms, services and banks. This helix concentrates the economic capital (entrepreneurship, machines, products, technology and money) of a state.

The political system: It is one of the most important helix of the model because it formulates the 'will' of the state by defining, organizing as well as administering the general conditions of the state. Consequently, this helix has a political and legal capital (ideas, laws, plans, and politicians).

2.6.3 The role of government in innovative clusters

The role of government is very significant in cluster process. Governments take action both to foster new clusters and to strengthen existing ones. Moreover, governments ensure that the fundamental infrastructure, including the institutional and regulatory conditions required for the evolvement of new clusters as well as for the development of existing ones, are in place. Governments can help to provide the business, innovative and institutional environments vital for cluster success. The key role for government is that of enabling – whether in the form of providing direct access to finance or in less direct ways through the creation of enabling policy frameworks, strategic action plans and trained, motivated public service employees. *"Government should have a high-profile role in the initial stages, such as guiding the cluster mapping process and in the final stages, such as leading public-private dialogue on policy and institutional bottlenecks that inhibit industry development and the business development*" (World Bank, 2009).

Ketels (2011) uses the next table (table 2) to summarize the role of government in clusters.

Government should	Government may	Government should not
Support all existing and emerging clusters	Initiate/convene	Pick favored clusters
Participate	Co-finance	Pick favored companies
Enable data collection and dissemination at the cluster level		Subsidize or distort competition
Be ready to implement recommendations		Define cluster action priorities

Table 2: The government's role in clusters (Source: Ketels, 2011)

The most important resource for knowledge-based clusters is a highly educated workforce. Governments support the development of skilled labor by investing in education and training. Governments also invest in knowledge infrastructure through the growth in size and capability of institutions and R&D laboratories and through the creation of science centers. Those centers are associated with educational institutions or they operate independently and they stimulate innovation and facilitate technology transfer. Furthermore, governments promote the use of incubators. Incubators are instruments for supporting new and small business enterprises by providing low-cost shared space and services combined with technical assistance. Limiting tenants to potential cluster members justifies more highly specialized services and assistance,

promotes inter-firm business within the incubator and encourages learning and technology transfer among firms.

Clusters rely on knowledge flows among a cross-section of players from industry, academia and government, so government is an integral part of networking- a social phenomenon of personal interactions that moves and spreads ideas, information and best practices throughout a cluster and imports them from other locations. Finally, governments set up appropriate financing mechanisms and they ensure minimum bureaucratic regulations and impediments to access these funds.

2.6.4 The role of industry in innovative clusters

As mentioned before, innovation refers to the effort to commercialize new ideas. In the case of innovation by firms, an often-used definition of innovation is *"the processes by which firms master and turn into practice product design and manufacturing processes that are new to them, whether or not they are new to the universe*" (Nelson and Rosenberg, 1993). Firms in clusters are involved in processes of technological, commercial and organizational change. They are the centre of cluster actions and policies. They are characterized by direct involvement in technical, business and market processes, and possess outstanding practical capabilities (Andersson et al, 2004). Under the right conditions, the individual firm plays an active role in improving the competitive environment, through communication of needs and desires to the local research and education system. Firms dynamically participate in cluster activities to identify issues of common concern and opportunities for mutual gain (Porter, 2001).

Large firms have greater capability to carry fixed costs and as a result they offer stronger analytical competencies than SMEs. Still, large firms have greater bargaining power in inter-firm relations. SMEs tend to be more flexible and niche-oriented. This enables them to provide specific knowledge and quicker reactions to market demands, helping the cluster to be more responsive (Andersson et al, 2004).

Many successful clusters have at least one large firm operating as an anchor company. Such firms tend to support cluster development by acting as magnets for other major companies (Porter, 2001). Large firms can build a critical mass of experienced managers and workers, provide a customer and supplier base, and have a multiplier

effect in terms of a region's local economy for materials and services (Ecotec, 2003). For example, much of Silicon Valley's success came from the organic entrepreneurship of past co-workers at Fairchild Semiconductors who formed their own firms and compete against each other, while at the same time co-operating on occasions.

Many innovations derive from existing firms and serve to improve efficiency in business and production routines. Yet, some do not fit the core business of existing firms. Schumpeter (1934) points out the role of entrepreneurship for *"breaking the circular flow*" and disturbing the current equilibrium. Entrepreneurs, vital for exploring alternative commercialization routes, can exploit existing technology that flows from R&D results in established firms or from universities, and establish new firms through start-ups. The inherent qualities of entrepreneurs are needed to boost the dynamics of innovative clusters, although they depend on complementary actors and functions. Spin-offs may or may not be promoted by the established firms. Firms may perceive benefits from testing untried possible opportunities and the emergence of potential future partners, but also fear the loss of competence and the emergence of future competitors. Some new firms take the form of joint ventures and may be partly supported, and controlled, by established firms.

2.6.5 The role of academia in innovative clusters

Academia which includes universities, public labs and research institutes, is generally characterized by in-depth knowledge and analytical competencies along with independence and specialized communication skills (Andersson et al, 2004). For that reason, academia has a supportive role throughout the clustering process by analyzing the cluster policy's strategic direction and actions, by driving actions especially in the areas of innovation and network creation and by facilitating trust and building social capital. Social capital is defined by the OECD as "*networks together with shared norms, values and understandings that facilitate co-operation within or among groups"*. The contribution of social capital to innovation is achieved by reducing transaction costs between firms and between firms and other actors, notably search and information costs, bargaining and decision costs, policing and enforcement costs (Maskell, 1999) Academia can also play a role in the continuous evaluation of

objectives and actions. Academia's contribution is also crucial for reaching the accumulation of a critical mass through the attraction of skilled labor to the region (Andersson et al, 2004).

Universities except for their historical missions, education and research, have a third one, namely to defuse technology and participate in economic and social development. Universities provide the motivation for new thinking. Moreover universities are major employers, technology providers, and a source of knowledge and skills in the region. University people and ideas are at the heart of many of the companies in a cluster, whether the company is based on university research (spin-off), or founded by a member of the university (start-up). Universities also contribute to the growth of the cluster by providing solutions to business problems through consultancy activity and through the licensing of discoveries to new and existing companies.

Universities act as "antennas" for adapting external knowledge. External knowledge is important for generating new knowledge and innovations. Universities hold a key function in this respect being inserted in global knowledge communities and networks such as conferences, workshops, research collaborations, co-publication, co-patenting etc.

Universities are source of highly skilled labor. High skilled labor is one of the key factors for the development of high technology clusters. Universities have become important knowledge sources and innovation partners for industry there is an increasing variety of relationships: R&D contracts, R&D collaborations, innovation partnerships, joint use of facilities, informal knowledge exchange. Except for a simple knowledge transfer universities offer knowledge sharing and interaction. Links between universities and industry are clearly more important in knowledge based industries and clusters.

2.6.6 The role of financial actors in innovative clusters

Although currently-available data identifies government and industry as the main sources of financing for cluster initiatives (Sölvell, 20003), their evolution has increased the need for financial actors to be involved. A significant component of the formulation of a knowledge-based innovation strategy is the invention of the venture

capital firm, which mission is to provide early stage financing and business advice to academic inventors. Financial actors are not likely to launch a cluster initiative but they support the internal dynamics of the cluster. They have an important role in ensuring that great ideas are spotted, encouraged, financed and delivered efficiently to the market.

Providing seed finance, helping in the initial stages of spin-offs, coordinating the set-up of special funds targeted to the specific needs of the cluster are all actions that can be launched and coordinated by financial actors. These are, in fact, well placed to provide input and judgments on which ideas and innovations deserve the support and attention, and could make it the whole way towards market introduction. There are different types of financial actors such as banks, insurance companies, public pension funds, investment funds, business angels and venture capitalists. Institutional investors such as pension funds, banks, and insurance companies, may operate through various intermediaries, with some funds diverted to venture capital. Venture capitalists on the other hand, are specialized in exposure to risk and in resolving principal agent problems. Venture capitalists generally assume active ownership in high-risk ventures. Venture capital funds often contribute funding rose from both private and public sources. Furthermore, they can play a vital role in providing the actors in a cluster with competencies that are in short supply.

2.7 Cluster Policies

2.7.1 What is cluster policy?

Sölvell (2003) defines cluster initiatives as *"organized efforts to increase growth and competitiveness of clusters within a region involving cluster firms, government and research community"*.Ketels (2009) defines cluster policy as '"*all efforts by governments, alone or in a collaborative effort with companies, universities, and others, that are directed at clusters to develop their competitiveness".* However, Andersson et al (2004) regard cluster policies *"narrower*" than cluster initiatives because the latter include measures undertaken by different kinds of actors beyond the public sphere.

Cluster policies have been widely used since their emergence in the early 1990s and they were applied in developed and developing countries and also in economies in transition (Ketels, 2006). Policies to create or support clusters try to capture the cluster benefits including knowledge spillovers, skills and tacit knowledge through labor pools, supply chains, and other public goods effects -including social capital and reputation. Some cluster policies are planned to gain the attention of, and to improve the conditions for foreign direct investment.

Cluster policies are promoted by different levels of government: supra-national (like the European Union), national, regional and local. Which level should apply what policy is determined by a number of factors, such as the footprint of the expected positive spillovers of the clusters to be supported, the available resources and instruments and the ability to design and implement such policy (OECD, 2010). Cluster policy is a combination of separate trends in more traditional policies such as industrial policy, regional policy and innovation policy and it is difficult to be isolated from other policy areas (Nauwelaers, 2003).

Within industrial policy, interest in clusters has to be transferred from a narrow set of industries, actors and infant industries, to the support of broader key sectors as key drivers of competitiveness, networks of SMEs, the restructuring and upgrade of declining sectors, and the promotion of inward investment (OECD, 2007). An increased interest in clusters has also been the result of an evolution in the characteristics of technology policy, particularly the influence of ideas around systems of innovation and the triple helix model (Etzkowitz and Leydesdorff, 2000) and a shift from supporting individual R&D projects towards addressing systems and networks of innovation (Smits, 2004).Finally, within regional policy the use of cluster policies has been related to the idea of the *'innovation paradox'* mostly affecting the lagging regions (Oughton et al, 2002).

According to OECD (2010), the cluster policy approach may take several forms: a *"light"* form through an intermediation/facilitation role to connect regional and local actors to support clustering; re-orientation of a number of policies towards prioritized clusters and supporting clusters through dedicated projects or addressing framework conditions most vital to the prioritized clusters.

Cluster promoting policies have typically an implied justification in addressing market, system and public failures. Market failures are associated with inadequate investment in knowledge and technology due to the presence of externalities,

information asymmetries or network effects. Innovation comes from the interaction between the different actors and failures therefore come when the connections between actors are poor or not sufficiently conducive to knowledge generation. Similarly, cluster policies may also be justified with perceived governmental failures, such as institutional lag in certain regions or poor performance of current programs.

2.7.2 Cluster policies categories

Cluster policies are divided into three categories (Terstriep, 2008):

- Cluster development policies directed at creating, mobilizing, or strengthening a particular cluster
- Cluster leveraging policies that use a cluster lens to increase the efficiency of a specific instrument
- Cluster facilitating policies directed the elements of the microeconomic business environment to increase the likelihood of clusters to emerge

Andersson et al (2004) divide cluster policies into five categories:

- Broker policies aiming at strengthening the framework for dialogue and cooperation by the various related stakeholders involved in clusters, and not favor individual players.
- Demand side policies directed at increasing openness to new ideas and innovative solutions.
- Training policies targeting at upgrading skills and competencies which are necessary for successful clustering of SMEs.
- Measures for the promotion of international linkages through the increasing of interaction between foreign and domestic actors.
- Framework policies which include macroeconomic stability; well-functioning product markets; factor markets such as labor and financial markets; education systems; physical, institutional and judicial infrastructure, including a governance system that is able to maintain effective and steady playing rules for innovation; the existence of proper communications and transport infrastructure. Social capital and attitudes that influence trust in transactions may also be included.

Sölvell (2013) uses the next figure (figure 7) to describe two policy categories. The first one tries to have an impact on economic geography and the emergence of clusters directly by creating incentives- from tax rebates to free infrastructure- for companies to co-locate in order to create more externalities. That kind of policies are based to the hypothesis that as agglomeration rises, competitiveness will naturally follow as cluster effects set in (Ketels, 2009). However they have to intervene early and massively to form an emerging economic geography profile and they also have to discourage competition between locations. The second policy category tries to leverage the existing clusters and organize knowledge sharing and joint action. The main idea is to internalize the existing externalities and promote activities that make better use of the potential from co-location. As competitiveness rises, agglomeration will naturally increase as the cluster becomes more attractive for new entrants (Rodriguez-Clare, 2005). That kind of policies concern clusters that have developed naturally and have worked consistently over time and clusters with modest resources. Moreover, they concern clusters that they have passed the early stages of development (Rodriguez-Clare, 2005). They include actions for better use of existing government programs rather than distributing new funds, and actions that encourage specialization linkages and competition across locations.

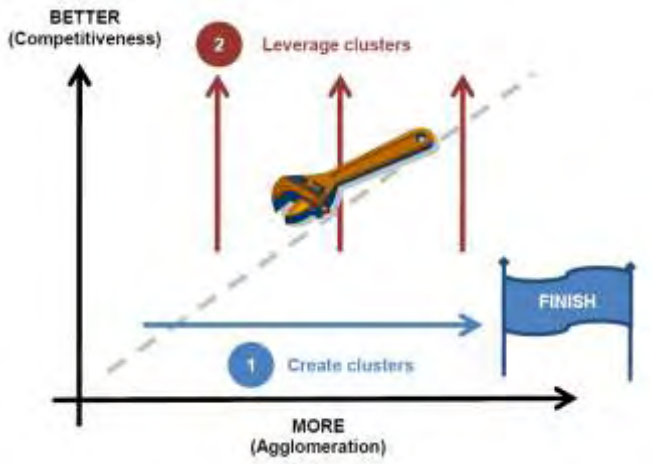

Figure 7: Two perspectives of cluster policies (Source*: "The Cluster Initiative Green Book 2.0"*, Sölvell, 2013)

2.7.3 Cluster Policy in Europe

Europe is an interesting case because policy makers have been most active in creating cluster programs (Sölvell, 2013). The European Competitiveness Council has identified clusters as one of the nine priorities to strengthen European innovation. European countries and regions have launched a wide range of cluster initiatives. Moreover, the European Commission operates many policies that affect cluster

development. Cluster policies are efforts of strengthening existing clusters and helping new clusters to emerge.

Clusters usually develop in competitive markets. A successful cluster policy can help cluster's emergence and also enable regional economies to leverage their entire economic potential. Still, there must be a further removal of barriers to trade and development that will lead to more competitive clusters and a stronger collaboration between companies, government, research institutions and financial institutions. Finally, Europe needs stronger trans-national cooperation between clusters.

Cluster policy requires action at three levels. The first level includes executing agencies for the implementation of cluster policies at national, regional and local level. Those agencies should support the emergence and growth of dynamic innovative clusters; apply evidence-based strategies; define which cluster- specific strategy is more appropriate for the unique needs of regional clusters; strengthen the trans-national cooperation between clusters; create business linkages; evaluate cluster initiatives and strengthen cooperation between cluster initiatives and their participants (Maxwell Stamp PLC, 2013).

The second level includes ministries and regional authorities responsible to set policies at both national and regional level. In detail, ministries and regional authorities should design and support cluster programs and initiatives open to all companies and institutions; design and execute action agendas along with the government; concentrate specific policy tools on initiatives that have the greatest chance to generate results; allow employment and capital to move from declining clusters to other parts of the economy; develop lead markets; strengthen risk capital availability; support global research excellence and invest in innovative capacity.

Finally the third level of actions includes European Institutions such as European Commission, the Committee of the Regions and the European Investment Bank. Those institutions should enable more effective use of available instruments through cluster efforts; review the impact of existing policies on clusters; design a more efficient geographic distribution of economic activities in Europe and provide platforms for facilitating trans-national cooperation.

The first wave of cluster policy efforts started around 2000. Cluster policies were firstly seen as an extension of existing programs to support small- and medium-sized companies.

Figure 8: History of Europe's Cluster Policy (Source: "*The Cluster Initiative Green Book 2.0*", Sölvell, 2013)

The European Commission started with some narrow experimentation of its own, supporting cluster efforts in countries in Central and Eastern Europe through the PHARE program. It also started collecting data on cluster policies and clusters. Following the 2005 re-launch of the Lisbon Agenda- EU's strategy to enhance the global competitiveness of the European Union that had not brought the expected results, cluster efforts were considered to be a new tool with potential. Clusters transformed into a tool of innovation policy.

In 2007 the European Commission started to make much more determined efforts to support cluster policies. At this time, the main objective was the understanding of the new tool and it's sharing with policy makers around Europe. The High Level Advisory Group on Clusters created the European Cluster Memorandum, a document that described the role and potential of cluster efforts. It provided orientation and support to both European Commission and Member States for the emergence and growth of word-class clusters in Europe. According to the Memorandum dynamic

clusters are the key driver of innovation and prosperity because they help regions to promote their specialized capabilities and have an active role in the global economy.

The European Commission invested in the knowledge infrastructure for cluster policies by introducing the European Cluster Observatory and by financing a number of pilot projects to develop tools and practice manuals. Around 2010, the center of attention shifted from encouraging the use of cluster policies to raising the quality of cluster policies across Europe. The European Cluster Policy Group defined some key characteristics of effective cluster programs. The European Commission developed a variety of new projects to develop tools to enhance the quality of cluster initiative management, using benchmarking as well as cluster initiative training. Cluster policy was further integrated into the policy mix, particularly in efforts to raise innovation but also as regards a new industrial policy for Europe.

The most recent development has been the integration of cluster efforts into regional policies. The smart specialization approach outlines the need to foster structural change together with a focus on regions' strengths and advantages. For that reason the European Commission has launched efforts to study the role of clusters in emerging industries and the broader framework of smart specialization. The challenge is now to further differentiate how cluster policies can be structured to meet the needs of locations and clusters at very different stages of economic development.

2.8 Conclusions

In conclusion, clusters are networks of cooperating firms and institutions and they play an important role in industrial competitiveness and economic growth. In many cases we observe high technology clusters spontaneously emerging or as a result of intended policy actions. Clusters may form either around research facilities (universities, research institutes etc.) or in their lack.

Clustering can lead to important advantages for firms. In high technology industries, geographical proximity plays a significant role in the early stages of the life cycle of a product or technology, facilitating the use and transfer of tacit knowledge that is a key to successful development. Clusters also offer the soil for innovation. Innovation is based on a process of continuous interaction across organizations, building ties, specialized language, and social capital within the region.

According to Triple Helix Model innovation can be brought out by the collaboration between three actors: academia, government and industry. The role of government is very significant in cluster process. Governments take action both to foster new clusters and to strengthen existing ones. On the other hand, firms in clusters are involved in processes of technological, commercial and organizational change and they are the centre of cluster actions and policies. Academia has a supportive role throughout the clustering process by analyzing the cluster policy's strategic direction and actions, by driving actions especially in the areas of innovation and network creation and by facilitating trust and building social capital.

Cluster policies are efforts of strengthening existing clusters and helping new clusters to emerge. They try to capture the cluster benefits including knowledge spillovers, skills and tacit knowledge through labor pools, supply chains, and other public goods effects -including social capital and reputation. Europe is an interesting case because policy makers have been most active in creating cluster programs.

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Chapter 3: High- Tech Innovation Clusters in Europe-case studies

3.1 Biotechnology Clusters in Europe

3.1.1 Introduction

Europe is home to leading life sciences and biotechnology industry clusters active in medicine and healthcare, agricultural and food and industrial and environmental areas. In Europe, biotechnology clusters are usually geographically concentrated in countries with a long tradition of life sciences research and activities in related industries such as pharmaceutical, chemical, agro-production and medical technology. Biotechnology clusters contribute to the growth and development of the biotechnology industry by stimulating and fostering the academia and industry collaborations for improved knowledge base and commercialization of research findings. Biotechnology industry is largely dependent on public and private R&D funding to finance business requirements.

Life sciences and biotechnology is a strategically important area for Europe, identified as one of the key enabling technology to strengthen Europe's global competitiveness, economic growth through increased employment and productivity, and quality of life (European Commission, 2002).

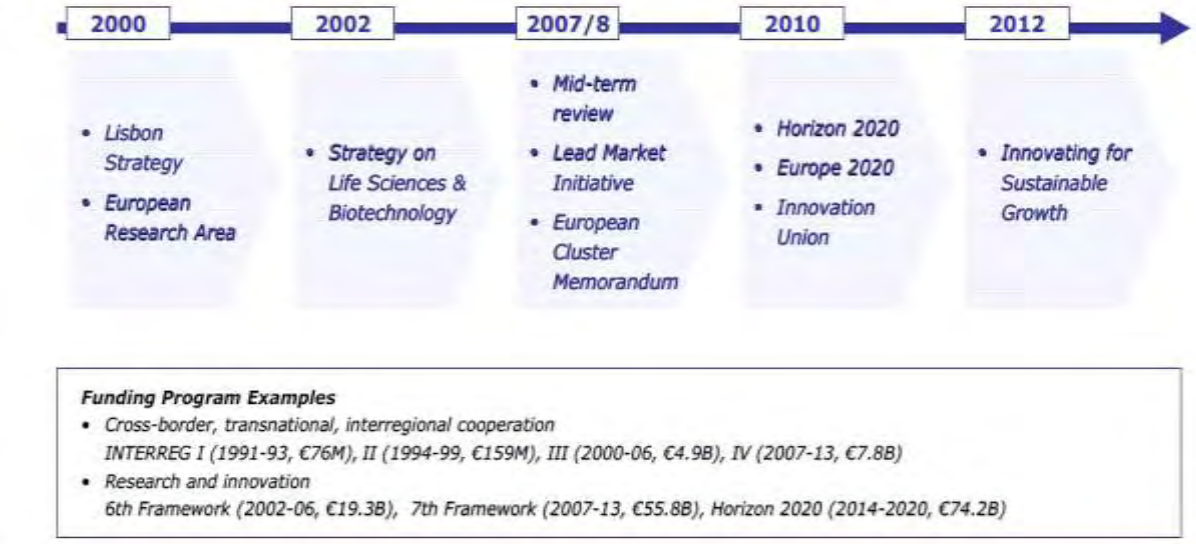

Figure 9: Europe Initiatives for Life Sciences and Biotechnology (Source: *Mizuho Corporate Bank analysis on European Union*, Noji and Omiya, 2013)

European Commission has launched and implemented various supportive measures and initiatives to promote research, development and commercialization of life sciences and biotechnology (figure 9). Action plans and strategies are mainly focused on trans-regional and trans-national collaborations, improved and more efficient access to information and collaboration networks, technology transfer, funding programs and finance. For example, a pan-European network Council of European Bioregions (CEBR) was established in 2006 as a network linking clusters, aiming to the promotion of collaborations, providing policy support and sharing best practices between clusters.

Department for Business Innovation and Skills in UK (2010) gives the following definition of life sciences *"any of the branches of natural science dealing with the structure and behavior of living organism which have commercial applications in wide-ranging number of sectors, including healthcare, food and agriculture, environmental goods and services and chemicals"* Life sciences industry in general covers healthcare and bio-economy areas. Biotechnology plays an important role in both fields.

OECD (2009) defines biotechnology as "*the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services".*

Biotechnology is applied to the development and production of processes and materials in wide range of industries such as pharmaceuticals, medical technologies, food, drinks and feed, chemicals, pulp and paper, textile, detergents, starch, energy and finally agriculture). In Europe, biotechnology industry is often categorized in three different subsectors (EuropaBio, 2013):

1) Medicine and healthcare, called red biotechnology

2) Industrial productions, energy and environment, called white biotechnology

3) Agriculture, food, livestock and veterinary products, called green technology

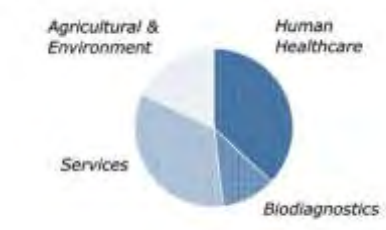

Figure 10: European biotechnology industry by sector (Source: "Mizuho Corporate Bank analysis on EuropaBio", Noji and Omiya, 2013)

European biotechnology industry mainly consists of small and medium-sized enterprises operating in the field of healthcare and medical biotechnology. Human healthcare sector accounts for around 40% of the whole industry in terms of company numbers (figure 10).

Biotechnology R&D base in Europe is concentrated in the western and northern European countries namely Denmark, France, Germany, Switzerland and the UK. Biotechnology industry is research and capital intensive. The industry is largely dependent on specialized knowledge and funding throughout research and product development stages.

The European pharmaceutical and biotechnology industry represent the highest research intensity of approximately 15% measured by R&D investment to net sales, significantly more than the 3% average of all sectors (European Commission, 2011)

The European biotechnology industry is supported by approximately 96,000 people and 40-50% of them are estimated to be involved in R&D functions.

Biotechnology development consists of often composite, timely and costly processes. Transforming research results into economic and financial return or to a marketable product or service requires processes such as obtaining patents and regulatory approvals, securing sufficient funding and investments for research projects. Funding is crucial and venture capital is an important source especially for early-stage biotechnology start-ups. One of the types of venture capital investment firms active in Europe is European national firms with dedicated focus on biotechnology, life sciences, and information technology sectors. Other funding sources include domestic and foreign investors such as business angels and family offices; private and public grants and funding; alliances such as joint research and development and licensing; mergers and acquisitions; capital market initial public offerings (IPOs) and equity or debt financing.

Europe comes second in most comparative analysis behind to world's dominant leader the United States, representing half the size in terms of the number of public biotechnology companies and employees. One reason is the historical development background. While Europe was going through a social and economic integration process after the fall of the Berlin Wall in 1989, the US biotechnology industry started to develop in the early 1980s. Sector's emergence and development was supported by government-lead measures implemented with aims to improve the regulatory and patenting and licensing systems and launch government-lead research initiatives. It was only around in the mid-1990s, almost a decade later to the US when the European biotechnology industry started to develop partly in response to EU-lead supportive measures, in regions and countries with prominent university centers, with a long tradition of life sciences and biotechnology research base and activities in

contributing industries such as pharmaceuticals and chemicals. The revenue of the European public biotechnology companies shows a constant growth. This growth is mainly supported by the relatively stable business environment in Europe; Europe's market diversity; continuous measures for operational efficiency improvements in companies and sales revenue from newly launched products. Today, biotechnology clusters are concentrated in Belgium, Denmark, France, Germany, Italy, Spain, Sweden, Switzerland and the UK.

Biotechnology clusters and initiatives are managed by specific institutions, known as cluster organizations, which have various forms, ranging from non-profit associations, public agencies to companies (European Commission, 2008). Cluster organizations offer a support system designed to promote entrepreneurial business environment for both science and industry participants. Initiatives and activities differ, but all leading biotechnology clusters have in common the ability to adapt and evolve with the strategic vision in tune with the changing business environment and market demands. Examples include providing support for spin-off companies; access to premises and infrastructure such as incubators, accelerators and shared services; access to partnership events such as promotion and networking; thematic projects; technology transfer programs and information-sharing platforms. Additionally, biotechnology clusters and cluster organizations are the first point enabling national and international partners and investors to explore cluster potentials and new business opportunities with innovative life science companies.

3.1.2 Biotechnology Clusters' Categories

The process of birth and development of a cluster varies from case to case. Three major categories can be identified (Mytelka and Farinelli, 2000):

- Spontaneous clusters, where the cluster is the result of the spontaneous concentration of the key factors leading to its birth and growth.
- Policy driven clusters, where the trigger is the strong commitment of governmental actors willing to set the conditions for the development of the cluster.
- Hybrid clusters

Spontaneous Clusters

Spontaneous clusters are born and develop as the result of the concentration of specific conditions, without the direct commitment of public actors. This model of cluster birth and development took place mostly in US and UK. The usual elements that allowed the cluster's development are:

- The presence of an excellent scientific base, which is frequently the result of vast public investments in basic research done in past decades
- exploitation mechanisms of scientific research, especially:
    - technology transfer mechanisms, strongly sustained by initiatives such as industrial liaison offices, technology transfer offices, venture supporting services provided directly by the universities and the research centers
    - a strong diffusion of the entrepreneurial culture, which means that among scientists and researchers, there is a strong inclination to commercialize the results of their research
- diffusion of innovative funding mechanisms, which means that there are in place funding schemes related to seed and venture capital, tailored and appropriate for high-tech new venture
- The presence of a well defined legal framework. US and UK were the pioneers to set up clear laws concerning the scientific research in the biotech sector and to facilitate the industrial exploitation of the research results

An interesting aspect of such clusters is that they have not grown around a central organization that favored the development of the cluster. Another specific factor is that incubators and science parks played a limited role in the development of the cluster. Usually they did not exist at the beginning and their establishment was the result of later initiatives.

Policy-Driven Clusters

In the case of policy-driven clusters, the real triggers of the birth of the clusters are the direct actions of policy makers.
Policies can be divided in two categories:

- industry restructuring policies, in which the decision of governmental actors to undertake direct actions is the reaction to an industrial crisis
- industry development policies, in which the direct actions of public actors are the consequence of the decision to promote the biotech sector

In the first category the starting condition is typically the crisis of an industrial sector or even of a single large company that was providing the strong industrial base to a certain region. In such cases, governmental actors may decide to undertake initiatives to ensure that new jobs are created for redundant people. This is usually done leveraging the existing competencies in the area. Usually these processes are governed by a central actor specifically created to promote and manage the restructuring process. The key driving forces in this case relate to the exploitation mechanisms of industrial research, especially favoring the processes of outsourcing of industrial research to third parties leading to the creation of industrial spin-offs and management-buyouts that allow the local managers to create a new company from the dismission of an existing facility; and governmental funds dedicated to support the creation of industrial spin-offs.
Examples of this kind are the cluster of Uppsala, which started as a response to the restructuring of the operations of Pharmacia after the merger with Upjohn and the case of the Biovalley which was created as a response to the unemployment generated by the merger between Ciba and Sandoz.

On the other hand, industrial development policies are the result of governmental actors' decision to facilitate the development of the biotech sector. Usually the preliminary condition is the existence of a large and strong scientific base. The intervention of the governmental actors aims to the birth and development of an industrial base of biotech firms. The key aspect is the improvement of the entrepreneurial attitude and the generation of new companies. The driving forces in such cases are the exploitation mechanisms of scientific research, especially those favoring the diffusion of entrepreneurial culture and facilitating the creation of new companies; supporting technology transfer mechanisms and supporting driving forces, especially those increasing the availability of infrastructures and services supporting the creation of new companies; establishing a clear and favorable legal framework, concerning both the legislation about biotech research and the management of IP and favoring the public acceptance of biotech.

The two most important examples are the German and the French cases. In the German case, the policy was directly devoted to supporting the foundation of new companies. Infrastructures such as incubators and science parks were already available. Therefore, the choice was to select few areas in the country and directly fund new companies. In the case of France, the governmental action concentrated on the creation of an infrastructure of technology transfer centers, devoted to promoting entrepreneurship among scientists and researchers, through the provision of funds, space and advice to new companies. These policies require a central organization acting as a pivotal actor in the cluster, managing services and funds to new companies.

Hybrid Clusters

In some cases, the birth of a biotech cluster is the result of hybrid processes.

The two major cases are San Diego and Milano. In the case of San Diego there was already a high-tech cluster focused on ICT that grew up spontaneously in place. The crisis of the military market brought a strong decline of the cluster, which was converted to biotech through supporting actions of local government. This means that there were in place the factors enabling a high-tech cluster to develop, and the action was directed to the conversion of the industrial base. Several initiatives were created

to support the process. In the case of Milano the governmental actors played a key role supporting the management-buy-outs which were the result of the dismission of facilities by large multinationals. However, the support was not part of a global plan aiming to develop the sector in Italy but simply was given case by case. Therefore the small cluster that is growing up in Milano is the result of the entrepreneurial initiatives of individuals supported by the public actors in the development of their ventures. No central actors play a role in such process.

3.1.4 Biotech cluster policies

The birth and development of a biotech cluster can be seen as a cycle, where a central role is played by the constant generation of new science-based companies. According to the Department of Trade and Industry in UK (1999) the critical factors for developing and building successful biotechnology clusters are: strong science base; entrepreneurial culture; growing company base; ability to attract key staff; access to funding and financing; premises and infrastructure; business support services and large companies in related industries; skilled workforce; effective network; supportive policy environment and effective business plan.

A more detailed analysis is given by Chiesa and Chiaroni (2005). In their opinion a condition to the birth of a cluster is the presence of a strong scientific or industrial biotech base. The generation of new companies also requires the availability of funding programs tailored to the funding of new high-tech ventures. Finally, a fourth factor is the presence of a favorable environment -normative, social, historical and infrastructural.

They identify four different driving forces (figure 11):

1) Financial driving forces, which concern the availability of funds for the biotech companies. They include:

- The availability of pre-seed capital which is the capital which a biotech start-up could use to carry out a proof of concept work and develop a credible business plan
- The availability of seed capital which is the necessary capital for the start-up of a new biotech company

- The availability of venture capital which comes from individuals who invest into private companies
- The availability of government funds which concern the direct intervention of the local or national government in funding biotech companies
- The availability of exit strategies for investors. The objective of investors is to remove their funds gaining profits after 5 to 10 years, through the selling of their equity position in the funded companies.

2) Scientific driving forces, which concern the exploitation mechanisms of scientific research. They include:

- Presence of scientific base: a successful biotech cluster includes extensive and successful academic research and education, and strong industry-academia cooperation
- Technology transfer mechanisms: technology transfer is the process of finding, creating, and leveraging intellectual property that has potential commercial applications
- Networking culture: the ability to create close relationships within universities and research centers and between these ones and existing companies in the cluster
- Entrepreneurial culture: it refers to the scientists' interest not only in the scientific side of researches but also in the commercialization of their results
- Mechanisms to attract key scientific people

3) Industrial driving forces, which concern the exploitation mechanisms of industrial research. They include:

- Presence of industrial base: a strong industrial base in the biotech sector represents a "dedicated" market for the research results of the universities and research centers as well as of small Dedicated Biotech Firms. Moreover, a strong industrial base represents a trigger for the creation of new companies both directly, through the mechanism of industrial spinoffs, and indirectly, favoring the establishment of suppliers and service companies as well as new core biotech companies

- Existence of success stories in biotech: the presence of such successful companies becomes an effective way to widespread the entrepreneurial culture among scientists, showing them how to create and run a company in the sector. Moreover, it may represent a key driver in localization choices of large companies.
- Attraction of new sites of other companies: the institution of new sites by foreign companies in the cluster enlarges the industrial base
- Integration among industrial actors
- Support to R&D outsourcing processes and industrial spin-offs
- Mechanisms to attract key managerial and commercial people

4) Supporting driving forces, which concern the presence of a favorable general context. They include:

- The legal framework: Significant issues regarding the biotech sector are:
    - IP rights which are the rules to regulate the rights of inventors in exploiting research results
    - bio-security which are the rules regulating the research and production activities, primarily aiming at avoiding risks for workers
    - bio-labeling which are the rules regulating the labeling procedures
- The attractiveness of the area: general infrastructures such as transports and ICT infrastructures and parameters like housing, schools, entertainment, as well as climate and landscape are key factors to improve the area attractiveness, particularly with regard to human resources
- The presence of dedicated support infrastructures:
    - incubators, providing spaces and shared service facilities for early-stage start-ups
    - science parks, providing infrastructures and services, house and support biotech companies emerging from incubators as well as later stage companies
    - hospitals and clinics
- The public acceptance of biotech activities which is the positive "feeling" of the social community towards the sector.

- The international promotion of the cluster. To make the cluster known worldwide as a centre of industrial and scientific excellence

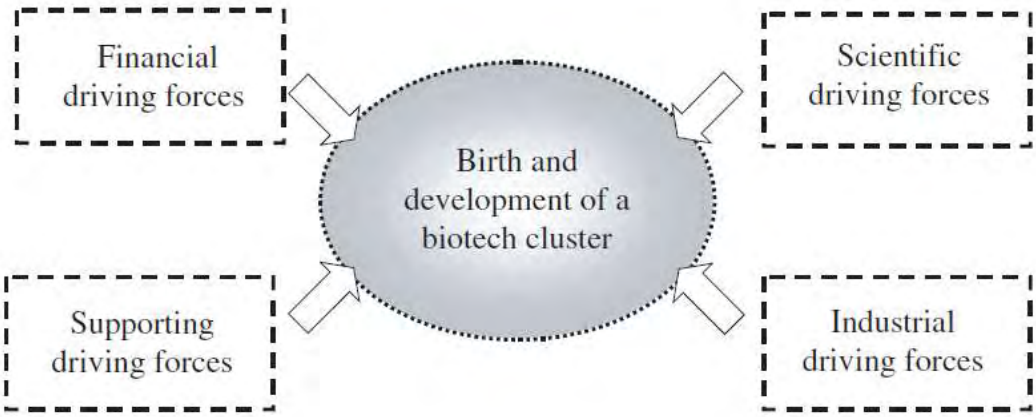

Figure 11: Driving Forces of a biotech cluster (Source: Chiesa and Chiaroni, 2005)

3.1.5 Case of United Kingdom

The UK life sciences industry is composed of over 300 pharmaceutical companies and 4,500 medical technology and biotechnology companies. In 2013 according to the UK Government, UK remained the largest country in Europe with regard to life sciences turnover at £50 billion. Almost 165,000 people are employed by the industry and life sciences industry is one of the largest contributors to the country's economic growth, due to its strong R&D base and large life sciences workforce. 77 percent of biotechnology companies in UK perform R&D activities. Leading clusters in terms of number of companies and annual turnover are east and southeast of England (London, Cambridge and Oxford often referred to as the

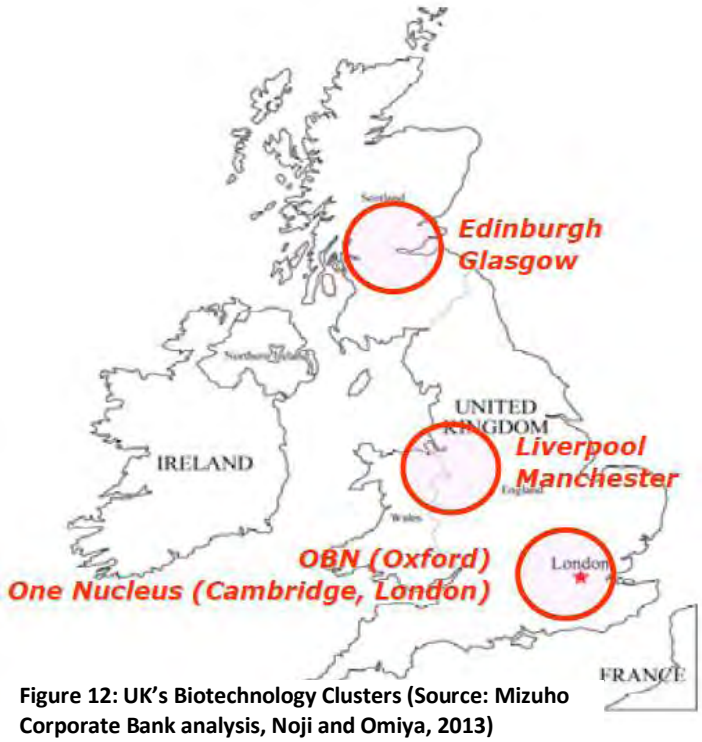

Figure 12: UK's Biotechnology Clusters (Source: Mizuho Corporate Bank analysis, Noji and Omiya, 2013)

"Golden Triangle"), northwest of England (Manchester and Liverpool) and central Scotland (Figure 12).

The southeast of England and Scotland account for over a half of all medical biotechnology companies in the UK. The southeast England contains the largest number of vaccines and therapeutic proteins companies and the highest concentration of small molecule companies. The London area is home to UCL Partners, one of Europe's largest academic health science partnerships of hospitals and medical research centers, and is home to 28 universities, over 1.500 biomedical researchers and 15 hospital sites. Oxford is home to more than 160 biopharmaceutical and healthcare companies. The cluster has four science parks, of which two are linked to the university. The University of Oxford is also a contributor to cluster's development. Since 2007, the Oxford cluster has added more than 28 new companies and over £700 million in investment from the private sector.

Scotland is the second largest life sciences cluster in UK and one of the most sizeable clusters in Europe. The region houses 650 organizations and biotechnology and pharmaceutical companies, contract research organizations and medical device and diagnostic companies along with specialist suppliers and support organizations.

Northwest England is the third largest bioscience cluster in the UK. AstraZeneca is one of the global pharmaceutical companies with a large base in the area. Strong academic research capabilities at the universities of Liverpool and Manchester along with partner hospitals and locally based national support facilities also help to anchor the cluster.

Research base in life sciences and biotechnology, history of government strategic measures for the area, access to finance, lower language barriers may have contributed to the relative maturity and the UK industry size. UK scientists have been awarded more than 70 Nobel Prizes in biomedical science related disciplines and have contributed to some groundbreaking research such as the DNA double helical structure and animal cloning. Four of the world top ten universities are located in the UK: University of Cambridge, University of Oxford, University College London and Imperial College London.

Current and past UK governments have introduced many policy initiatives focused on aspects such as providing incentives for investors; expanding the range of available funding options for companies; encouraging research and development activity; developing the technology sector; and promoting regional growth (Copeland and

Scott, 2014). In the early 1980s, the UK government established the Biotechnology Directorate with The Science and Engineering Research Council with an aim to fund academic biotechnology research. The Biotechnology Unit within the Department of Trade and Industries (DTI) was also established to further support the industry. Furthermore, UK government created the UK Trade and Investment in order to support overseas investment from early stage development through product commercialization and also to help companies maximize government tax breaks and incentives.

In 2011, the UK government launched the ten-year strategy for the UK life sciences with aims to re-establish global leadership in life sciences sector and promote the UK as the best destination for business. Main measures include £1 billion a year investment to improve translational research infrastructure, manage talented human resources (attract, develop and reward) and facilitate healthcare innovation (through funding, regulator reviews).

UK has some of the strongest tax incentives in Europe for institutional and individual investors. The Enterprise Investment Scheme (EIS) and Seed Enterprise Investment Scheme (SEIS) have both proven to be highly effective at stimulating investment in early stage businesses (Copeland and Scott, 2014).Small and medium enterprises can claim relief worth almost 25 pence per every pound of qualifying expenditure, one of the most generous tax breaks in the world. Larger companies can benefit from the Regional Growth Fund, a £ 2.4 billion fund that supports private capital projects that contribute to economic growth. Other programs and funds like the UK Research Partnership Investment Fund, Invest Northern Ireland, Life Sciences Investment Fund(Wales), Biomedical Catalyst and Scottish Enterprise, offer over £ 500 million in funds and additional economic development incentives solely for life science companies across the UK. UK's government is giving the sector strong backing through Med City, a new body modeled on the immensely successful Tech City Investment Organization. Better access to finance may be helped by the fact that 50-60% of UK venture capitals are reported to be concentrated in the London area as well as by having access to the London Stock Exchange and financial services industry.

There are more than 650 policies to promote innovation in the UK (Table 3 summarizes the most important). Large companies with plenty of financial and legal advisers can carefully select and benefit from them. For entrepreneurs and startups,

however, their vast number and complexity may be confusing. Moreover, policies such as Entrepreneurs' Relief only help founders after their business has been successful, not in the beginning.

Date	Name	Description
For investors, venture capitalists and business angels		
1994	Enterprise Investment Scheme	Income Tax and Capital Gains Tax (CGT) incentive for investors that purchase share options in SMEs, up to a value of £1m p/a
1995	Venture Capital Trusts	Income Tax and CGT incentive for investors in Venture Capital Trust schemes purchasing shares in SMEs, up to a value of £200,000 p/a
2012	Seed Enterprise Investment Scheme	Income Tax and CGT incentive for angel investors that purchase share options in small firms, up to a value of £100,000 p/a
For companies seeking investment and mentorship		
2006	Enterprise Capital Funds	12 commercial funds backed by government, 11 of which are based in London/South East
2008	Enterprise Finance Guarantee	Encourages banks to extend credit to riskier small companies by providing a Government guarantee against 75% of the value of the loan
2009	UK Innovation Investment Fund	£325m in two venture capital funds of funds that invest in technology businesses within strategically important sectors
2011	Business Angel Coinvestment Fund	£50m equity investment fund backed by government with a focus on certain regions
2012	Business Bank	The Business Bank will bring together existing Government SME finance support schemes and manage new funds to improve the UK's business finance markets
2012	Startup Loans Company	Provides small loans and mentorship to new entrepreneurs and start-up companies
For companies seeking investment and mentorship		
2012	Growth Accelerator	A consultancy scheme backed by Government providing business advice to small, high-growth firms
2013	New Enterprise Allowance	Provides welfare claimants with a loan and mentorship when starting a new business
2013	Launchpad Funding	Run by the Technology Strategy Board, Launch pads are small funding competitions for innovative companies to develop specialist projects, targeted at firms within certain tech clusters
2013	High-growth Segment (HGS) on London Stock Exchange	A new growth market for high-growth companies wanting to raise capital through the sale of a small percentage of shares
2014	Stamp Duty Exemption on LSE Growth Markets	For both AIM and the HGS on the London Stock Exchange, purchased shares will be exempt from Stamp Duty liability

For innovative businesses and entrepreneurs		
2000	Enterprise Management Incentives	Income Tax and NIC incentives for employees of small firms who purchase share option in their company
2000	Research and Development Relief	Corporation Tax incentive for SMEs and large firms that invest in qualifying R&D activities
2008	Entrepreneurs' Relief	Entrepreneurs benefit from reduced rate of 10% Capital Gains Tax on any value (up to a maximum of £10m) realized upon the disposal of business assets or shares
2009	Small Business Research Initiative	Expanded in 2013, SBRI provides 100% R&D funding to companies seeking to develop innovative products not offered by the market for the public sector
2011	Government Procurement IT	Target to achieve 25% of total IT procurement from SME suppliers and introduction of the G-Cloud portal, with a further target of 50% of all new IT spending awarded to SMEs through the supply chain
2013	Patent Box	Allows companies to apply a lower rate of 10% Corporation Tax on revenues earned though their patented inventions and innovations
2014	Games Tax Relief	Tax credit payable to games developers based on production cost of qualifying games
For a connected and supportive ecosystem		
2010	Tech City UK	A publically funded body created to represent the tech community within Westminster and encourage growth of technology clusters around the UK
2013	Catapult Centres	A network of technology transfer centers with the purpose of connecting businesses with academics to commercialize innovative products and services in valuable technological markets
2013	Information Economy Strategy	Strategic plan from Government for the technology industry to develop support and stimulate investment. The Information Economy Council meets to discuss progress and issues against the strategy
2013	Future Fifty	A scheme for fifty of the UK's highest growth digital companies to access fast-tracked regulatory and business advice from Government
For provision of digital connectivity		
2010	Rural Broadband Program	Broadband Delivery UK, part of DCMS, has funded 44 locally led broadband connectivity projects, designed to rollout superfast broadband in rural areas typically underserved by commercial providers
2012	Super Connected Cities	22 Super Connected Cities received investment from the Urban Broadband Fund to deliver superfast broadband infrastructure and Connection Vouchers
2014	Connection Vouchers	A credit from Government for small businesses

		to upgrade to superfast broadband
For nurturing domestic digital skills and attracting tech talent from abroad		
2003	Global Entrepreneur Programme	Targets overseas entrepreneurs and startups with assistance to relocate their businesses to the UK
2011	Entrepreneur Visa	Tier 1 Visa for foreign nationals securing investment to start a business in the UK
2011	Investor Visa	Tier 1 Visa for foreign nationals willing to invest £1million in UK businesses
2013	Graduate Entrepreneur Visa	Tier 1 Visa for international students looking to take forward (viable) business ideas
2014	Exceptional Talent Visa	Tier 1 Visa route for talented foreign technologists to work in a UK technology firm
2014	Sirius Programme	A competition for foreign graduates with tech talent to win a place at a UK accelerator and receive financial and business support
2014	Computing Curriculum	Introduction of Computing into the curriculum for 5–16 year olds, including coding and understanding how computers
For regional economic growth		
2010	Regional Growth Fund	£3.2billion economic development fund that support private and public sector projects in targeted geographical areas
2010	Local Enterprise Partnerships (LEPs)	Working across the private and public sector 39 LEPs have a responsibility to achieve local economic growth through development of strategies and rollout of investment
2011	Enterprise Zones	24 LEPs awarded an Enterprise Zone where companies are offered relief from business rates, relaxed planning regulation and business ready connectivity
2011	Growing Places Fund	£730m infrastructure and housing fund provided to LEPs
2012	City Deals	28 cities have agreed devolved financial, planning and skills powers in return for a greater responsibility in achieving local economic growth
2014	Growth Deals	A Growth Deal was agreed with each LEP in July 2014, competitively allocating £6 billion drawn from the Local Growth Fund and the European Structural and Investment Fund. The deals will prioritise spending on new infrastructure and projects to create jobs and build new homes.

Table 3: UK policy initiatives (Source, Copeland and Scott, 2014)

The biotechnology cluster in Cambridge

The evolution and performance of the high-technology cluster in Cambridge is recognized as one of the most interesting in Europe. Often characterized as the Cambridge Phenomenon, the high-tech cluster in Cambridge has a sectoral mix - drug discovery, biotechnology, software, computer hardware, electronics, ink-jet printing, computer games, clean tech and web-based new media and a diversity of business models (Table 4). The cluster possesses a world-leading biotech research profile through organizations such as the University of Cambridge, the Institute of Biotechnology, the Babraham Institute, Addenbrooke's Hospital, the Medical Research Council Laboratory of Molecular Biology, the Sanger Centre and the European Bioinformatics Institute, along with over 250 biotechnology companies.

The industrial biotechnology cluster in Cambridge emerged in the early ’80s in a high-tech environment consisting of computing and electronic industries. Cambridge Science Park which is owned by Trinity College hosted the initial companies although it was primary built to attract computing companies. In the mid ’70s the UK Government published a national strategy paper in order to make universities more proactive in industry and this lead to the creation of initial science park buildings by Trinity College. Nowadays the Park is dominated by established pharmaceutical and biotechnology companies such as Amgen, Millennium, Genzyme and Gilead Sciences. The availability of scientific premises was supported by a reverse attitude from some major investors within the Cambridge area. Barclays Bank, one of the largest banks in Britain started investing in more high-tech industry and venture capitalists followed the notion.

Biotech companies grew steadily until the mid-’90s, when a global explosion of investment in high-tech industries accelerated company creation at a continuous rate. Several factors combined almost spontaneously to create an environment beneficial to life science company start up. A number of biotechnology entrepreneurs were focused in Cambridge at the time and the combination of increased funding, availability of premises, a high-tech atmosphere and altered attitudes to risk resulted in pioneer companies such as Celsis. The arrival of engineering consultancy firms in the area ignited the cluster by combining academic research and talent with commercial focus and by producing a significant number of spin outs

The majority of biotech SMEs in the Cambridge cluster was born within it instead of becoming established from external sites. However, several external companies moved to the area, even if virtually none have moved their entire operation to the region from elsewhere, rather they have established additional research laboratories within the cluster. This has been done in two ways (Chiesa and Chiaroni, 2005):

- Opening of a completely new operation within the cluster. This is a high risk strategy for a company because it involves significant expenditure for the expansion of existing capabilities. Companies which do this have a strong draw to the region. Cyclacel, for example, is a biotechnology company based in Dundee, Scotland that opened a Cambridge section after one of its founders moved to Cambridge to take up a position within the University;
- Becoming established through the merger with or acquisition of an existing Cambridge company. This is the most important way of becoming established within Cambridge as it has the additional benefit of acquiring new technologies or products in an already functional organization.

Cambridge cluster benefits hugely from the presence of its internationally-renowned university in terms of research, the creation of spin outs, and also in providing a highly-educated pool of labor. One in five recent Cambridge graduates works or studies in the region. The university also earns more from Intellectual Property (IP) developed by its students, alumni and staff than any other higher education organization in the UK (Copeland and Scott, 2014). As the cluster has evolved over the last two decades, the University of Cambridge has adopted a more proactive approach to commercial application of academic research.

Cambridge has focused on developing its own networks. Several initiatives, including the Cambridge Network and Cambridge Wireless provide regular opportunities for members of different communities within the cluster to meet. These have been created and led by serial entrepreneurs who have become ambassadors for the cluster and mentors to newer firms. Specialized support networks and dedicated office space are also available for tech companies at all stages of their development (Copeland and Scott, 2014). The Babraham Bioincubator for example provides small laboratories and office units on flexible leases and many of Cambridge's newest companies are placed in this convenient location. The Bioincubator provides little or no subsidized services as is typical of incubators supported by Government funding and, indeed, was created

many years after the cluster developed. East Region Biotechnology Initiative (ERBI) was established in 1997 by industry led initiative which started after discussions between a number of individuals from the local biotechnology community and local/national government officials. It acts as a networking and cluster promotion organization, and contributes to cluster cohesion and identity through its networking meetings and annual conference. Additionally, the cluster has its own established and self-sustaining group of angel and venture capital firms providing finance, support and contacts to help high-growth companies (Copeland and Scott, 2014). Public bodies have little or no impact on the industry and public funds are not available within the Cambridge cluster. No particular strategy has been followed by regional or national public bodies to develop the cluster and it has developed purely on commercial lines (Chiesa and Chiaroni, 2005).

In conclusion, even without proactive support from local or central government, Cambridge has managed to built an entrepreneurial culture and develop a successful cluster due to the local private sector. High-tech companies and new technologies have spun out from both the university but also from large anchor companies. The outstanding scientific achievements and reputation of Cambridge University has played a key role in cluster development. The Cambridge region has a community of highly experienced entrepreneurs and investors willing to give their time and energy to mentor new companies and to promote the cluster. The diversity and strength of the cluster are closely related to the fact it has been developing for at least fifty years and has consequently achieved critical mass in high tech clusters' key success factors.

Original business model	**New business model**
High barriers to entry	Low barriers to entry
Rely on external finance – VC, angels, etc.	Rely on own finance, sweat equity, etc.
Protection of IP is a key milestone in value creation	Knowledge is created by sharing it, not protecting it
Many years before a viable revenue stream is established – hastens need for exit	Clever applications – but more D than R
"Cutting edge" in terms of R&D	Value is created quickly – which may mean quick exit

Table 4: Business models within the Cambridge high tech community (Source: SQW, 2011)

3.1.6 Case of Germany

Germany faced divided social and political structures until the unification in October 1990 when it started to regain its political, economic and social stability. Germany built its economic success through maintaining high-value added engineering and heavy industries, which demonstrates the strength of the German innovation system. The integration of high-tech into medium and low-tech products forms the basis of German innovation.

Figure 13: Biotechnology Clusters in Germany (Source: Mizuho Corporate Bank analysis, Noji and Omiya, 2013)

The German system has a decentralized structure with multiple actors, strong SME networks, and national technology and infrastructure priorities. Some federal states have their own innovation programs which contribute to competition, regional differentiation and cluster development. Germany's federal states are involved in joint policy co-ordination processes and co-fund research organizations and university infrastructure. Germany has a well-funded research landscape. 70 Max Planck institutes specialize in basic research, while about 60 Fraunhofer institutes conduct applied research, collaborating closely with industry. About 80 Leibniz institutes and 17 Helmholtz large science centers engage in basic, strategic and applied research. According to American Chamber of Commerce Germany (2012) the top location advantages that distinguish Germany from its competitors are:

- Stability, reliability, security, continuity
- Skilled workers, qualified employees, education
- Market size, market relevance, capacity
- Infrastructure, logistics
- Innovation and research intensity

Biotechnology cluster growth and development were triggered by the BioRegio contest launched by the Federal Ministry of Education and Research in 1995 to promote business development and commercialization of biotechnology. BioRegio was a contest where 17 German regions competed for a given amount of public funding and the winners were Munich, Heidelberg, and Cologne. Another driving force was the 1999's BioProfile competition planned to allow regions to define expertise within the overall biotechnology area in which they have a regional competitive advantage. The initiatives facilitated industry growth with increase in the number of dedicated biotechnology companies.

Germany's life science sector is the largest in Europe and the third largest globally. The sector includes variable life science activities such as biotechnology, pharmaceutical and medical devices. Oncology is the strongest area of development- 34 per cent of the total product development in biotechnology industries.

Germany is Europe's largest market for medical goods. The country's gradually aging population is a significant health care industry growth driver. The increased demand for health goods significantly enlarges the potential market for all medical biotechnology products, biopharmaceuticals, molecular diagnostics products, and regenerative medicine approaches. Moreover, the country is ranked very highly among innovation indexes, ranking behind only Switzerland in Europe.

According to the World Economic Forum (WEF), Germany is one of the world's best places in terms of planning and operating security. Germany is also one of the world's leading nations in terms of intellectual property protection and security from organized crime. German regulatory authorities are highly specialized in their operations. The German legal system also is one of the world's most efficient and independent. Social, economic, and political stability provides a solid base for corporate investment projects. Moreover, Germany has Europe's best and the world's third best infrastructure behind Hong Kong and Singapore (World Economic Forum Global Competitiveness Report, 2013).

Germany is considered to be an international biotechnology hub. There are about twenty industry relevant clusters in Germany. Clusters are located in Berlin, Munich, the Rhine-Neckar Metropolitan Region, Cologne and Frankfurt (figure 13) but Berlin/Brandenburg and Munich/Bavaria are the largest. The first one has 50 institutions of higher education and nine technology parks- the highest number in Germany, while the second one is distinguished by its focus on human-use biologics.

An important point in the German's history of biotechnology policy in support of clustering was BioRegio, an initiative started in 1995 with funding from 1997-2002 to support new firm formation in biotechnology clusters. BioRegio was the first land policy which fulfilled the commercialization aim. Other policies e.g. and BioChance, BioChancePlus, BioProfile, BioFuture and the new High Tech Foundation Fund complemented the firm formation emphasis of BioRegio later on (Cooke, 2006).

The German government has identified personalized medicine as a field of strategic importance for public health and is providing significant funds for the support of related R&D work. It invested approximately EUR 5.5 billion in a program called the "Health Research Framework Program of the Federal Government" in the period 2011-2014. The initiative focused on research into major diseases and emphasized on individualized therapy approaches, the health care industry and globally networked research efforts. This campaign was part of the German Federal Government's "High-Tech Strategy" which includes biotechnology as one of the eight key technologies being promoted (Table 5).

The High-Tech Strategy developed in 2006 and involved all country's ministries. The cluster strategy involved modular, region-specific or technology-specific measures for fostering and funding high-powered, highly productive leading-edge clusters. The main characteristic of the strategy was the efforts to foster cooperation between science and industry and to set up a comprehensive and coherent cluster strategy. Figure 14 describes the activities involved in the government's cluster strategy. The new High-Tech Strategy 2020 has identified five societal and global challenges: climate, nutrition/health, mobility/transport, security, and communication (Table 5). The Strategy aims to create lead markets and identified wide-ranging "*forward-looking projects*" over the next years that will affect society. Leading companies such as BASF, Bosch, Daimler, Deutsche Telekom, Siemens and Deutsche Post DHL contribute to Germany's High-

Figure 14: Germany's High- Tech Strategy (Source: "*Europe Innova Cluster Mapping Project*", Terstriep, 2008)

Tech Startup Funds launched in 2005 and 2011, providing over €500 million for start-ups. The Higher Education Pact, the Initiative for Excellence and the Academic Freedom Act are complementary. Key policy priorities are to keep pace with global trends, fund private and public R&D, reform the education system, and improve industry-science links. New policy measures include Validation of Innovation Potentials of Scientific Research, Go Innovative and Research Campus, a scheme that funds complex technologies with potentially radical impact. There are also subsidy programs in place for all types of technology that are primarily targeted at small and medium-sized enterprises. The "Central Innovation Program for SMEs" (ZIM) is the best known of these programs aiming to promote innovation and competitiveness at SMEs.

Germany offers one of the most competitive tax systems of the main industrialized countries: For corporations the average overall tax burden is below 30 percent. Significantly lower rates are available in certain German municipalities. Moreover, Germany also provides an extensive network of double taxation agreements ensuring that double taxation is ruled out.

Bio^{M}, centered in Munich is a unique not-for-profit organization supported by the Bavarian Ministry of Economic, Affairs, Infrastructure, Transport and Technology to foster development of the cluster. It is divided in two firms with different functions. The first one, Bio^{M} AG specializes in financial aspects of business such as seed financing, venture capital fund management and consulting. On the other hand Bio^{M} Biotech Cluster Development GmbH focuses on cluster management. Bio^{TOP}, located in Berlin, capitalizes on the extensive network composed of public research institutions and university hospitals especially in the field of regenerative medicine. Venture capital firms (either government-owned or co-owned by the government), offer capital for the early stages of a company development. A prime example of these programs is High-Tech Gründerfonds, an initiative of the German Federal Ministry of Economic Affairs and Energy that provides innovative start-ups with funding.

Lead Markets and Priorities	Key Technologies
Communication	Information and Communication Technologies
Health/Nutrition	Optical Technologies
Climate/Energy	Production Technologies
Mobility	Materials Technologies
Security	Biotechnology
	Nanotechnology
	Microsystems Technology
	Innovative Services

Table 5: Germany's High-Tech Strategy (Source: www.gtai.de)

The cluster of Munich

Munich is one of Europe's leading metropolitan regions for high-tech activity. It covers a range of sectors, global players – with some world-leading technology firms such as BMW, Siemens, Knorr-Bremse and MAN, as well as global insurance companies Allianz and Munich Re headquartered in the city – as well as SMEs (Musterd and Kovacs, 2013). Munich's large firms play important roles in the innovation process: they have considerable in-house research and development facilities, they are embedded in the metropolitan region's spatial clusters, and they are well connected with local SMEs – through supply-chain relationships and wider collaboration (Musterd and Kovacs, 2013). Besides the networks of SMEs and large enterprises, the cluster comprises links to the numerous research institutions as well as links to commercialization protagonists. An important factor for the development of the clusters is the numerous universities as well as the large number of partly federal-funded public research institutes. In Hafner et al. words (2007) "*The current positive economic situation of Munich is reflected in the dynamic labor market, the low unemployment rate, the dynamic service sector, the high purchasing power as well as the positive demographic development. One part of Munich's strength as a business location is based on the diversity of its economic structure and the mixture of global players and SME's*."

Munich and Bavaria were among the first regions in Europe where policies for supporting innovation and technology were formulated. In the beginning, technology and innovation policy concentrated on investment in physical and knowledge infrastructure as well as the promotion of start-ups (Rode et al, 2010). Since the 1980s several programs have targeted R&D, training, infrastructure development, support for start-ups and technology transfer to make Bavaria an attractive location for the high-tech industry. Munich as regional capital has attracted most of the benefits of these programs. The promotion of clusters initiated in 2006 by the Bavarian state government. The Munich region has a "thick" regional institutional, educational and research environment (Musterd and Kovacs, 2013).

The Munich Metropolitan Region is one of Germany's largest locations for the biotechnology and pharmaceutical industries. According to a ranking of "Genetic Engineering & Biotechnology News, GEN", March 2014, (www.genengnews.com), the Munich region ranks within the TOP 9–10 of all listed US clusters when looking at employment, public funding and granted patents.15% of the country's biotech firms are headquartered in the region and 30% of Germany's development of biotechnological actives takes place here. The cluster has developed a strong specialization in oncology with around 50% of clinical candidates indicated for cancer. In 2013, the biotech and pharmaceutical companies in the cluster employed 23,000 people and generated sales of around € 8.5 billion, making a significant contribution to the region's economic output. Munich biotech cluster comprises 350 life science companies including 118 SMEs; two leading universities (Ludwig-Maximilians-Universität and Technische Universität München); three Max Planck Institutes (Biochemistry, Neurobiology and Psychiatry); two university clinics and 60 other hospitals and two incubators specializing in biotechnology.

The cluster originates back in 1970's with the foundation of Grosshadern University Clinic and Max Planck Institute of Biochemistry. In the late 1980's the first biotech companies began to form in the cluster including Morphosys and Medigene. The first biotechnology company Mikrogen was established in 1989. Bio^{M} was one of the winners of BioRegio contest. Many global pharmaceutical companies have been attracted to the cluster with Roche Diagnostics, GSK, Gilead, Sandoz, GE Healthcare, Merck Sharp Dohme, BMS and Daiichi-Sankyo all present. In addition to the global pharmacy firms a number of European publicly listed biotech companies are present

in the cluster including: 4SC, Bavarian Nordic, Agennix, Medigene, Morphosys and Wilex as well as numerous private and venture back biotechs.
There are many reasons for a company to move to the Munich cluster:

- The public funding to the creation of new firms directly aimed at stimulating private funding particularly in the seed stage
- The diffusion of entrepreneurial culture among scientists and academics, leveraging the existence of a strong research environment
- The presence of dedicated infrastructures offering hosting services for the new biotech companies
- The presence of a clear and well defined legal framework like the Genetic Engineering Act facilitating the exploitation of research results in the life science area

All the mentioned factors above are strongly related to the intervention of public actors. The BioRegio competition, settled in 1995 by the German central government, represented for the area the opportunity to leverage both its excellence in life sciences research and its tradition in sustaining the technology transfer trough dedicated infrastructures. The availability of public funds, conditioned by the availability of at least the same amount of private funds from venture capitalists or business angels, led to the establishment of a virtuous circle where scientists are "forced" to become entrepreneurs.
In conclusion, in the late nineteenth century, instead of becoming heavily industrialized, Munich became a centre of commerce, culture and higher education, and royal patronage in the sciences enabled the city to capitalize on new technologies. After World War II, the city benefited strongly from the immigration of large companies and a skilled labor force from Eastern Germany, and the move of Siemens from Berlin to Munich, which created the basis for the attraction of other German and international firms (Musterd and Kovacs, 2013). The cluster comprises links to numerous research institutions as well as links to commercialization protagonists; numerous universities as well as a large number of partly federal-funded public research institutes. Munich's large firms provide considerable in-house research and development facilities and they are well connected with local SMEs – through supply-chain relationships and wider collaboration (Musterd and Kovacs, 2013).

3.2 ICT clusters in Europe

3.2.1 Introduction

Information and Communication Technologies (ICT) definitely represent one of the key innovations of the past century. In most advanced economies, an increasing share of economic inputs and outputs takes the form of ICT and knowledge (Bristow, 2003). Consequently, the traditional determinants of industrial location - access to raw materials, transportation networks, low costs, and a large pool of general labor- are becoming less important in these economies. Instead, locational choice is increasingly affected by access to particular skills, technology, knowledge, entrepreneurial talent and financing.

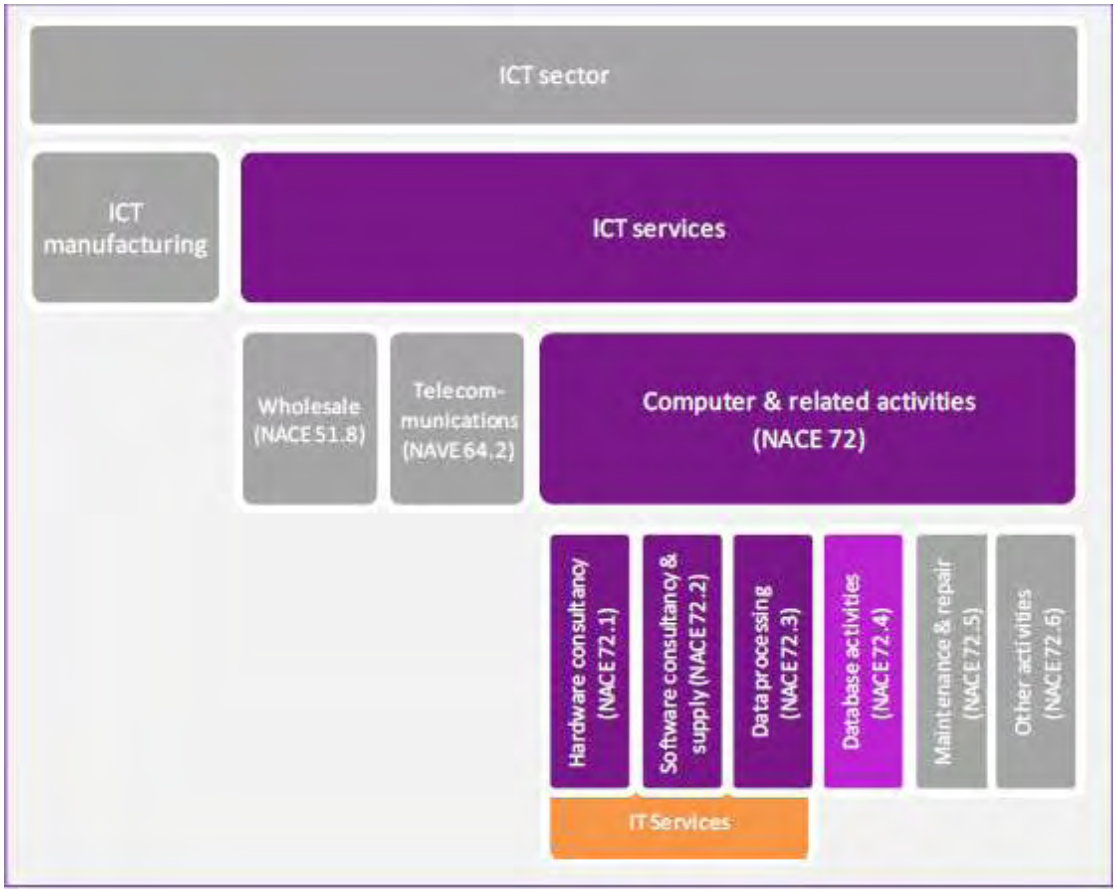

Figure 15: The ICT sector and sub-sectors (Source: "*Cluster Mapping – Analysis Grid*", Terstriep, 2008)

The OECD defines ICT sector as "*a combination of manufacturing and services industries that capture, transmit and display data and information electronically*" (OECD, 2004). As we can see from the figure below (Figure 15) the sector is divided into ICT manufacturing and ICT services. The ICT service sector includes hardware

consultancy, software consultancy and supply as well as data processing. The core activities which make up the ICT service sector are planning, building and running ICT systems.

The ICT sector has provided major contributions to economic growth and increasing productivity and innovation in all European countries and regions. Software and ICT services represent about one third of the entire ICT market and it's most dynamic component (European Commission, 2008).According to Tsang (2005), in the past decade the software sector has been one of the fastest growing knowledge-intensive industries in Europe. Every business in the European Union depends on the software and ICT services industries to facilitate the development, marketing, and support of its products and services

ICT sector is on many aspects the most innovative sector of all in the European Union (Terstriep, 2008). Because of the very short life-cycles in ICT, the sector is almost innovative by definition. According to Isaksen (2006) there are three roles of ICT companies as "*innovation agents*". They act as facilitators of innovation by supporting their customers in the innovation process as specialist consultants; carriers of innovation by propelling the diffusion of innovations such as new software and hardware solutions within the economy and sources of innovation by initiating and developing innovation in client firms.

Another characteristic of the sector is the high degree of globalization of ICT markets and production. Furthermore, the share of employees with higher education is much higher than in most other sectors, with the highest share in the ICT service industry. Also the share of firms with in-house R&D and the share of firms co-operating in innovation with others is in ICT on average higher than in the other sectors. The ICT sector has attracted the largest fraction of private equity investment in the EU25 over the past 10 years. In terms of productivity the ICT sector in Europe is lagging the ICT sectors of the US and especially Japan.

The ICT sector has a smaller weight in the EU economy than it does in other major economies, and it has a dominant service component. The structure of the ICT sector is fairly similar in the EU and the US, but very different from what it is in Japan, Korea or Taiwan. The Asian countries have a comparatively much bigger ICT manufacturing sector. Japan's share of ICT manufacturing relative to GDP is three times bigger than the EU's and China, Korea and Taiwan all have a share in GDP of ICT manufacturing higher than Japan's. The structure of the EU ICT sector is strongly

oriented towards ICT services. The ICT services share is still growing as compared with the ICT manufacturing share, helped in part by declining relative prices of ICT manufactured products. Although European ICT companies make substantial and increasing R&D investments, the EU is still lagging behind its main competitors, especially the US, in this regard. This lag seems to be largely due to the smaller number of large European ICT companies, rather than to a lower R&D intensity of individual EU companies. The number of ICT patent priority applications worldwide by inventors from the EU was significantly below those by inventors from Japan, Korea, China or the US. Applications by inventors from Germany, France and the UK accounted together for 80% of all applications by EU-based inventors; with Germany-based inventors alone generating half the total ICT applications for the EU. US firms own more foreign ICT inventions than EU firms do, and US firms, as an aggregate, appear therefore to be better able than EU firms to take advantage of the process of internationalization of ICT inventive activity.

A major disadvantage for EU ICT companies is the relatively small market size in EU countries. The degrees of knowledge-intensity and economies of scale are main determinants of the localization of ICT activities in Europe; the less knowledge-intensive production and the higher the degree of economies of scale, the easier it is to re-locate production of ICT goods or services to low-cost, off-shore locations.

Europe's ICT research is strong, but it is weak in bringing inventions successfully to the market. Co-operation matters in ICT research. In-house R&D is essential in the ICT sector. A considerable share of ICT companies in Europe co-operates with universities, but the share of co-operation with government research institutes is rather low. A major challenge for Europe is to make better use of the results of the research community as a whole, including both public and private research. A future challenge is that private–public partnerships with regard to R&D collaboration are to be improved.

The ICT software and service sector represents two thirds of the ICT sector in Europe. ICT service firms have a higher share of highly educated employees; a lower share in sales of new products; higher own R&D expenditures, but lower external R&D; less often apply for patents, more often use copyright and informal strategic methods to protect IP; and receive less often public funding for innovation. According to the 2011 Report on R&D in ICT in the European Union:

- The degrees of knowledge-intensity and economies of scale are main determinants of the localization of ICT activities in Europe. The less knowledge- intensive production and the higher the degree of economies of scale, the easier it is to relocate production of ICT goods or services to low-cost, off-shore locations.
- Europe's ICT research is strong and performs very well, but it is weak in bringing inventions successfully to the market.
- ICT companies in Europe cooperate with universities, but the effectiveness of technology transfer between industry and universities is generally poor.
- The share of cooperation with government research institutes is rather low. A major challenge for Europe is to make better use of the results of the research community, including both public and private research.
- A major challenge for the EU ICT sector is the availability of high educated human resources for the ICT sector. The problem has many aspects such as the declining numbers of students of scientific and engineering disciplines, the brain drain to the US, the shortage of experts with specific skills, the shortage of the absolute number of ICT-workers in general, the large supply of high educated labor in emerging economies, such as China and India.
- Important prospective technological innovation challenges in ICT are linked to the convergence of technologies and to the wider integration of technology into products, services and processes and the tighter links between technology and its specific use in applications of ICT.
- Countries with a high level of innovation performance in the ICT sector are also likely to have domestic firms with a high level of international orientation, availability of venture capital and smaller sized firms.
- Socio-cultural factors are important for the future of the ICT sector in Europe. Entrepreneurial behavior of all the involved actors and levels of society must be emphasized, not only in relation to diffusion and ICT-uptake, but also within the ICT sector itself.

One of the major common conditions for the establishment of ICT firms is the existence of a technological infrastructure in terms of a telecom infrastructure, a skilled labor force and the use of ICT in other firms as well as a public demand for ICT. These factors are important for attracting foreign investments to an ICT cluster or an ICT agglomeration (Hansen and Serin, 2010). Studies show that high-tech

companies locate to urban areas and often near other high-tech firms and institutions. There is often more than one high-tech cluster or agglomeration within a defined urban area. These areas are often supported by a strong public infrastructure in terms of research and education institutions. For example there are many capital and core metropolitan regions in Europe which already have very high rates of knowledge-intensive service employment such as Stockholm, London, Brussels, Helsinki, Berlin and the Île-de-France in Paris. Although it is possible to locate elsewhere, it is clear that the ICT sector locate to specific areas, which is close to urban areas and places of higher education, but also to areas where there are other high-tech sectors. These framework conditions are crucial conditions for the development of localization for ICT companies.

So, the framework conditions for ICT cluster are according to Arnoud de Meyer (2008) are:

- Highly developed infrastructure
- Accessible roads
- Central airports
- Dependable public means of transportation
- A well developed technical infrastructure such as speedy and reliable internet- and telephone connections.
- An excellent educational infrastructure. Universities play a role here, but good schools are also important to create skilled workers.
- Local availability of financial engineering skills. There is need for people nearby who are willing to finance risky projects. Financial engineering is about more than having enough money at the right time – you also need access to sophisticated specialists who can find the appropriate financing for the project.
- A society that places a high value on creativity, imagination and entrepreneurship and provides role models, for instance successful people or people who tried and failed but tried again.
- A good legal infrastructure allowing you to enforce contracts and protect intellectual property rights, as well as stable tax laws. Ever changing tax regulations scare businesses and investors off as it makes planning impossible.
- A strong network to access markets

3.2.2 ICT Cluster Policies

Europe is a global force in ICT. The World Wide Web, the mobile GSM standard, the MPEG standard for digital content and ADSL technology were all invented in Europe. Maintaining this leadership position and turning it into a competitive advantage is a significant policy goal. Over the past four years, ICT policies have been a major driver of Europe's economic and social modernization and have made Europe more flexible in times of crisis. ICT accounts for half of the rise in EU productivity and available high-speed broadband is a key to new jobs, new skills, new markets and cutting costs. It is essential to businesses, public services and to making the modern economy work. This has been recognized in the Commission's proposals to speed up economic recovery by smart investments in broadband networks in rural areas. ICT policies are part of European central policies for growth and jobs and they are implemented through various instruments, such as the Structural Funds or the Rural Development Funds. All EU Member States have ICT policies implemented in National Information Society and Innovation policies and consider them a significant contributor to national growth and jobs under the renewed Lisbon agenda, which is a growth and competitiveness strategy aiming at job creation and boosting productivity eventually determining EU's capacity to innovate and compete (European Commission, 2005).

ICT and particularly the fields of microelectronics, computing, electronic communications including broadcasting and the Internet have been accorded a major role within the overall budgets of the EU's framework programs since the 1980s. For instance, the *"User-friendly Information Society"* was the main research stream concerned with the development of ICT within the fifth framework program covering the period 1998–2002 while the *"Information Society Technologies"* research stream was part of the sixth framework program covering the period 2002-2006.

One of the most direct ICT centered program was the ICT Policy Support Program. This program was one of the ways to support the renewed Lisbon agenda stressing the ICT dimension explicitly. It was built on the lessons learned from previous programs like eTen, eContent and MODINIS.

The ICT Policy Support Program aimed at stimulating innovation and competitiveness. It was one of the three specific programs of The Competitiveness

and Innovation Framework Program and ran for the years 2007-2013. The ICT Policy Support Program aimed at stimulating smart sustainable and inclusive growth by accelerating the wider uptake and best use of innovative digital technologies and content by citizens, governments and businesses. It provided EU funding to support the realization of the Digital Agenda for Europe. Program's actions in detail were:

• Development of the single European information space and to strengthening of the internal market for information products and services;

• Stimulation of innovation through a wider adoption of investment in ICTs;

• Development of an inclusive information society, more efficient and effective services in areas of public interest and improvement of the quality of life

Particular emphasis was put the unique solutions that ICT can bring to the societal challenges that lie ahead such as health and ageing, inclusion, energy efficiency, sustainable mobility, culture preservation and learning as well as efficient public administrations. Finally, the program covered technological and non-technological innovations that have moved beyond the final research demonstration phase. It did not support research activities but technical adaptation and integration work in order to achieve the objectives.

In 2005 the Commission presented the i2010 strategy to boost Europe's lead in ICT and to unlock the benefits of the information society for European growth and jobs. Main actions of the strategy were:

- The boost of the single market for businesses and users by the elimination of regulatory barriers and by enhancing regulatory consistency in the telecoms sector and for audiovisual media services
- To motivate ICT research and innovation in Europe by pooling both public and private research funding and focusing it on areas where Europe is or can be a global leader, such as on long-term evolution mobile technology, which will revolutionize wireless broadband, or electronic stability control, which helps prevent car accidents in case of unexpected manoeuvres or on slippery roads
- To ensure that all citizens benefit from Europe's lead in ICT, in particular through first-class online public services available to all; safer, smarter, cleaner and energy-efficient transport and by putting the cultural heritage of the EU at our fingertips by creating the European digital library.

In 2009 the European Commission's Communication proposed "*A Strategy for ICT R&D and Innovation in Europe: Raising the Game*" to establish Europe's industrial and technology leadership in ICT, to make Europe more attractive for ICT investments and skills, and to ensure that its economy and society benefit fully from ICT developments. Based on Europe's assets, the strategy sought to step up the effort in ICT research and innovation and to maximize its impact in today's economic context. The strategy involved increased investments in programs on both the supply and the demand side, stronger collaboration between stakeholders and support for projects that cut across the innovation chain. Main actions of the strategy were:

- Raise both public and private investments in ICT Research Development and Innovation(R&D&I) in Europe and increase their efficiency
- Prioritize ICT R&D&I in Europe into key areas and reduce the fragmentation of efforts
- Facilitate the emergence of new public and private markets for ICT-based innovative solutions

Horizon 2020 is the new EU's program for research and innovation planned to run from 2014 to 2020 with an €80 billion budget. The program is designed to provide funding for every stage of the innovation process from basic research to market uptake, in line with the EU's commitments under the "Innovation Union". It brings together all funding currently provided through the Framework Program for Research & Technological Development, the Competitiveness & Innovation Framework Program and the European Institute of Innovation and Technology.

ICT brings unique responses to society's challenges such as the growing needs for sustainable healthcare and ageing well, for better security and privacy, for a lower carbon economy and for intelligent transport. EU investment supports the ICT research and innovation that can best deliver new business breakthroughs, often on the basis of emerging technologies. In particular, ICT in Horizon 2020 supports the development of ICT in Science, ICT in industrial leadership and ICT in societal challenges.

3.2.3 Case of France

France is the second largest economic power in the European Union (International Monetary Fund, 2012), the fifth largest economy in the world, the sixth largest

exporter of goods and the fifth largest exporter of services (World Trade Organization, 2012).It is also number one in Europe in the aerospace and nuclear sectors (Eurostat, 2012), number two in Europe in the chemical industry and agri-food sectors (Eurostat, 2012) and third largest in ICT and pharmaceutical sectors (European Information Technology Observatory, 2011). France embraces innovation as the country's key to a dynamic and attractive future and that commitment to innovation is illustrated by many incentives for businesses, most notably the best research tax credit system in Europe. France has highly skilled and educated workforce including more researchers per 1,000 employees than in Germany or the UK (Eurostat, 2012). According to OECD, France is the leading European country for investment in education, spending 6.3% of gross domestic product on education, more than the OECD average of 6.0%. It is also first in Europe for the number of higher education graduates in science and technology (OECD, 2012).

France, as one of the leading nations in the ICT sector, has one of the highest rates of electronic communications in Europe. The country attracts a lot of foreign investments in ICT. The Île-de-France region remains the most attractive region for such investments, mainly due to the fact that it encompasses the largest ICT cluster in Europe (especially in central Paris & Hauts-deSeinne). The region ranks second in Europe with regards to the number of foreign investments in ICT. Some of the country's big players in ICT sector are France Telecom, Capgemini, Dassault Systèmes, ST Microelectronics, Motorola, LG Electronics, Atmel, IBM, NXP and Free scale.

Major ICT Clusters are Minalogic in Rhône-Alpes, SYSTEM@TIC in Ile-de-France, Images et Réseaux in Bretagne (Brittany) & Pays de la Loire, Cap Digital in Ile-de-France and Aerospace Valley in Midi-Pyrénées and Aquitaine (figure 16).

Minalogic fosters innovation in the development and production of intelligent miniaturized products and services for industry such as micro

Figure 16: Major ICT Clusters in France (Source: www.investinfrance.org)

nanotechnologies and embedded software intelligence; System@tic specializes in ICT and encompasses complex systems and generic software, electronics and optoelectronics technologies; Images et Réseaux specializes in communication networks and new digital image technologies; Cap Digital specializes in the creation, distribution and multimedia exchange of digital content and finally Aerospace Valley is a leader in the field of aeronautics, space and embedded systems.

Each cluster draws up a five-year strategic plan based on the common vision of different participants (competitivite.gouv.fr). This plan allows the cluster to establish partnerships between participants with recognized, complementary skill; set up collaborative R&D projects, as well as structuring projects such as innovation platforms that can benefit from public subsidies and promote an overall environment that fosters both innovation and growth among the cluster's members. This is accomplished by providing leadership, exchange and support for members in areas such as private funding for firms, industrial property, forward-looking management of jobs and needs for new skills and qualifications, developing international technological partnerships, regional synergies, etc.

The French model of public support to the digital economy fluctuates between two models: a vertical set of specific policies to support technological infrastructure and usages and a horizontal set of policies to create an enabling business. The French government works hard to create a favorable environment for both firms and innovation. It offers assistance for cluster-based research and development, particularly via the Single Interministerial Fund, which provides support for cluster policy and for the forward-looking investments that are part of France's National Loan Program. The *"National Investment Program"*, launched in 2010, draws from a €35 billion state funded budget to enhance the competitiveness of the French economy in five strategic areas:

- Higher education and training
- Research
- SMEs and the industrial sector
- Sustainable development
- Digital economy

The French government provides support for cluster development, at both national and regional level by allocating financial aid to the greatest R&D projects and innovation platforms, through calls for projects from the Single Interministerial Fund and the Investments for the Future Program and through partial financing of cluster governance structures together with local authorities and firms; by relying on local authorities, who may also provide financial support for cluster projects; by helping clusters and their member firms find the best international partners and set up technological connections to them focused on value creation; by providing financial aid for theme-based joint actions, through the intermediary of decentralized government departments and by bringing additional partners on board such as the French National Research Agency which provides financing for R&D projects carried out by cluster members and the Caisse des Dépôts et Consignations which supports innovation platform projects. An innovation platform provides a structure that is open to cluster members, in which participants have access to high-quality facilities and services. The goal is to facilitate R&D projects, testing, and the development of pre-series and prototypes.

The Île-de-France ICT cluster

Île-de-France is the largest ICT cluster in Europe and France's leading region in terms of population and population density in France. This large population concentration clearly plays an important role for the size and structure of the ICT sector (Hansen and Serin, 2010). Ile-de-France is the top region in France and one of the leading regions in the world for software and complex systems. It encompasses 320,000 private-sector and 11,000 public sector jobs in R&D and 42,000 employees working in industrial research and 8,000 in academic research

Located in the centre north of France by the river Seine, Île-de- France is the commercial and industrial centre of the country, but also a cultural and intellectual centre of global importance. The cluster has Europe's highest concentration of R&D and hosts Europe's highest concentration of the ICT sector's 500 leading international groups together with a network of highly innovative SMEs and start-ups.

The European ICT Poles of Excellence (EIPE) research identifies for Paris the following features:

- ICT R&D activity: a diverse public research infrastructure with considerable scientific output, computer science faculties acknowledged for their scientific output, very high private R&D expenditures and ownership of R&D centers. It is one of the major hubs of the European ICT R&D network.
- ICT innovation activity: very high investments in intangibles by ICT firms, number two in Europe in terms of the venture capital funding, but rather average innovation performance and innovation internationalization.
- ICT business activity: a high level of new investments in the ICT sector, a strong business base in the ICT sector, a relatively high level of internationalization of business activity. Paris is one of the key hubs in the ICT business network

The ICT sector in Île-de-France is especially located in the City of Paris, Hauts-de-Seine, Yvelines and Essonne, which are the most central areas for ICT enterprises. Nearly 70,000 local units are engaged in the ICT sector comprising three main categories: telecommunication activities, IT services and R&D. The cluster is especially known for its concentration of players in the field of optic fiber in a small area.

The main strength of the Île-de-France ICT cluster is clearly the strong localization position near a large urban area. Moreover, the area is also dominated by a number of other high-tech firms and industries, and strong educational institutions. There are 70 educational institutions training more than 20,000 ICT students every year. Because of the concentration of large firms from all the sectors ICT companies benefit from better access to vertical markets (automotive equipment, luxury, large retailers, consumer products). The presence of leading companies (pharmaceutical – Sanofi; energy/chemistry – Total and Air Liquide, and automotive) turns out to be a major advantage for the ICT sectors (Simon, 2014).

Especially aerospace industries have a strong position, but also a lot of research laboratories are located in the area run by major industry players such Orange Labs, Technicolor, Thales, Bell Labs, Google, Microsoft, Huawei, Swissvoice and Comelit Immotec. Moreover globally renowned state-funded research bodies are present in the region including CEA (the alternative energies and atomic energy commission), INRIA (the national institute for research in computer science and control), LIP6

(laboratory of computer sciences, Paris 6), CNRS (the national center for scientific research) and IRCAM (institute for research and coordination in acoustics and music). As mentioned before Île-de-France hosts two major ICT clusters, SYSTEM@TIC and Cap Digital.

SYSTEM@TIC is an Île-de-France business cluster created in 2005 devoted to complex systems and ICT. It consists of almost 800 SMEs which represent more than 35000 jobs. SYSTEM@TIC focuses on six working groups sharing strategic visions and monitoring collaborative R&D projects: Automotive & Transport, Free and Open Source Software, Digital Trust & Security, Smart Energy Management, Systems Design and Development Tools and Telecoms. Embedded Systems and Internet of Things, Digital infrastructures, Modeling, Simulation and HPC, Digital Trust, Open Source and Big Data are technological areas developed by SYSTEM@TIC within the Software and Digital sector. Since its emergence the cluster has developed 438 R&D projects representing a total R&D investment of €2.26 billion including €817 millions funded by the French Government, Regional economic development agencies and the Paris-Region local authorities.

Since 2009, SYSTEM@TIC deploys its technologies towards new markets, including ICT & Sustainable Cities and ICT & Health. The commitment of all the clusters' actors in the "cooperation-competition" way creates synergies between SMEs, industrial firms, research laboratories and industrial groups and allows the emergence of innovative projects. Moreover, the cluster benefits from recognized experience in cooperation between its members and their European partners. SYSTEM@TIC is already involved in European and international networks and has opened technological hubs for the benefit of its members in key places on the globe: USA (Boston-Cambridge, MIT), China (Beijing, Z-Park), Tunisia (Tunis, Technopark Elgazala), India (Bangalore) with a view to promote the cluster, the Paris region and its members; to facilitate international partnership projects and to support SME export drive.

SYSTEM@TIC's main challenge is to boost the economy and employment through innovation, training and partnerships. The researchers, industries, training organizations, French national and local governments involved within the cluster have three priorities: consolidate the leadership of major integrators in order to secure the sustainability of their R&D activities; stimulate the creation and development of new high tech businesses with global ambitions and strengthen the region's attractiveness

by developing its image on an international scale in order to attract new global companies' R&D departments. The cluster's main challenge is to develop new approaches to design future generations of complex systems and objects. Moreover, the cluster seeks to attract capital and talents to the region; help laboratories and companies export their patents and products and also face the challenge of growing global competition from large systems integrators, low cost software development and new players in embedded systems.

Cap Digital is the French business cluster for digital content and services. The cluster was created in 2006 as a result of a public policy for the development of economic sectors with strong growth potential located in the same geographical area. The cluster consists of 650 SMEs, 26 major corporations, 55 institutions of higher education and 12 capital investors. Since 2009, the cluster has been implementing the Paris Region's strategy for digital content and services, supporting innovative SMEs in this field.

Cap Digital's main priority is the promotion of competitiveness within the digital content and media industry. Moreover, the cluster provides cluster's members with essential information, networks, and resources including current competitive intelligence, training, partnerships, funding solutions and project reviews. Cap Digital aims to create or promote links across market players; to support collaborative research, development and innovation; to contribute to the dynamics of creative industries in France and globally. Cap Digital contributes to France's international reputation in the digital area by organizing major events such as Futur en Seine and Digital World Festival or by taking part in other prominent events.

European collaborations were one of the main initial objectives of the cluster. To achieve this objective, Cap Digital has created a strategy based on different types of actions. Those actions include strong relationships with European clusters using EU initiatives on R&D programs, and build a European Digital Think Tank; development of platforms such as the THD Open City one, allowing European companies to test their technology or service on a European scale; large European events, to promote collaboration in research, innovation and business, and BtoB meetings between European companies, to develop collaborations and facilitate the access to the European market.

In conclusion, Île-de-France is the largest ICT cluster in Europe and France's leading region in terms of population and population density in France. The main strength of

the cluster is clearly the strong localization position near a large urban area. Moreover, the area is also dominated by a number of other high-tech firms and industries, and strong educational institutions. Because of the concentration of large firms from all the sectors ICT companies benefit from better access to vertical markets. No specific policies have been designed for Il de France, and national schemes are being applied in the region. Public funding plays a positive but not apparently determinant role. Public policies have triggered a lot of projects, but none of these appears to be profitable. In addition, public policies are still fragmented. Private players remain the key to creating economic activity and bringing incentives for other players such as SMEs, research centers and incubators (Simon, 2014).

3.2.4 Case of Sweden

Sweden has a central position in Northern Europe and is the largest market in the Nordic region, which includes Sweden, Denmark, Finland and Norway. Research and development is a strong priority and the country is home to a number of globally recognized research facilities and universities. Sweden is a global leader of innovation with a highly skilled labor force, sophisticated consumers, smooth business procedures, openness to international ownership and a stable economy. Environmental issues are high priority for the country and it is the most sustainable country in the world for its use of renewable energy and low carbon dioxide emissions.

Research and development output in Sweden is well beyond that of other European economies. According to the Innovation Union Scoreboard 2014, published by the European Commission, Sweden is above all other EU member states in terms of innovation. "*Innovation has long been a pillar of Sweden's development, even before it was explicitly highlighted as a key driver of economic growth and social development*" (OECD, 2012). The country has a strong tradition of inventors and this, together with strong relations between research institutes and the private and public sectors, make for a productive, forward-thinking country.

Nowadays Sweden‘s competitiveness is largely based on its strong R&D performance (OECD, 2012), as the country invests more in R&D that any other country in relation to its GDP. The EU target for R&D is three per cent of GDP investment by 2020. Sweden had invested 3.37 per cent by 2012(1% is government spending and 2.37% industry spending). The Swedish Parliament finances R&D through grants paid

directly to higher education institutions and through support for research councils and sectoral research agencies. Several research foundations have been started with public funds. The Swedish Parliament grants R&D funds in all of the ministries' spheres of responsibility. By far the greatest share of publicly funded research in Sweden is conducted in higher education institutions. Universities are considered to be the main R&D and innovation actors (OECD, 2012).

The Swedish innovation system is made up of many organizations under the national innovation agency (VINNOVA). For instance, the industrial research institutes' main mission is to provide research services to the business sector, the Government covering the costs of facilities and skills development. Their work is demand-driven and they act as an interface between academic research and product development in the business sector. VINNOVA promotes sustainable growth through financing of needs-driven R&D of effective innovation systems. Primarily, VINNOVA works within the areas of IT, biotechnology, product development and materials, working life, environmental and energy technology, and transportation (Sweden's national research portal, forskning.se). The Swedish Research Council, the Swedish Foundation for Strategic Research and the Foundation for Knowledge and Competence Development are institutions for supporting fundamental research in all scientific fields.

Sweden has a wealth of skilled professionals and the standard of living is fine. The government invested heavily in education and attracted top international researchers for the creation and diffusion of new knowledge (OECD, 2012). According to OECD the country has the third highest life satisfaction among its 34 member countries. The country has an employment rate of 74 per cent, which makes it fifth among OECD countries. Moreover, 22% of the population aged between 25 and 64 has the equivalent of a Bachelor's degree.

Sweden offers a dynamic business environment for developing ICT and it is also a world leader in converting technology into commercially viable products and applications. Sweden together with Finland is the birthplace of wireless technologies such as GSM, WCDMA, LTE and Bluetooth. Telecoms, electronics, computer game development, web applications and wed design are other ICT related fields developed by Swedish industries. Apple, ARM, Electronic Arts, Ericsson, Google, Huawei, IBM, Intel, Mediatek, Opera, Qualcomm, RIM, Skype and Sony as well as many others are part of Swedish ICT sector. Ericsson for example, has a long history in the

country. Nowadays with 30 billion € revenue and 17000 employees is the dominating player in the Swedish ICT sector.

ICT sector has been growing fast and has been identified as a critical sector for the country's future with a potential to gradually replace traditional manufacturing industry. According to the Swedish IT and Telecom Industries the total turnover in the sector is about 70 billion € with more than 200000 persons employed. This makes the ICT sector one of the most significant parts of the Swedish economy.

The sector is represented in almost all regions of Sweden, but the concentration to the Stockholm area is high. Stockholm is dominating with almost 50% of the ICT workforce, followed by the Gothenburg region with 18% and Malmö-Lund and Linköping regions with 5% each. Table 6 presents the largest Swedish ICT related clusters.

Organization	**Region**	**Field of interest**
Process IT Innovations	Norrbotten, Västerbotten	New IT solutions for the base industry
Internet Bay	Norrbotten, Västerbotten, Oulu	Support local ICT companies to reach international markets
Future Position X	Gävleborg	Geographical IT
Fiber Optic Valley	Gävleborg, Västernorrland	Sensor- and broadband
Compare	Värmland	Competence provision and local establishment of ICT companies
Automation Region	Mälar-valley	Industrial automation
Robot Valley	Västmanland, Södermanland, Örebro	Robotics for industry, logistics and healthcare
Kista Science City	Stockholm	ICT, particularly wireless communication
Skåne	Mobile Heights	Mobile communication
Telecom City	Karlskrona (Blekinge)	Telecommunication and IT

Table 6: ICT-related regional clusters (Source: *Sweden's ICT market report*, Niblaeus, 2013)

The most important of these is Kista Science City, which is a world-leading hotspot in telecom and IT. In addition to these clusters there are a number of Science Parks and Incubation Centers, usually connected to a university. There is a non-profit association called Swedish Incubators & Science Parks (SISP) with national coverage.

SISP has 64 members representing 5000 companies. The focus is growth in knowledge-based companies. Some of these Science Parks have a long and successful history. Many successful ICT companies have their origin in Ideon Innovation in Lund, Chalmers Innovation or Mjärdevi Science Park in Linköping. Lately Minc in Malmö has been noticed in media in connection with Apple's acquisitions of two Swedish companies, Polar Rose and AlgoTrim.

Government's vision for Sweden is to be a leading IT nation, where technology serves the people. The government launched a Digital Agenda in 2011, named "*ICT for everyone"* and the purpose was to include the whole society in the development and use of ICT. It is stated that the government's task is to create good conditions through rules, to formulate policy goals and to reduce obstacles to development. In detail, Digital Agenda's strategic areas based on the user's perspective were:

- easy and safe to use
- services that create benefit
- the need for infrastructure
- the role of ICT for societal development

In addition, the Swedish government has recently taken strong measures to promote e-Government and e-health solutions by initiating respective national strategies as well as authorizing increased public spending. Finally, the Social Security System aims to provide financial security through a stable welfare society for all. The system is administered by the Swedish Social Insurance Agency and covers all Swedish residents.

Stockholm's ICT cluster

Stockholm is the world's sixth most competitive knowledge region, according to the World Knowledge Competitiveness Index 2008. The ranking is based on a large number of variables including level of education, the number of employees in knowledge sectors, the number of registered patents, access to broadband and productivity. A recent report lists Stockholm as the second fastest growing market for venture capital in high-tech sectors. CB insight released its latest list of high-tech's fastest growing markets in terms of deal growth that shows that Stockholm ranks second in the world after Beijing.

In the greater Stockholm area the ICT sector is partly located in the town of Kista 10 km from the city center. The ICT cluster is part of Sollentuna, Järfälla and Sundbyberg municipalities. The town is a research city built after 1970. The initial idea was to create a city where work, housing and commercial town centers were close to each other. Kista Science City is home to about 1,400 companies with 31,000 employees, two-thirds of whom work in one of the cluster's 520 ICT companies.

Kista Science City has made the Stockholm Region an international centre for wireless technology, broadband and mobile applications and services. Research is conducted in the broad range of high-tech areas, mainly related to ICT sector, such as: Materials and Semiconductor Physics; Electronic devices; Optics, Photonics and Quantum Electronics; Electronic and Computer Systems; Communication Systems; Information and software systems / System analysis; Software Development; Communication and Cognition; IT and Society and IT Security.

The region is home to many innovative and leading international companies. World-leading telecom provider Ericsson for example is headquartered in Kista Science City. Ericsson chose Kista to move its headquarters in 2003 because is one of the world's leading ICT clusters and therefore an extremely important place for the management of global research and development; because it offers good access to skilled employees as well as proximity to the Stockholm's Arlanda airport; because it offers active and stimulating networks between firms; attractive environment; excellent geographic location and long-term and strong support from the City of Stockholm. The cluster also has two international academic institutions – The Royal Institute of Technology (KTH) and Stockholm University. Academia, private enterprise and the public sector collaborate in Kista Science City – a partnership that benefits all parties and promotes development in the region.

At the beginning of the century, Kista region was a military training ground for Swedish government. During the 1970s, the government started a housing construction program on the region. The construction of the industrial section of Kista began in 1970s, when companies such as SRA (Svenska Radio Aktiebolaget, which is now part of Ericsson), RIFA (later Ericsson Microelectronics and now Infineon Technologies) and IBM Svenska AB (the Swedish branch of IBM) located in the region. However, the real growth in the number of ICT companies in Kista had mainly occurred since 1992. Nowadays Kista is Sweden's largest corporate center and one of the most important ICT clusters in the world.

There are many foundations helping in the development of the ICT sector in Stockholm such as the Electrum Foundation, Organization of Stockholm Innovation and Growth and Stockholm's Teknikhöjd.

The role of the Electrum Foundation, commissioned by representatives of the ICT sector (Ericsson, IBM, Packetfront), a real estate company, the research institute Acreo, the KTH Royal Institute of Technology, and the Stockholm Municipality, is to stimulate growth and cooperation in research based and innovative growth companies in the ICT sector. The mission is supported by six strategic councils(namely Strategy Council for a Living City, Strategy Council for Higher Education, Skills-Provision and Entrepreneurship, Strategy Council for Innovation, New Growth Businesses and Global Expansion, Strategy Council for Infrastructure for Growth, Strategy Council for Marketing and Strategic Business Recruitment, Strategy Council for Research and the Business Community) focusing on various aspects, including education, competence development and entrepreneurship, research, marketing and innovation. Operational activities are administered by two subsidiaries; the Kista Science City AB and the business incubator STING AB. The Electrum Foundation is active in issues concerning higher ICT training, global growth and innovation and its board comprises leading representatives from Ericsson, Acreo, IBM, Atrium Ljungberg, PacketFront, KTH and the City of Stockholm. The Electrum Foundation is responsible for developing a growth model in accordance with the Triple Helix Model.

Organization of Stockholm Innovation and Growth (STING) is a business incubator, assisting entrepreneurs and innovators from academia, research institutes and the business sector, primarily within the sectors of ICT, media, medtech and cleantech. It is owned by the Electrum Foundation and is a sister company to Kista Science City AB. In order to support entrepreneurs and innovators to develop international growth companies, STING provides business development support, financing, and networking through four different activities:

- start-ups – training program that verifies the business idea
- business lab – from idea to industry, including business testing and coaching
- business accelerator – preparation for market launch; and
- Go Global Medtech – expansion international

Finally, Stockholm's Teknikhöjd supports the commercialization of research results and business ideas originating from students from KTH and the University of Stockholm.

In conclusion, the Swedish economy has a strong international orientation and this is reflected in its innovation system. The high performance of Sweden is also linked to the interplay between large multinational companies, industrial policy, university research, and dynamic public sector organizations. The Swedish industrial system is characterized by a large knowledge intensive and export-oriented manufacturing sector dominated by a small number of large multinational groups grown from traditionally strong domestic industries, such as Ericsson, Volvo, SAAB, AstraZeneca, Electrolux, etc. A few universities (Karolinska Institutet, Lund, Uppsala, Goteborg, Chalmers and Stockholm) and the Swedish Royal Technical Institute dominate Swedish research. Sweden‘s competitiveness is largely based on its strong R&D performance (OECD, 2012), as the country invests more in R&D that any other country in relation to its GDP. ICT sector has been growing fast and has been identified as a critical sector for the country's future with a potential to gradually replace traditional manufacturing industry. Kista region is home to many innovative and leading international companies and one of the world's leading ICT clusters.

Chapter 4: Comparative Analysis

4.0 Introduction

Chapter 4 provides the comparative analysis of the four cases studies presented in the previous section, targeting on the identification of the common initial conditions, policy and business elements that were adopted for the processes of the clusters' formation and further strengthening.

4.1 German, UK's, French and Swedish Clusters

As mentioned in chapter 3 initial conditions to the birth of a high-tech cluster is the presence of a strong scientific or industrial base. The generation of new companies also requires the availability of funding programs tailored to the funding of new high-tech ventures. Finally, a fourth factor is the presence of a favorable environment - normative, social, historical and infrastructural (Chiesa and Chiaroni, 2005).

- Strong scientific base
    - The World Economic Forum rated the UK as having the fifth most efficient labor market in the world as part of its Global Competitiveness Report 2012-2013. 77 percent of biotechnology companies in UK perform R&D activities. UK scientists have been awarded more than 70 Nobel Prizes in biomedical science related disciplines and have contributed to some groundbreaking research such as the DNA double helical structure and animal cloning. Four of the world top ten universities are located in the UK: University of Cambridge, University of Oxford, University College London and Imperial College London. The UK's research base is second only to the USA for number of citations, and is the most productive in the G8. (With only 1% of the world's population, the UK produces 6.9% of world publications, receives 10.9% of citations and 13.8% of citations with highest impact (Witty, 2013). Cambridge cluster is a technology-based business community and a wider research community, encompassing the University of Cambridge and various research institutes such as the Institute of Biotechnology, the Babraham Institute, Addenbrooke's Hospital, the Medical Research Council Laboratory of Molecular Biology, the Sanger Centre and the European Bioinformatics Institute.

- Germany has a strong science base, with high public-sector spending on research, highly rated universities and research publication outputs. Recent efforts to strengthen the science base include increases of up to 20% in the funding mechanisms for university research by both the German Research Foundation and Federal Ministry of education and research. Germany's capital Berlin has 50 institutions of higher education and nine technology parks- the highest number in Germany, while Munich is distinguished by its focus on human-use biologics. Munich's cluster has a fantastic blend of universities, leading hospitals, clinical trial facilities, research institutes and significant government incentives: 350 life science companies including 118 SMEs; two leading universities (Ludwig-Maximilians-Universität and Technische Universität München); three Max Planck Institutes (Biochemistry, Neurobiology and Psychiatry); two university clinics and 60 other hospitals and two incubators specializing in biotechnology. Highly skilled and specialized employees are a key feature of the German labor force. The German workforce comprises over 40 million people – making it the largest pool of ready labor in the EU. According to OECD, Germany has one of the highest rates of graduates with a doctoral degree. With 315 PhD graduates per million inhabitants, it ranks second in a comparison of OECD countries. Germany's share of university students in the sciences, mathematics, computer sciences, and engineering is the second highest in the EU, with 31 percent of all students. German universities have introduced master's and bachelor's degrees for improved international acceptance and comparison.
- France has more researchers per 1,000 employees than in Germany or the UK (Eurostat, 2012). Ile-de-France is the top region in France and one of the leading regions in the world for software and complex systems. It encompasses 320,000 private-sector and 11,000 public-sector jobs in R&D and 42,000 employees working in industrial research and 8,000 in academic research. There are 70 educational institutions in the region is training more than 20,000 ICT students every year. A lot of research laboratories are located in the area run by major industry players along with globally renowned state-funded research bodies.

- Sweden has excellent educational infrastructure and skilled workers. 22% of the population aged between 25 and 64 has the equivalent of a Bachelor's degree. Sweden is also committed to R&D. The EU target for R&D is three per cent of GDP investment by 2020. Sweden had invested 3.37 per cent by 2012. Kista Science City is home to about 1,400 companies with 31,000 employees, two-thirds of whom work in one of the cluster's 520 ICT companies. The Lund University has played a major role in the country‘s transformation, as it is responsible for the commercialization of research, the maintenance of academic standards and the promotion of social development (Benneworth et al., 2009).

- Strong industrial base
  - The UK life sciences industry is composed of over 300 pharmaceutical companies and 4,500 medical technology and biotechnology companies. The London area is home to UCL Partners, one of Europe’s largest academic health science partnerships of hospitals and medical research centers. Some of the strongest biotech companies in Europe are based in the UK’s clusters such as AstraZeneca, Amgen, Millennium, Genzyme and Gilead Sciences, providing a fertile ground for industrial start ups and spin offs. ICT, Creative, Financial and Professional Business Services, Aerospace and Automotive engineering industries are part of British industrial base.
  - Germany’s life science sector is the largest in Europe and the third largest globally. Many global pharmaceutical companies are present in the country’s clusters such as Roche Diagnostics, GSK, Gilead, Sandoz, GE Healthcare, Merck Sharp Dohme, BMS and Daiichi-Sankyo. In addition to the global pharmacy firms a number of European publicly listed biotech companies are present including: 4SC, Bavarian Nordic, Agennix, Medigene, Morphosys and Wilex.
  - France is the second largest economic power in the European Union (International Monetary Fund, 2012), the fifth largest economy in the world, the sixth largest exporter of goods and the fifth largest exporter of services (World Trade Organization, 2012).It is also number one in Europe in the aerospace and nuclear sectors (Eurostat, 2012), number two in

Europe in the chemical industry and agri-food sectors (Eurostat, 2012) and third largest in ICT and pharmaceutical sectors (European Information Technology Observatory, 2011). Some of the country's big players in ICT sector are France Telecom, Capgemini, Dassault Systèmes, ST Microelectronics, Motorola, LG Electronics, Atmel, IBM, NXP and Free scale.

- Sweden together with Finland is the birthplace of wireless technologies such as GSM, WCDMA, LTE and Bluetooth. Telecoms, electronics, computer game development, web applications and wed design. Apple, ARM, Electronic Arts, Ericsson, Google, Huawei, IBM, Intel, Mediatek, Opera, Qualcomm, RIM, Skype and Sony as well as many others are part of Swedish ICT sector. Ericsson for example, has a long history in the country. Nowadays with 30 billion € revenue and 17000 employees is the dominating player in the Swedish ICT sector.

- Availability of funding programs
  - Biotechnology Directorate funds academic biotechnology research while UK Trade and Investment supports overseas investment from early stage development through product commercialization. Larger companies can benefit from the Regional Growth Fund, a £ 2.4 billion fund that supports private capital projects that contribute to economic growth. Other programs and funds like the UK Research Partnership Investment Fund, Invest Northern Ireland, Life Sciences Investment Fund(Wales), Biomedical Catalyst and Scottish Enterprise, offer over £ 500 million in funds and additional economic development incentives solely for life science companies across the UK.
  - BioRegio initiative supports new firm formation in biotechnology clusters. German government invested approximately EUR 5.5 billion in a program called the "Health Research Framework Program of the Federal Government" in the period 2011-2014, funding research into major diseases and individualized therapy approaches, the health care industry and globally networked research efforts. Venture capital firms government-owned or co-owned by the government offer capital for the early stages of company development. A prime example of these programs is High-Tech Gründerfonds, an initiative of the German Federal Ministry

of Economic Affairs and Energy that provides innovative start-ups with funding. High-Tech Gründerfonds is supported by renowned partners from German industry.

- The French government offers assistance for cluster-based research and development, particularly via the Single Interministerial Fund, which provides support for cluster policy and for the forward-looking investments that are part of France's National Loan Program. The *"National Investment Program"*, launched in 2010, draws from a €35 billion state funded budget to enhance the competitiveness of the French economy. French National Research Agency provides financing for R&D projects.
- The Swedish government finances R&D through grants paid directly to higher education institutions and through support for research councils and sectoral research agencies. In addition, several research foundations have been started with public funds. The greatest share of publicly funded research in Sweden is conducted in higher education institutions. VINNOVA, the Swedish Agency for Innovation Systems, promotes sustainable growth through financing of needs-driven R&D of effective innovation systems. Primarily, VINNOVA works within the areas of IT, biotechnology, product development and materials, working life, environmental and energy technology, and transportation (Sweden's national research portal, forskning.se).

- The legal framework, taxation, general infrastructures, parameters like housing, schools, entertainment, climate and landscape, incubators, science parks
  - In UK SMEs can claim relief worth almost 25 pence per every pound of qualifying expenditure, one of the most generous tax breaks in the world. Babraham Bioincubator provides small laboratories and office units on flexible leases. East Region Biotechnology Initiative contributes to cluster cohesion and identity through its networking meetings and annual conference. UK has an attractive living environment and successful entrepreneurs. UK has an integrated system of airports, seaports, rail and road and the largest air transport system in Europe. In April 2013, the Government introduced a preferential regime for profits arising from patents, known as a Patent Box. The Patent Box encourages companies to locate the high-value jobs and

activity associated with the development, manufacture and exploitation of patents in the UK. It also enhances the competitiveness of the UK tax system for high-tech companies that obtain profits from patents.

- Germany is Europe's largest market for medical goods. The country is ranked very highly among innovation indexes, ranking behind only Switzerland in Europe. Germany is one of the world's best places in terms of planning and operating security and also one of the world's leading nations in terms of intellectual property protection and security from organized crime. German legal system is one of the world's most efficient and independent. Social, economic, and political stability provides a solid base for corporate investment projects. Germany has Europe's best and the world's third best infrastructure behind Hong Kong and Singapore (World Economic Forum Global Competitiveness Report, 2013). Finally Germany offers one of the most competitive tax systems of the main industrialized countries and an extensive network of double taxation agreements ensuring that double taxation is ruled out.
- France has the best research tax credit system in Europe. It is also the leading European country for investment in education, spending 6.3% of gross domestic product on education, more than the OECD average of 6.0%. Located at the center of the European Single Market of more than 500 million consumers, France offers investors a strategic springboard into Europe, the Middle East and Africa. France offers world-class infrastructure of extensive high-speed road and rail networks, major ports and airports. According to IMD (2012) France ranks third in Europe and fifth in the world for providing an efficient health infrastructure. This positions the country well ahead of Germany (12th), and the UK (25th).
- According to OECD Sweden has the third highest life satisfaction among its 34 member countries. The Social Security System aims to provide financial security through a stable welfare society for all. Environmental issues are high priority for the country and it is the most sustainable country in the world for its use of renewable energy and low carbon dioxide emissions. The country offers free education system, a state-subsidized healthcare system and well functioning transport networks. Sweden is a world leader when it comes to access to media technology such as digital TV, computers, mobile devices and

internet. 92% of Swedes have access to the internet and courses are available for all ages.

4.2 Conclusions

In conclusion, we presume that all high tech clusters examined in the chapter have common success factors. They offer competitive tax conditions, first class infrastructure and a business friendly environment through effective networks of firms, knowledge institutions, financial and public actors. One of the most important success factors is having access to a strong base of highly productive and skilled workers. For that reason all cluster examined, both ICT and biotechnology, are based near leading universities that provide a regular supply of talent.

Successful clusters require not just the proximity but the collaboration of different cluster actors such as entrepreneurs, investors, universities, research organizations, science parks, firms and local government. Cambridge has developed its own network without proactive support from local or central government. The Cambridge region has a community of highly experienced entrepreneurs and investors willing to give their time and energy to mentor new companies and to promote the cluster. Munich's large firms are well connected with local SMEs – through supply-chain relationships and wider collaboration. The cluster also comprises links to the numerous research institutions as well as links to commercialization leaders. Cluster's success is strongly related to the intervention of public actors. Il de France is dominated by a number of high-tech firms and industries, and strong educational institutions. The commitment of all the cluster actors in the "cooperation-competition" way creates synergies between SMEs, industrial firms, research laboratories and industrial groups and allows the emergence of innovative projects. Finally, the high performance of Sweden is linked to the interplay between large multinational companies, industrial policy, university research, and dynamic public sector organization.

Witty(2013) underlines that universities play a vital role for clusters in "*providing national and international connections, strong links with leading companies in their sectors and the capability to analyze and understand research from across the globe and the markets in which that research can be applied*." For many high-tech clusters, the commercialization of ideas from universities or other organizations is a vital source of innovation. The University of Cambridge has adopted a more proactive

approach to commercial application of academic research. Germany's BioRegio contest promoted business development and commercialization of biotechnology firms. Sweden is a world leader in converting technology into commercially viable products and applications. Stockholm's Teknikhöjd supports the commercialization of research results and business ideas originating from students from KTH and the University of Stockholm.

Successful clusters depend on having strong representation from angel and venture capital groups to ensure businesses have the necessary investment to grow. Cambridge has its own established and self-sustaining group of angel and venture capital firms providing finance, support and contacts to help high-growth companies (Copeland and Scott, 2014). Bio^{M} AG in Munich specializes in financial aspects of business such as seed financing, venture capital fund management and consulting. Sweden has no angel investors and two main venture capital firms.

Successful clusters cannot be composed exclusively of startups; the presence of larger organizations is also vital. Larger organizations can act as hubs, helping by funding in-house research and development; investing in specialized training for their own staff; producing spin outs; offering office space and mentoring to startups; becoming a customer or supplier of local SMEs; improving the reputation of the area; and providing an anchor for local industry. In Munich world-leading technology firms such as BMW, Siemens, Knorr-Bremse and MAN, as well as global insurance companies such as Allianz offer considerable in-house research and development facilities and they are well connected with local SMEs through supply-chain relationships and wider collaboration (Musterd and Kovacs, 2013). The presence of leading companies (pharmaceutical – Sanofi; energy/chemistry – Total and Air Liquide, and automotive) turns out to be a major advantage for the French ICT sector because it benefits from better access to vertical Moreover, major industry players such Orange Labs, Technicolor, Thales, Bell Labs, Google, Microsoft and Huawei offer a lot of research laboratories. Kista Science City in Sweden is home to many innovative and leading international companies. World-leading telecom provider Ericsson for example is headquartered in the region offering business units and R&D networks.

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Chapter 5: Conclusions

5.0 Conclusions

The aim of this dissertation was to examine four different cases of innovation clusters in new high-technology fields. Conclusions on the determinant factors of cluster development such as institutions, public administration, social and economic factors, path dependencies, innovation policies and also the initial conditions of a region such as educational infrastructure and local availability of financial engineering skills and the region's comparative advantages were reached.

Life sciences and biotechnology is a strategically important area for Europe, identified as one of the key enabling technologies to strengthen Europe's global competitiveness, economic growth through increased employment and productivity, and quality of life (European Commission, 2002).Cambridge cluster and Munich cluster were examined as two of the strongest biotech areas worldwide. ICT sector on the other hand is on many aspects the most innovative sector of all in the European Union (Terstriep, 2008). Île de France -the largest ICT cluster in Europe -and Stockholm were examined. The findings of the analysis were compared taking under consideration the conclusions derived from the theoretical approach of the research work. Following the Triple Helix model, we tried to examine the role of each system (economic, political and education) in cluster emergence and evolution.

Cambridge even without proactive support from local or central government, has managed to built an entrepreneurial culture and develop a successful cluster due to the local private sector. High-tech companies and new technologies have spun out from both the university but also from large anchor companies. The outstanding scientific achievements and reputation of Cambridge University has played a key role in cluster development. The Cambridge region has a community of highly experienced entrepreneurs and investors willing to give their time and energy to mentor new companies and to promote the cluster. The diversity and strength of the cluster are closely related to the fact it has been developing for at least fifty years and has consequently achieved critical mass in high tech clusters' key success factors. Other key success factors were the country's strong R&D base; the research base in life sciences and biotechnology; the history of government strategic measures for the area; the access to finance and the lower language barriers.

After World War II, Munich benefited strongly from the immigration of large companies and a skilled labor force from Eastern Germany, and the move of Siemens from Berlin to Munich, which created the basis for the attraction of other German and international firms (Musterd and Kovacs, 2013). The cluster comprises links to numerous research institutions as well as links to commercialization protagonists; numerous universities as well as a large number of partly federal-funded public research institutes. Munich's large firms provide considerable in-house research and development facilities and they are well connected with local SMEs – through supply-chain relationships and wider collaboration (Musterd and Kovacs, 2013). Cluster's success is strongly related to the intervention of public actors: public funding to the creation of new firms; diffusion of entrepreneurial culture among scientists and academics; presence of dedicated infrastructures; presence of a clear and well defined legal framework.

Île-de-France is the largest ICT cluster in Europe and France's leading region in terms of population and population density in France. The main strength of the cluster is clearly the strong localization position near a large urban area. Moreover, the area is also dominated by a number of other high-tech firms and industries, and strong educational institutions. Because of the concentration of large firms from all the sectors ICT companies benefit from better access to vertical markets. The commitment of all the clusters' actors in the "cooperation-competition" way creates synergies between SMEs, industrial firms, research laboratories and industrial groups and allows the emergence of innovative projects. No specific policies have been designed for Il de France, and national schemes are being applied in the region. Public funding plays a positive but not apparently determinant role. Public policies have triggered a lot of projects, but none of these appears to be profitable. In addition, public policies are still fragmented. Private players remain the key to creating economic activity and bringing incentives for other players such as SMEs, research centers and incubators (Simon, 2014).

Swedish economy has a strong international orientation and this is reflected in its innovation system. The high performance of Sweden is also linked to the interplay between large multinational companies, industrial policy, university research, and dynamic public sector organizations. The Swedish industrial system is characterized by a large knowledge intensive and export-oriented manufacturing sector dominated by a small number of large multinational groups grown from traditionally strong

domestic industries, such as Ericsson, Volvo, SAAB, AstraZeneca, Electrolux, etc. A few universities (Karolinska Institutet, Lund, Uppsala, Goteborg, Chalmers and Stockholm) and the Swedish Royal Technical Institute dominate Swedish research. Sweden‘s competitiveness is largely based on its strong R&D performance (OECD, 2012), as the country invests more in R&D that any other country in relation to its GDP. ICT sector has been growing fast and has been identified as a critical sector for the country’s future with a potential to gradually replace traditional manufacturing industry. Kista region is home to many innovative and leading international companies and one of the world's leading ICT clusters.

In conclusion, all high tech clusters examined have common success factors. They offer competitive tax conditions, first class infrastructure and a business friendly environment through effective networks of firms, knowledge institutions, financial and public actors. They are all based near leading universities. They have strong representation from angel and venture capital groups and large organizations are present. However, the role of each system (economic, political and education) is not the same in all examined cases. Cambridge has developed its own network without proactive support from local government due to the scientific achievements and reputation of Cambridge University while Munich has a strong industrial base and support from public actors. No specific policies have been designed for Ile de France and private players are the key to creating economic activity. Sweden has no angel capital groups but government’s commitment to R&D is vital.

Further research

This study examined four different high-tech clusters following the Triple-Helix Model. It would be interesting to further examine them following the Quadruple Helix Model which adds media, creative industries, culture, values, lifestyles, art and the notion of the creative class as a fourth helix. The study focused in ICT and biotechnology clusters but it would be interesting to examine other high tech clusters such as nanotechnology, aerospace and automotive.

References

Andersson, T., Serger, S.S., Soervik, J. and Hansson, W.E. (2004) "The Cluster Policies Whitebook", IKED, Malmo

Bathelt, H., Glückler, J. (2003): Wirtschaftsgeographie: Ökonomische Beziehungen in räumlicher Perspektive (Economic Geography: Economic Relations in Spatial Perspective). 2nd edition. Stuttgart: Ulmer.

Bathelt, H., Malmberg, A., and Maskell, P. (2004) "Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation", *Progress in Human Geography*, **28** (1) 31-56

Benner, Maximilian (2009) "What do we know about clusters? In search of effective cluster policies". SPACES online, Vol. 7, Issue 2009-04: Toronto and Heidelberg: www.spaces-online.com

Bumbacher, U. (1995): The Swiss watch industry. In Enright, M. J., Weder, R. (eds): Studies in Swiss Competitive Advantage. Bern, Berlin, Frankfurt am Main, New York, Paris, Wien: Peter Lang, 113 – 51

Chiesa, V., Chiaroni, D. (2005). "Industrial clusters in biotechnology: Driving forces, development processes, and management practices". London: Imperial College Press.

Coleman, J. S. (1988) "Social capital in the creation of human capital", *American Journal of Sociology*, 94, pp 95-120

Czamanski, S., Ablas, L.A(1979) "Identification of Industrial Clusters and Complexes: A Comparison of Methods and Findings. Urban Studies 16: 61-80.

European Commission (2005) ―Private Sector Interaction in the Decision Making Processes of Public Research Policies: Country Profile: Sweden‖.

Feldman, M. P. (2001): The entrepreneurial event revisited: firm formation in a regional context. Industrial and Corporate Change, 10, 861 - 91.

Fountain, J.(1997) "Social Capital: A Key Enabler of Innovation." In Lewis M. Branscomb and James H. Keller, eds., Investing in Innovation: Creating a Research and Innovation Policy That Works (Cambridge: MIT Press, 1997), p. 87.

Freeman, C. (1991) 'Networks of Innovators: A Synthesis of Research Issues', Research Policy, Vol. 20, 499-514

Frenken, K., Boschma, R. A. (2007): A theoretical framework for evolutionary economic geography: industrial dynamics and urban growth as a branching process. Journal of Economic Geography, 7_ 635 - 49.

Gertler, M. S., Wolfe, D. A. and Garkut, D. (2000) 'No Place Like Home? The Embeddedness of Innovation in a Regional Economy', Review of International Political Economy, Vol. 7 (4) Winter, 688-718

Glückler, J. (2007): Economic geography and the evolution of networks. Journal of Economic Geography, 7: 619 - 34

Hambouch, A. (2008): "Conceptualizing Innovation Clusters and Networks", International Conference on Innovation Networks, Tacoma-Seattle, 14-16 May 2008, 27 p

Jacobs D., DeMan A.P. (1996) "Clusters, Industrial Policy and Firm Strategy: a Menu Approach", Technology Analysis and Strategic Management, vol. 8, n. 4, 425–437

Karlsson, C., (2008) "Handbook of Research on Innovation and Clusters: Cases and Policies", Edward Elgar, Cheltenham

Ketels, C. (2003). "The development of the cluster concept – present experiences and further developments", NRW Conference, Duisburg, Germany, 5 December, pp. 1–25

Ketels, C. (2006). "Michael Porter's Competitiveness Framework—Recent Learnings and New Research Priorities," Journal of Industry, Competition and Trade, Springer, vol. 6(2), pages 115-136

Krugman, P. (1991): Geography and Trade. Leuven: Leuven University Press, Cambridge (Massachusetts), London: MIT Press.

Lécuyer, C. (2000): Fairchild Semiconductor and its influence. In Lee, C.-M., Miller, W. F., Hancock, M. G., Rowen, H. S. (eds) The Silicon Valley Edge: A Habitat for Innovation and Entrepreneurship. Stanford: Stanford University Press, 158 - 83.

Lindqvist, G., Sölvell O. (2011) Ogranizing clusters for innovation: Lessons from city regions in Europe. Clusters and City networks, European Union's Regional Development Fund, EU

Lord Sainsbury, Minister for Science (1999) "Biotechnology Clusters", UK Counsel

Lundvall, B. (1992): Introduction. In Lundvall, B.National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. London: Pinter, 1 - 19.

Maskell, P. (1999): Globalization and industrial competitiveness: the process and consequences of ubiquitification. In Malecki, E. J., Oinas, P. (eds) Making Connections: Technological learning and regional economic change. Alder shot: Ash gate, 35 - 59.

Markusen, A. (1996): Sticky places in slippery space: a typology of industrial districts. Economic Geography, 72: 293 - 313.

Marshall, A. (1920). "Principles of economics (8th ed.)", London: Macmillan. (Original work published 1890)

Martin, R. and Sunley, P. (2003) "Deconstructing Clusters: Chaotic Concept or Policy Panacea?" Journal of Economic Geography, 3, pp 5-35

Musterd, S. & Z. Kovács (eds.) (2013), Place-making and Policies for Competitive Cities, Chichester: Wiley-Blackwell

Mytelka, L. and Farinelli, F. (2000), Local Clusters, Innovation Systems and Sustained Competitiveness, UNU/INTECH Discussion Paper 2005, October 2000.

Nelson R. and Rosenberg N. (1993) "Technical innovation and national systems" National Innovation Systems Oxford University Press, Oxford

Nauwelaers, C. (2003), "Innovative Hot Spots in Europe: Policies to Promote Trans-Border Clusters of Creative Activity", Background Paper on Cluster Policies, European Commission, European Trend Chart on Innovation, Luxembourg.

OECD (1999) "Boosting Innovation: The cluster approach", OECD Publications, Paris

OECD (2001) "Innovative Clusters: Drivers of National Innovation Systems", OECD Publications, Paris

OECD (2002) "Panel III: Social Capital and Clusters", East West Cluster Conference 28-31 October 2002

OECD (2005) "Business Clusters: Promoting Enterprise in Central and Eastern Europe", OECD Publications, Paris

OECD (2006) "Policy Mix for Innovation in Iceland", OECD Publications, Paris

OECD (2007) "Competitive Regional Clusters: National Policy Approaches", OECD Publications, Paris

OECD (2010) "Regional Development Policies in OECD Countries", OECD Publications, Paris

OECD (2012) "OECD Reviews of Innovation Policy: Sweden".

Porter, M. E. (1990) “The Competitive Advantage of Nations”, London: Macmillan

Porter, M.E. (1998) “Location, Clusters and the ‘New’ Microeconomics of Competition”, Business Economics, 33, 1, pp. 7-17

Porter, M.E. (2000) “Location, Competition and Economic Development: Local Clusters in the Global Economy”, Economic Development Quarterly, 14, 1, pp. 15-31.

Porter, M.E. (2003) “The economic performance of regions”, Regional Studies, 37(6&7), August/October, pp 549–78.

Redman, J. (1994) “Understanding State Economics through Industries Studies”. Washington DC: Council of Governor’s Policy Advisors

Roelandt, T. & P. den Hertog (1999) “Cluster analysis and cluster-based policy making in OECD-countries, forthcoming at the OECD in 1999.

Roos, G., Gupta, O., & Fernstrom, L. (2005) “National Innovation Systems: Finland, Sweden & Australia: Learnings for Australia”, The Australian Business Foundation, London.

Rosenfeld, S.A. (1995) “Industrial Strength Strategies: Regional Business Cluster and Public Policy”. Washington, DC. The Aspen Institute

Rosenfeld, S.A. (1997) “Bringing Business Clusters into the Mainstream of Economic Development”, European Planning Studies, vol. 5, n.1, 1–23

Schumpeter, J. A. (1934) “The Theory of Economic Development”, Cambridge, Mass.,

Harvard University Press

Scott, A. J. (1998) Regions and the World Economy: The Coming Shape of Global production, Competition, and Political Order, Oxford, Oxford University Press

Sölvell, Ö., Lindqvist, G. & Ketels, C. (2003) “The Cluster Initiative Greenbook”, Bromma Tryck, Stockholm

Sölvell, Ö., 2009. Clusters – Balancing Evolutionary and Constructive Forces. Stockholm: Ivory Tower Publishers.

Sölvell, Ö., Lindqvist, G. & Ketels, C. (2013) “The Cluster Initiative Greenbook 2.0”, Bromma Tryck, Stockholm

Storper, M., Walker, R. (1989): The Capitalist Imperative: Territory, Technology, and Industrial Growth. New York, Oxford: Basil Blackwell

Swann G.M.P, Prevezer, M., Stout D. “The Dynamics of Industrial Clustering - International Comparisons in Computing and Biotechnology New York: Oxford University Press, 1998, pp. 124- 193.

Utterback, J. (1974), “Innovation in Industry and the Diffusion of Technology”, Science 183, 658-62.

Witty, A. (2013), Encouraging a British Invention Revolution: Sir Andrew Witty’s Review of Universities and Growth,