Fraunhofer Institute Systems and Innovation Research

Thomas Reiss
Axel Thielmann

ComplexEIT - From Nano to Large Electronic Systems

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1 Introduction

The present preliminary report on cluster ecosystems (task 2.2) addresses one of the transversal themes related to innovative solutions for the governance of an European Institute of Technology (EIT) and its Knowledge and Innovation Communities (KICs). In specific, within task 2.2 cluster ecosystems will be explored with a focus on three dimensions which are also outlined in the call for proposal:

- Small and medium-sized enterprises (SMEs),
- Cooperation and
- Virtual and physical clusters.

Small and medium-sized enterprises (SMEs) are important components of cluster ecosystems as they are positioned somewhere in-between scientific research, technology development and industrial application and important drivers at the forefront of technological progress transferring research results into innovative products and speed up the time to market in the commercialisation of technologies. Thus, SMEs are often understood as innovation motor and driving force in economic growth. This is confirmed by more than 75 million Europeans working in SMEs and accounting for more than 60% of industrial jobs in the European Union (EU). Furthermore, the 23 million SMEs in the EU compared to 41.000 large enterprises (LEs) make up about 99% of all enterprises in Europe (European Commission 2008).[1] In addition, SMEs are also an important source of new employment. There is a clear negative relationship between net job creation rates and size of firms (Schreyer 1996, OECD 2002). Finally, EC underlines that, in a changing innovation environment, SMEs and Public Research Organisations are playing an ever increasing role, with licensing of intellectual rights becoming more important[2]. However, SMEs are often faced with problems like a limited visibility or access to international markets as well as enormous administrative, regulations and a lack of human resources. In addition, SMEs often lack financial resources for industrialisation and commercialisation of innovation (like start-ups). They also are concerned with problems related to access to norms and standards. Cluster ecosystems could on the one hand play an important role for SMEs with respect to supporting economic relations, simplifying administrative tasks and providing human and financial resources. On the other hand, SMEs could help to improve the performance of cluster ecosystems, for example by providing high technology components and equipments to

1 http://ec.europa.eu/enterprise/sme/index_en.htm

2 Communication from the Commission to the European parliament, the council and the European economic and social committee: an Intellectual property rights strategy for Europe; COM 2008 465;16.07.2008

big integrators, and not at least lead to a growth in innovation and create new actors (e.g. spin-offs, start-ups). An important matter for the cluster is to identify the value chains for each industrial activity in order to highlight the involvement of each enterprise, including big companies, SMEs and start-ups. This identification of value chains could also facilitate definition of external cooperations.

Task 2.2 will therefore consider in particular three issues related to the role of SMEs in cluster ecosystems. Firstly, the question will be explored how existing SMEs can be integrated into cluster ecosystems, thereby getting access to the knowledge communities within these clusters and also to European and global markets via the international networks which interconnect different cluster ecosystems. The second question deals with the issue of start-up formation. The creation of start-ups within cluster ecosystems is an important means for transferring academic knowledge into commercial applications. Certain factors can hinder or support start-up formation. Therefore, with the perspective of a future EIT and its KICs it is important to work out the configurations of cluster ecosystems which support best start-up formation. The third question to be explored is the capability of the cluster to improve innovation capacity of the existing SMEs and the employment in these SMEs. This matter within cluster ecosystems is also an important means for transferring academic knowledge into commercial applications.

External cooperation is the second main issue of task 2.2, which deals with interregional collaboration between several cluster ecosystems. Such cooperation basically helps to enhance the capabilities of individual clusters with respect to several functional features of such systems.

More and new resources in terms of skills, capacities, infrastructures become available for the cooperating systems. Complementarities in terms of scientific and/or technological focal activities can be used. The diversity of different technological options is increased and flexibility of potential actions is enhanced. In total, more potential choices for developing solutions to the challenges of complexity become available. In addition, interregional clusters could offer new opportunities for SMEs for getting access to larger European and international markets and to cooperations with large international firms and public research organisations. Against this background the shaping forces of international cluster collaborations considering all actors of the knowledge triangle (education, research, innovation) will be explored. In this context also the role of cities and regions will be analysed. Additional research questions related to intercluster collaborations are the following:

- What will be the added value of interregional clusters compared to stand-alone clusters with respect to mastering complexity?

- Which governance structures in an EIT and its KICs would support best interregional cluster collaboration?
- Which structural and functional features should be considered in designing such governance structures?

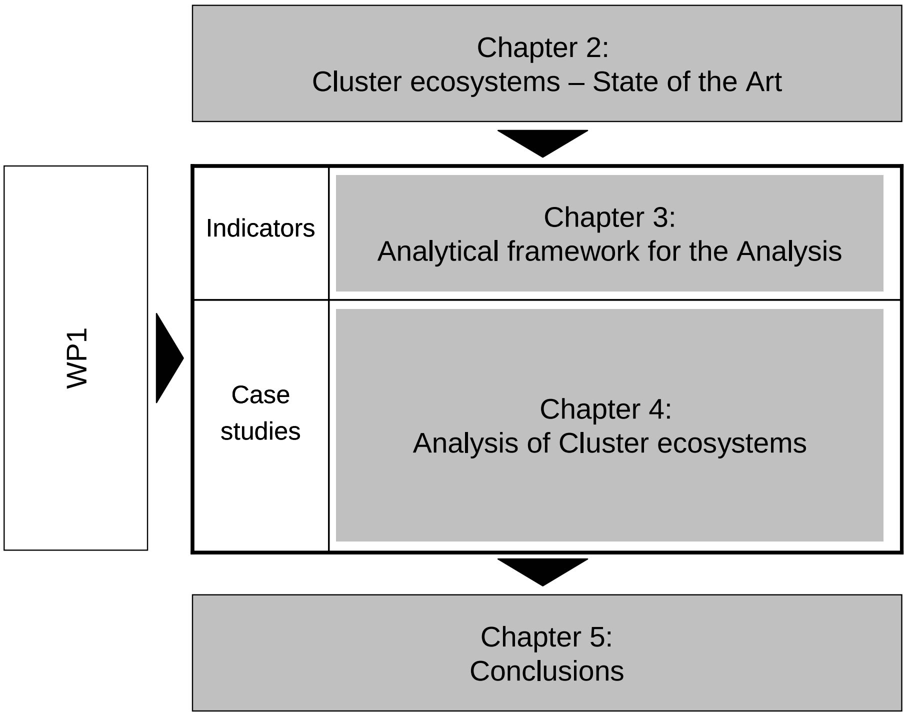
According to the original understanding of innovation clusters (e.g. Porter 1990, 2001), geographic proximity is a key feature of cluster ecosystems since it facilitates the utilisation of some of the key benefits of cluster ecosystems such as sharing tacit knowledge, knowledge spillover or using common infrastructures. In addition to such physical clusters, high-speed communication networks also allow for cluster type collaboration where resources and expertise are geographically distributed. Geographically concentrated clusters also have the important advantage that informal and spontaneous meetings can be arranged without time consuming preparations, thus supporting the exchange of creative ideas and innovative realisations.

Virtual and physical cluster ecosystems will be considered and opposed within task 2.2 as well. With a perspective of a future EIT and its KICs the question is not whether one or the other concept should be favoured. Rather, it is important to analyse how the two concepts could complement and nourish each other.

The above introductory discussion already shows that obviously SMEs are an important ingredient or basis for innovative and efficient cluster ecosystems, whereas external cooperations provide a dynamic component in a cluster, optimised by a virtual, physical or combined infrastructure.

Our approach within task 2.2 comprises the following major steps, which are indicated in Figure 1. Firstly, based on scientific literature, the state-of-the-art of cluster ecosystems research with a particular focus on the three issues to be considered (SMEs, external cooperation, virtual and physical clusters) will be analysed in chapter 2. Secondly, based on the state-of-the-art analysis a framework for the analysis of the empirical WP1 case studies will be elaborated in chapter 3. Within the analytical framework a set of input and output indicators for cluster ecosystems will be identified, characterised and considered with respect to their suitability as measure for the assessment of cluster ecosystems and the availability of the needed data. Thirdly, using this framework the case studies of WP1 will be analysed in chapter 4. Missing information will be complemented by interviews with representatives of the WP1 cases. Finally, based on the theoretical and the empirical analysis conclusions for the design of a future EIT and its KICs will be drawn in chapter 5.

Figure 1: Schematic overview of the major steps in the present preliminary report (Task 2.2 of WP2) and the link to the case studies prepared within WP1



2 Cluster ecosystems – State-of-the-art

2.1 The cluster concept

The localisation of economic activities has been studied since many decades and already in the late nineteenth century an agglomeration of related industrial activities was observed and explained under the heading of "industrial districts" (Marshall 1890). Following this early work, a relationship between geographic agglomeration and scale economies was observed and explained among others by potential benefits of minimising production and delivery costs in the case of agglomeration (Weber 1909).

The discussion on the geographic concentration of industrial activities was further enriched and expanded by a number of theoretical and empirical contributions. An important influence was the work of Schumpeter (1934), who pointed out the role of technological change in industrial development and the significance of innovation with respect to products, processes and organisations. Within his concepts the entrepreneur was highlighted as a key actor in innovation searching for new combinations, and playing an important role in the evolutionary process of creative destruction which contributes to the renewal of industrial structures. As an important incentive for innovation competition between different firms was outlined (Arrow 1962) and the interrelationship between market structures and innovation was highlighted (Nelson and Winter 1982).

Considering the current discussions of "knowledge-based economies" and "learning societies" the realisation of the role of knowledge exchange and proximity of actors was an important step in the economic discussion. The concept of tacit knowledge versus codified information was introduced by Polanyi (1962) with the important notion that some important exchanges are not communicated formally since knowledge cannot be fully codified. Rather, tacit knowledge which is attached to specific individuals or structures plays an important role.

Another important strand of research is concentrated on the issue of flexible industrial structures and organisations. In this context the role of small and medium-sized enterprises (SMEs) was considered crucial in this setting up of flexible and dynamic structures (Sengenberger et al. 1990). Inter-firm collaboration and relations to services created by the government and trade associations were some of the factors contributing to the creation of flexible structures.

All these various contributions had in common the notion that the regional concentration of industrial actors complemented by their interaction with external institutions, such as research units, universities or governmental bodies enhances the innovative performance of these actors thus creating benefits at a regional level. The concept of clusters finally was related to the competitiveness of industries and of nations (Porter 1990). According to Porter (1998)

"Clusters are a geographically proximate group of interconnected companies and associated institutions in a particular field linked by commonalities and complementarities. Clusters encompass an array of linked industries and other entities important to competition including governmental and other institutions

- *such as universities,*
- *standard setting agencies,*
- *think tanks,*
- *vocational training providers and trade associations".*

For understanding the development of collaborative networks between cluster actors Porter (1990) developed a "diamond model" which comprises four sets of interrelated forces to explain industrial dynamics in cluster settings. The first set consists of factor conditions which are available as inputs to firms including, for example, human resources, capital resources, physical infrastructures, administrative infrastructure, information infrastructure and scientific and technological infrastructure. The second group of determinants describes the context for firm strategy and rivalry. This set includes, for example, the local context and rules that encourage investment, the location of public investments and the local context that fosters competition. The third component of the diamond refers to demand conditions, arguing that sophisticated and demanding customers, customer needs that anticipate those elsewhere, or local demand in specialised segments that can be served nationally and globally are important driving forces of cluster development. Finally, the fourth determinants are related and supportive industries which includes, for example, the access to capable, locally based suppliers and firms in related fields. Porters diamond has been used widely in the literature for explaining cluster phenomena.

One of the main ideas of the cluster concept, namely that mutual exchange of information and collaboration are important driving forces in innovation, is well reflected in the innovation system literature, which points out that innovation is not undertaken in isolation. Rather innovation is the result of collaboration among a wide variety of actors. Research facilities, universities, small and medium-sized companies, multinational corporate groups, public and private investors, government authorities, customers and others, exchange knowledge, technologies and goods which they modify and recombine to generate innovation. Accordingly, the collaboration between innovators and institutions accompanying and supporting innovation plays a central role as does the integration of the innovation user. Innovation is thus a system process (Freeman 1987, Lundvall 1992, Nelson 1993, Edquist 1997).

This short review of the literature has shown that currently there is no exact definition of cluster. Rather the cluster concept can be considered as a puzzle of different pieces which may vary in their size, role or influence in the whole cluster ecosystem. There might be a stronger focus on the supply side, for example, emphasising those factors driving technological progress and resulting innovations. In other cases the demand side including the pull forces of the market, marketing skills, governance and the role of entrepreneurs may be of particular importance. Considering the structure of clusters a focus could be on the actors in the cluster or alternatively on the linkages and interactions between the individual actors.

2.2 Main elements of clusters

In this section the main elements of clusters as discussed in the literature will be presented. The section is based largely on "The Cluster Policies White Book" by Andersson et al. (2004).

Geographical concentration

Geographical proximity is at the core of the cluster concept for various reasons. On the one hand there are "hard factors" related to benefits due to geographical proximity. These include, for example, the availability of specific natural resources, opportunities for lowering transaction costs especially in accessing and transferring knowledge, economies of scale and scope gained from a limited number of plants in a given geographic area, specialisation of supply from factor markets with respect to labour, capital or technology sources, the interplay with local customers triggering learning processes and more sophisticated demand.

On the other hand there are also important "soft factors" related to geographic proximity. First of all, proximity facilitates informal exchange and the accumulation of tacit knowledge. Despite a broad variety of technical solutions for communication with any individual at any distance at any place at any time, information exchange via face-to-face contact and the sharing of day-to-day experience contribute a specific quality of knowledge exchange and learning which cannot be substituted by technical solutions (Utterback 1974, Saxenian 1988). In addition, attractive conditions for working and living may also play an important role for cluster development as shown, for example, by Florida (2002). The soft factors of clusters are related to the concept of social capital which is comprised of elements such as family, school, local communities, firms, civil society, public sector institutions, gender, and ethnicity. The central idea behind the notion of social capital is that social networks have a value which stimulates members of these networks to do things for each other (Putnam 1993, 2000). In this context, trust is a crucial factor for making clusters work.

Specialisation

Cluster actors usually are linked together via a core activity which provides a direction for cluster development and cluster performance. A key issue of this specialisation is knowledge spillover. Individuals working for the same mission tend to share experience formally for example via professional bounds or even more important informally via the "cafeteria effect". It is important that specialisation does not imply that clusters need to focus on a specific industrial sector or branch. Rather, a common activity could also bridge different industries. For example, biotechnology clusters could combine different industries such as food, health care, agriculture or environment.

Actors

Firms are the key actors of clusters, and in particular small and medium-sized firms play an important role as has been shown by a recent mapping of European clusters (Commission 2003a). However, in particular considering insights on how innovation is generated in a systemic way by the interplay of different actors, it is clear that also within clusters a variety of different types of actors is beneficial. According to Sölvell et al. (2003) four main categories of clusters actors can be differentiated:

- companies,
- governments,
- the research community and
- financial institutions.

In addition there are also so-called "institutions for collaboration" defined as formal or informal actors promoting interest in the cluster activity among the actors involved.

Cluster dynamics and linkages: Competition and cooperation

Also within clusters firms naturally compete. This competition creates the pressure for improvement, thus, exerting an important driving force for innovation. At the same time firms within a cluster cooperate around a core activity. Cooperation enables complementation of missing skills via the integration of external knowledge. In addition, cooperation allows pooling of resources and risks, thus, enabling firms to achieve economies of scale and scope. A central precondition of cooperation is trust. In particular, tacit knowledge will only be exchanged if the involved actors can trust each other that information will not be misused. Trust can be enhanced by sharing a common vision and sharing the believe that mutual exchange of information will create benefits that not only compensate but outweigh potential risks of misuse. Thus, creating trust is a key challenge in cluster development.

Not only internal relationships are important for cluster development. In addition, extra-cluster relationships at an international level are often crucial. Thereby, clusters on the one hand are able to tap into frontier knowledge created internationally. On the other hand, global markets can be accessed. Thus, clusters can be conceived as local nodes in global networks (Maskell and Malmberg 1999).

Critical mass

Critical mass is important to allow for the required internal dynamics of a cluster. It is obvious that economies of scale and scope can only be realised if a sufficient number of different actors is engaged in a cluster. Critical mass also contributes to stability of a cluster making it more resistant to exogenous shocks or other events such as loosing "key companies". There is no clear definition in quantitative terms what critical mass means. Rather it is important to realise that the issue of critical mass is also depending on the technologies and industries pursued by the cluster. In some fields, such as motor vehicles or pharmaceuticals, achieving critical mass is very demanding. In other fields, for example, in textiles this may not be the case.

The cluster life cycle

Clusters are long-term endeavours exerting a certain dynamic and following an inherent logic in their development which can be differentiated into the following phases: In the agglomeration phase the number of companies and actors is situated in a certain region. In the next step, the emerging cluster phase, a number of actors in the agglomeration start to cooperate around a core activity realising common opportunities through their linkage. More actors are moving into the emerging cluster sharing joint activities leading to a "developing cluster". Finally, a cluster has reached critical mass of actors, has developed relations outside of the cluster and is characterised by an internal dynamics in the sense of firm creation, joint ventures and others. As markets, technologies and processes may change in the long-run, transformations within the cluster will emerge and a given cluster can also give rise to new specialised or differently oriented sub-clusters starting the life cycle again.

2.3 Types of clusters

Clusters can be categorised according to a functional and to a spatial dimension. Functionally linked systems are commonly referred to as **industrial clusters**. These focus on competitiveness within sectors. All actors, resources and activities that are required to develop, produce and market various types of goods and services combine within an industrial cluster. Such clusters are not confined to a narrow urban area. Rather, they tend to have a rather broad scope, in some cases even covering a state or a nation such as, for example, the Finnish Forest Cluster.

Along the spatial dimension **regional** or **localised clusters** can be categorised as spatial agglomeration of similar and related economic activities. SMEs commonly play an important role in such clusters and social capital and geographical proximity are important features of such clusters. A variation of regional clusters is the **knowledge base cluster** which is spatially confined but has a stronger focus on innovation and technical progress. Another categorisation of clusters considers their role in the value chain. Clusters may cover different parts of the value chain. There are examples of **research clusters**, of **production clusters** or of **marketing and sales clusters**, for example, in the tourism industry.

2.4 Clusters and innovation

Innovation is not only concerned with technical advances in terms of the creation of new products or processes. Rather, considering especially the knowledge-driven society of the future, non-technical innovations are becoming increasingly important. Here a distinction can be made between organisational innovations and service innovations. Organisational innovations at a firm level often establish the initial prerequisites for the development of technological innovations. In addition, organisational innovations are becoming increasingly important in cooperative arrangements between different innovation actors along the value chain. Service innovations are playing an important role in the highly competitive environments of industrialised nations because they allow to enrich the value of products by offering complete problem solutions consisting of products and product-related services. Such services include, for example, consulting, training, maintenance and initial implementation of systems.

With such a broad understanding of innovation it becomes obvious that cluster settings constitute important enabling conditions for innovation. There is a broad agreement in the literature about the connection between clusters and innovation (Andersson et al. 2004). As most important features of clusters favouring innovation the pooling of highly skilled labour forces, specialised suppliers and intense rivalry (Audretsch and Feldman

1996, Porter 1990), the gathering of venture capitalists, and the presence of demanding lead customers have been identified (Bengtsson and Sölvell 2004).

Recent research (Cotic-Svetina et al. 2008) emphasised in particular the important role of the interaction of firms with the local labour market as driving force for innovation. These authors also find that the interaction with local firms is negatively related to innovation performance. On the other hand, the interaction with external firms was identified as an important driving factor for innovation, supporting the notion that inter-cluster cooperation is an important factor in keeping clusters innovative (see chapter 1). The importance of the local labour market as input factor for knowledge production was also underlined by Tappeiner et al. (2008) who observe that the spatial autocorrelation of innovation indicators (e.g. patents) cannot be explained by knowledge spillover. Rather, the spatial location of input factors such as R&D investment and human capital sufficiently explain autocorrelation.

2.5 Success factors for cluster ecosystems

In this section success factors for the development of cluster ecosystems will be discussed. The issues of existing SME growth, start-up/spin-off creation and new SME integration, inter-cluster collaboration, and virtual versus physical clusters will be included. The chapter is divided into two subsections: a first one which is based on the so-called Global Cluster Initiative Survey and a second one based on experience with the Silicon Valley.

2.5.1 Experience from the Global Cluster Initiative Survey

In 2003 Sölvell et al. (2003) reported the results of a Global Cluster Initiative Survey in the "cluster initiative greenbook". During this survey more than 500 cluster initiatives around the world were identified and surveyed. 238 clusters completed the survey providing a broad empirical basis for analysing and discussing critical features of clusters. In the following, based on this survey, factors will be presented that have been identified as supportive for the attraction of new firms in clusters.

A first group of factors relates to **cluster settings**. The following factors were identified as supportive for firm attraction:

- the presence of an advanced scientific community,

- a high level of trust, in particular between companies, between companies and academia and between companies and governmental bodies[3],
- a long history of a cluster,
- the strength of a cluster in terms of regional or national importance of the cluster, the presence of many companies and the international competitiveness of a cluster,
- the presence of international competitive buyers and suppliers in the cluster and
- the existence of tight networks between buyers and suppliers.

A second group of factors can be related to the **objectives** of the cluster including the following:

- having the explicit objective of attracting firms and talents,
- having in place promotion measures for spin-offs,
- supporting foreign direct investment,
- lobbying the government for new infrastructure and
- fostering personal networks among the people within the cluster.

Finally, also several **cluster processes** were identified as correlating positively with attracting new firms:

- those clusters which have done research for identifying attractive industry sectors in advance are performing better in attracting new firms;
- clusters which have own budgets, own offices and are used to exchange experience with clusters in the same industry (not necessarily in the same region) are more successful.

Interestingly, a number of factors have no significant effect on the attraction of new firms including, for example,

- the source of financing of cluster activities being it private or public,
- the specific picking of companies for joining the cluster by government,
- efforts to avoid competition between firms and cluster and
- the setting up of clusters of firms only from one level of the value chain.

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3 Experience from the GAIA ICT cluster (www.gaia.es) also points to a changing meaning of trust over time. While two or three decades ago trust could be considered as a value per se, nowadays trust means "do not copy" and formal agreements between cluster actors are required to secure this principle. It is selfevident that such a trend towards more formal relationships limits the participation of SMEs in cluster activities.

Aiming mainly at domestic firms as members of the cluster has even a negative impact on attracting new firms.

2.5.2 Experience from the Silicon Valley

Silicon Valley is the most famous and the most dynamic economic region in the world. It is the largest concentration of venture capital in the world receiving the greatest amount of investments (Wonglimpiyarat 2006). Since 1992 more than 200.000 new jobs have been created in Silicon Valley and in the 1990s over 29.000 new companies emerged (Wonglimpiyarat 2006). Using the "diamond model" of Porter (s. chapter 2.1) Wonglimpiyarat (2006) identified success factors which were crucial for the development of Silicon Valley. It should be pointed out that Silicon Valley may not be the best benchmark for European cluster ecosystems since it is a very unique location which cannot be copied or transferred to any other location. Still, the experience of Silicon Valley can serve as a best practise example offering lessons to be considered in other regions of the world. The first group of success factors refers to the **factor conditions** of Porter's diamond (Porter 1990) and includes the following factors:

- As a key success factor the cooperation and the building of dense networks between entrepreneurs, research units, universities and venture capital institutions was identified.
- Capital sources for creating firms composed of stock markets, business angel networks and venture capitals play a crucial role.
- The presence of research centres and universities is as beneficial as the availability of skilled human resources.

With respect to the **context for firm strategy and rivalry** (Porter 1990) Wonglimpiyarat (2006) identified the following supportive conditions:

- First of all, the entrepreneurial culture is referred to which is characterised by risk-taking attitudes aiming for personal achievements and wealth which are supported by a climate of failure tolerance.
- Information sharing between competing firms is an important factor.
- Finally, tax policies can provide a supportive environment including, for example, tax exempt for capital gains, the support of pension funds as investment incentives and the support of the creation of a venture capital market.

Concerning the **demand conditions** (Porter 1990) the presence of sophisticated local customers and the collaboration with local demand for identifying future needs were identified as important factors (Wonglimpiyarat 2006).

Finally, with respect to **supporting industries** the support of industrial parks and specialised research centres by governmental initiatives as well as governmental initiatives for supporting related industries turned out to positively influence industrial development in Silicon Valley.

2.5.3 Conclusions on cluster ecosystems

The presented empirical analyses point to a number of key issues characterising successful cluster ecosystems:

- Dense networks between all actors of the knowledge triangle (education, research, industry) are playing a crucial role for the success of clusters, in particular if they are complemented by vertical cooperations between suppliers and buyers. This implies that not only the knowledge and innovation supply side needs to be well developed, but also the demand side. The interaction with sophisticated local customers is important for identifying future needs directing the development of the cluster ecosystem. A prerequisite for setting up and maintaining such dense networks is a high level of trust between all involved actors and in particular between the industrial actors. At the same time competition between firms is important. In addition to the networks between different organisations of cluster ecosystems also personal networks between people are supportive to cluster development.
- The outstanding role of networks and trust between the actors of cluster ecosystem leads to the question how these factors can be supported best in different types of clusters. In particular it seems difficult to create and maintain such networks in virtual cluster settings.
- On the other hand, virtual clusters could contribute to the success of physical clusters by providing additional ideas and resources via inter-cluster collaboration. Thereby, the development of physical clusters could be enhanced by an additional virtual cooperation mode.
- The observation that a long history and existing strengths of a cluster ecosystem positively correlate with the attraction of additional firms, points to the notion that it will be rather difficult to "create" successful cluster ecosystems from scratch. Rather it seems important to build on existing strengths. This notion is supported by the observation that the presence of an excellent scientific community and the existence of attractive industry sectors are important factors for the success of cluster ecosystems.
- Policy could play a role at different levels in supporting cluster ecosystems. First of all, supporting the development of an excellent scientific community could be named as a policy task of high priority. This scientific community, according to Commission Recommendation on the management of intellectual property in knowledge transfer activities and code of practice for universities and other public research organisa-

tions[4] should also demonstrate good practices in technological transfer and in Intellectual property management. Secondly, the provision of infrastructure for cluster ecosystems is important at several levels, starting from budgets and office space for cluster management, extending to physical infrastructures such as information networks, and in particular providing all types of supports for the setting up of cooperations and networks between the cluster actors. Thirdly, in particular the experience from Silicon Valley points to the importance of tax policies at a cluster level. Finally, policy could also guide cluster development by taking care that all the representatives of the knowledge triangle including buyer-supplier relationships get well established in cluster ecosystems.

- Furthermore, policy furthering an efficient technological transfer (TT) between academia and industry is important. Policy should be optimised for a given ecosystem and to given value chains. For example, such a policy could distinguish transfer from academia to industrial end users and transfer to industrial manufacturer of components or equipments, or transfer to big industrial companies or to SMEs. A given percentage of funding of a cluster could be reserved to programs of TT between academia and SMEs, like in the FP7 Capacity programs ("research for SMEs or associations of SMEs"). Similar measures could be studied for TT between academia and big companies. Thus, supporting the development of TT models adapted to cluster ecosystem (big industrial companies, SMEs and start-ups/spin-offs) in order to maximise value and job creation, would also be a policy task of high priority.
- Policies targeting industrial developments made by SMEs to adapt their products for big industrial companies needs, possibly supported by institutional funding, would also be important. An example for such an approach is the "Passerelle" scheme in France proposed by OSEO[5] and the high tech SME association "Comité Richelieu": An end user (big company) needs a component adapted from an existing component of the SME and the SME develops the adaptation. The financial costs of the SME’s development is funded in a shared way: 1/3 by end user, 1/3 by SME, 1/3 by OSEO.
- Policies on financial support to SMEs in case of TT from academia would also be important, in order to finance industrialisation and commercialisation. Business angels or venture capital institutions could be involved in such cases, in a similar way as in the case of start-up creation. Thus, the creation of suitable framework conditions furthering the attraction of such private capital could be a policy task.
- Norms and standards are important in some ICT areas and SMEs usually do not have the resources to participate in respective activities (e.g. meetings, committees, lobbying). Accordingly, cluster policies could close this gap by providing suitable supportive measures (e.g. support for participating in workshops, provision of information on these issues, setting up of a "norms and standards board" to coordinate respective activities).

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4 EC COM (2008) 1329 10.04.2008

5 www.oseo.fr

3 Analytical framework for the analysis of Clusters

The state-of-the-art analysis in chapter 2 has already brought some insights into the main elements and most important factors of cluster ecosystems and helps to identify crucial indicators for measuring the performance of clusters of different type. In order to develop a robust analytical framework for the systematic analysis of cluster ecosystems, information from chapter 2 is used as an input together with the background information from the case studies of WP1. This approach has been shown schematically in Figure 1 and provides the basis for the analysis in chapter 4.

3.1 Framework dimensions

A careful choice of the dimensions defining the framework is essential for the reliable analysis of clusters. The case studies providing one of these dimensions will be analysed systematically with respect to the main characteristics indicating advantages and disadvantages of the considered cluster types. A first step is therefore the identification and description of such indicators.

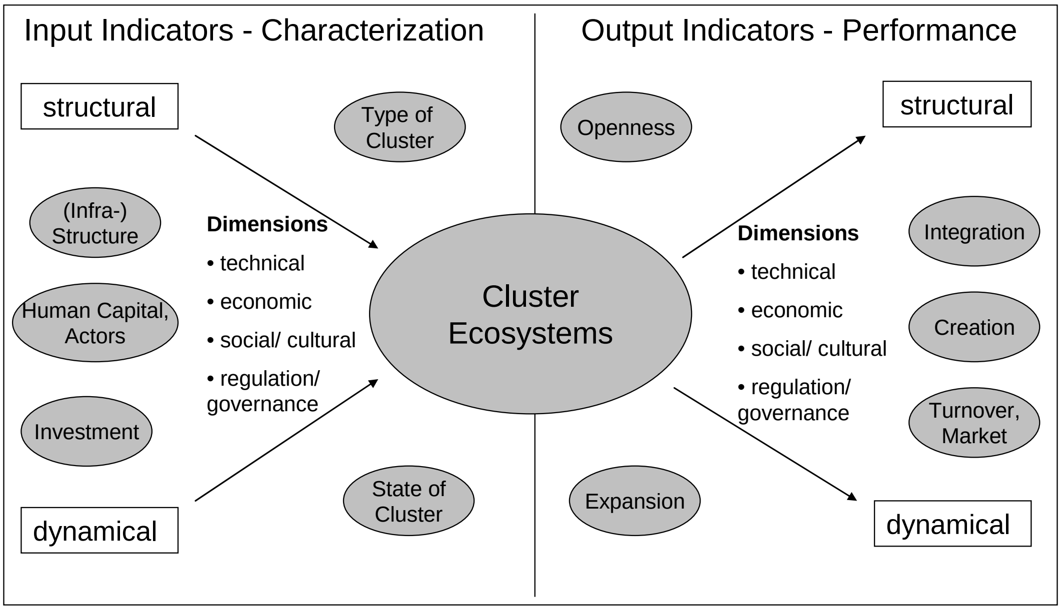
3.1.1 Characterisation and Indicators

The "diamond model" developed by Porter (1990) comprising four sets of forces or "indicators" explaining the industrial dynamics in cluster settings has been discussed in chapter 2 and serves as one ingredient for the development of the analytical framework. Porter identified social, scientific, technical, etc. infrastructures, public and private investment as well as supply and demand conditions as main forces.

Together with a further in depth analysis of available state-of-the-art literature on cluster ecosystems we identified a set of input indicators characterising cluster ecosystems and a set of output indicators for measuring their performance. We find that both sets of indicators comprise structural and dynamic components. On both sides the indicators relate to scientific-technical, economic, social/cultural or regulation/governance dimensions (see Figure 2).

In the following we list and explain in detail the various input and output indicators as identified and verified for relevance with respect to data availability from the case studies. As input indicators five main groups, focusing on different cluster aspects have been identified: the type of clusters, (infra-)structure, human capital/actors, investment and state of clusters. The output indicators are grouped according to aspects of openness, integration, creation, turnover/market and expansion as shown in Figure 2 and explained in Table 1 and Table 2.

Figure 2: Input and Output indicators for cluster ecosystems.



Beginning with the main structural characterisation, three indicators for **types of clusters** are considered. First, vertical and horizontal clusters are distinguished. Vertical clusters cover activities along the whole value chain, integrating research, development up to supplier and demander or consumer. Horizontal clusters are active in a specific segment of the value chain. Second, virtual cluster types characterised by geographically distributed actors or members (not partners) of the cluster are compared to physical or geographically concentrated clusters with significant proximity or density of the members, e.g. in certain regions or in and around cities. Third, cluster may focus on specific thematics with respect to defined technology sectors or market segments (e.g. the semiconductor industry). The opposite type is a cluster with a broad thematic orientation being active in several research and technology sectors (e.g. nanoelectronics, nanobiotechnology, sensor systems, etc.) with relevance to several market sectors.

The above cluster type indicators are among the most fundamental but also most important indicators for the characterisation of clusters, since thematic scope, activities along the value chain and geographical aspects are closely related to the relevance of external cooperations for the clusters and the possibility to integrate SMEs or create start ups..

The next group of input indicators relates to the cluster **infrastructure** and can be characterised by several aspects: social (e.g. facilities for social interaction of staff inside the cluster), quality of life (facilities for private activities outside the cluster, e.g. sports in local environment, region, proximity to large cities, culture), technical (e.g. laboratory space), SME distribution (which may be very concentrated or widely scattered), demand conditions (relating to economic aspects, asking for presence and strength of lead users), density of network (regarding the cooperation of the actors or staff, e.g. by means of collaborative projects), physical or virtual management (e.g. presence of separate office and allocation of budget for cluster management, which may be different in virtual or physical clusters) as well as the hierarchy (which may be flat or not). Furthermore, the role of local authorities as well as regulation and governance aspects may be additionally considered. Also, the second group of input indicators has a significant relevance to questions of SME integration and cooperations. These aspects will be of different importance depending on the type of cluster.

The third group of input indicators relates to **staff and actors** of the cluster. The number of professors gives an indication of the strength of education activities, programs and knowledge transfer. Also the number of students or the ratio of students to professors may provide further insights to questions of education. The number of researchers indicates the innovation potential and competitiveness in research and development, and the total number of staff (including non technical staff) or relation of technical staff to the total employment may give insights to the productivity of a cluster.

On a more global level, **actors** of a cluster can be characterised by counting the total number of units or large firms, SMEs and public units, separately. A large number of staff and actors should be closely connected to aspects of effective cluster management and infrastructures and also depend on the cluster type. With regard to SME integration, the number of units is more relevant than the number of total staff, for example. For start-up/spin-off creation, a certain number of researchers may be of importance and external cooperations may be essential in particular for small and/or virtual clusters.

The fourth group of input indicators concerns the **investment.** Here, the annual R&D investment in terms of public and private investment as well as the relation between public and private investment is of interest to assess the economic independence of the cluster but also the innovation potential. The presence of venture capitalist near to physical networks or investment, existence of venture capital funds is a further important indicator for high risk and innovative technologies. Also regulation aspects like exploitation (i.e. the existence of transfer offices, which may be public or private facilities), state aid (e.g. tax reduction or subsidies) indicate the potential of a cluster to be internationally competitive with a strong industrial background.

The **state of the cluster** by means of its age and stage or phase in a cluster life cycle (latent, developing, established or transformational) is the fifth and last group of input indicators. Especially the history of clusters has turned out to be of importance, since older and mature clusters or clusters set up upon existing structures have shown to be more visible and are more likely to attract new members and customers.

Table 1: Five groups of input indicators relevant to characterise cluster ecosystems have been identified. The comments and information explain the kind of data needed to assess the 14 cases and the way the information is filled into the framework.

Input indicators			
Group	**Indicator**	**Comment**	**Information**
Type of cluster	vertical or horizontal	vertical: along value chain, Horizontal: specific segment	V, H
	virtual or physical	virtual: geographically distributed actors, physical: local, regional clusters	V, P
	specific or broad thematic	specific topics or thematic fields or Broad thematic over various fields	S, B
Infra-structure	technical	laboratory space/production	m²
	social	facilities inside cluster (e.g. coffee rooms)	yes/no
	quality of life	facilities outside cluster (regional environ.)	yes/no
	SME distribution	concentrated (C) or scattered (S)	C, S
	demand conditions	with respect to lead users, demanders: average (A) or sophisticated (S)	A, S
	density of cluster	actor-linkages, measure: joint projects	number
	phys. or vertical management	office budget for management	yes/no yes/no
	hierarchy	flat or strong hierarchy	F/S
Human capital and Actors	total staff	human capital, employment	number
	professors	link to education	number
	researcher	academic and industrial	number
	students	link to education	number
	total units	sum of all units in cluster	number
	large firms	staff > 250	number
	SMEs	staff < 250	number
	public units	universities, research centres, etc.	number
Investment	venture capital	annual investment (in million €)	number
	R&D investment	public funding/year (in million €) private investment/year (in million €)	number number
	exploitation	existence of technology transfer offices	yes/no
	state aid	aid by reduced tax aid by subsidies	yes/no yes/no
State of cluster	age	established/opened in	year
	stage/phase	latent (1), developing (2), established (3), transformational (4)	1, 2, 3, 4

In addition to the input indicators, the output indicators are listed in Table 2 and can be related to the input indicators in parts. The first group describes the **openness between clusters** and concerns thematic aspects like the inclusion of new topics, exchange programs supporting mobility of employees and hence the knowledge transfer as well as external cooperations. According to the cluster type, new topics (e.g. for thematically broad clusters), intensive exchange programs and strong external cooperations (e.g. for virtual and/or horizontal clusters) may be of special relevance.

The **integration** of new members and actors into a cluster, in particular SMEs, and the **development of existing SMEs** change the infrastructure of a cluster and provide information on its dynamics. Also, the innovation potential and activities along the value chain can be optimised.

The fourth group of output indicators relates to the **creation** of new actors, knowledge, etc. out of clusters. Such indicators provide a measure for technical and innovation performance. Suitable indicators are the number of SME creation (start-ups and spin-offs) as well as the creation of start-ups and spin-offs independently. Patents and publications respectively indicate an economic-technical and technical-scientific output.

The annual **turnover and world market** share of clusters are purely economic output indicators and the **expansion of clusters** in terms of annual employment growth, turnover growth rate and increase of funding and investment (public/private) also points to a dynamical development of the cluster.

Table 2: Five groups of output indicators relevant to measure the performance of cluster ecosystems have been identified. The comments and information explain the kind of data needed to assess the 14 cases.

Output indicators			
Group	**Indicator**	**Comment**	**Information**
Openness (between clusters)	thematic	inclusion of new topics	yes/no
	exchange	programs supporting mobility of staff/ knowledge transfer (intra-/intercluster)	yes/no
	cooperations	external cooperations (intercluster) and strength of cooperation (scale 0 to 2)	yes/no 0, 1, 2
Integration (into clusters)	***SME integration***	integration of SMEs into cluster rate of integrated SMEs/year annual growth rate	yes/no number %
	actors	integration of new members/year	number
Existing SMEs development	growth of existing SMEs	creation of jobs in existing SMEs linked to cluster activities annual growth rate	number %
	development of innovation skills of	See, for example, works of CEN/Workshop on this matter	to be defined

Output indicators			
Group	**Indicator**	**Comment**	**Information**
	SMEs		
Creation (out of clusters)	***SME creation (Start-ups and Spin-offs***	creation of SMEs out of cluster rate of created SMEs/year annual growth rate	yes/no number %
	start-ups	total creation of start-ups	number
	start-ups	total of jobs creation in start- ups	number
	spin-offs	total creation of spin-offs	number
	spin-offs	total of jobs creation in spin -offs	number
	academia Patents	filed patents/year	number
	industry Patents	filed patents/year	number
	licences between academia and industry	signed licences/year	number
	publications	publications/year	number
Turnover and market (of clus-ters)	turnover	in million €/year	number
	world market share	export relative to world market share	%
Cluster expansion	employment	annual growth rate of total staff	%
	turnover	annual growth rate	%
	R&D investment	annual increase of public funding annual increase of private investment	%%

3.1.2 Case studies

In WP1 14 cases have been studied within 4 types of cluster ecosystems. The cases are listed in Table 3 together with links to the respective homepages and are opposed to the identified and prestructured indicators from Table 1 and Table 2.

Table 3: The four types of cluster ecosystems and 14 case studies as analysed in WP1 with links to the Homepages.

Cluster Ecosystems	**Cases**	**Homepage**
Industrial Eco-systems	Aerospace Valley	http://www.aerospace-valley.com/
	SafeTRANS	http://safetrans-de.org/
	System@tic (Paris, France)	http://www.systematic-paris-region.org/en/
Centres of Excellence	MINATEC (Grenoble, France)	http://www.minatec.com/
	DIGITEO (Paris, France)	http://www.digiteo.fr/
	IMEC (Leuven, Belgium)	http://www.imec.be/

	Fraunhofer VµE (Germany)	http://www.vue.fraunhofer.de/

Cluster Ecosystems	Cases	Homepage
Regions and Cities	Cork (Ireland)	http://www.tyndall.ie/
	Grenoble (France)	http://www.english.grenoble.isere.com/
	Dresden (Germany)	http://www.silicon-saxony.net/
Universities	Cluster University Network	http://www.cluster.org/
	EECI – European Embedded Control Institute	http://www.eeci-institute.eu/
	INL – International Nanotechnology Laboratory	http://www.mitportugal.org/ http://www.iinlrecruitment.com/
	ICGEE – International Center for Graduate Education in Micro- & Nano- Engineering	http://www.icgee.ie/

3.2 Framework content and linkages

The indicators and case studies as discussed in chapter 3.1 define the dimensions of the framework for the analysis of the cluster ecosystems. The next step is to fill this framework with data in order to derive conclusions on good practice and favourable models for an EIT and its KICs. As discussed in the introduction, aspects of SME integration and creation as well as external cooperations and the comparison between virtual and physical clusters are important points from scientific, technical, economic, etc. perspectives in order to assure an innovative and sustainable framework for the KICs within an EIT. Therefore, in the following we discuss these relations and point out important factors to be considered in the analysis.

3.2.1 Relations to SMEs, cooperation, virtual vs. physical clusters

Indicators for existing SME development, SME integration and start-up/spin-off creation, external cooperations and virtual vs. physical clusters are included in the above described indicators. These are independently related to the case studies additionally to the whole set of indicators. By classifying the 14 cases on a nominal scale (relevant Yes/No or Virtual/Physical) it is possible to assess each indicator according to its relevance for each of the four aspects. Indicators being relevant to more aspects will be signified by crosses (see Table 4) and indicate a stronger impact on the elements being crucial for a cluster with optimal performance. This helps to priorise most important indicators and serves as basis for the discussion of the analysis results and the conclusions.

3.2.2 Relation between case studies and indicators

Also, the indicators are related to the 14 case studies via the acquired data. The fact that the available data is partly heterogeneous due to different degrees of granularity, ambiguity, etc. makes simplifications necessary (e.g. the number of staff will have to be grouped in <100, 100 to 1.000, 1.000 to 10.000 and >10.000, etc.). After such a simplification each indicator can be analysed across the 14 cases and each case defining a certain kind of cluster across the set of indicators. Also, the dependence of several indicators and/or cases among each other can be analysed.

3.2.3 Data sources and availability

While collecting the data several challenges had to be met. Consequently, besides the information from the cases in WP1 further sources for data acquisition are needed in order to complete the missing data and validate and possibly correct the collected data. Only with a completed and validated set of data points, a reliable in depth analysis of cluster ecosystems will be possible. Therefore additional interviews with the representatives of the WP1 cases during a meeting of the consortium in Dresden in September were carried out.

In summary, three general types of data sources are used:

- the case study reports from WP1,
- the homepages of studied clusters and brochures, annual reports provided there,
- interviews with representatives of the WP1 cases.

Concerning the handling of missing, unavailable or imprecise, ambiguous data the problems and ways to face them are pointed out below:

- In case of no data availability the data gaps have been filled with abbreviation n.n. for no number.
- Often, data from the case study reports and homepages are available for different time frames, years or with different level of granularity only and thus extracted in a non-uniform way. However, most of the numbers do not change dramatically over the years and for all cases, the most recent available data has been taken from the sources. For the further analysis the grouping of data into regimes as described in 3.2.2. (e.g. on scales 0, 1, 2, …) will be useful.
- Also, different definitions of types, states, etc. of clusters are misleading or difficult to interpret making a clear classification vulnerable. As an example, in many case

studies the extensive cooperation with partners is pointed out, but it is not properly defined, if these are members and part of the cluster or not. Or most of the clusters state to have a broad thematic orientation. Therefore, firstly the indicators in 3.1 have been characterised as clear and detailed as possible. Secondly, we strictly take up the perspective of each cluster independently and then relate the cases among each other. Although the different clusters may have a different perception regarding their classification with respect to some indicators, the comparability among the clusters will improve. Finally, the interviews with the representatives of the cases will help to discuss, validate and definitely fix the data points.

4 Analysis of cluster ecosystems

In the present chapter, the developed and assessed framework based on the indicators and case studies will be analysed. Due to the problems with respect to data availability as pointed out in chapter 3, it was possible to retrieve information on parts of the indicators only. We therefore focus on a subset of input indicators for which data was available almost completely. As indicated in Table 4, the groups: state of cluster, human capital and actors as well as type of cluster have been elaborated. Regarding the aspects of existing SME growth, SME integration and start-up/spin-off creation, external cooperations and virtual vs. physical clusters additional rows have been integrated and related to the 14 cases.

Considering the **state** (age and stage) of the individual studied clusters, we find that clusters in a latent or developing phase are not older than 3 years and clusters older than 8 years can be considered to be in the transformational phase. The industrial ecosystems, cities and regions as well as centres of excellence in this study have achieved a mature state in general and are well established. It has to be stated, that from the cluster perspective a further dynamical development of clusters classified as established (stage 3 in Table 4) can be expected, although the individual members can mostly look back on a longer history. This may be the reason for a rather good visibility of these recently established clusters. For example, the three industrial clusters are represented by well known large firms, cities like Grenoble or Dresden have a strong background and have been well positioned in the semiconductor industry for many years.

Concerning the **human capital**, industrial ecosystems and even more cities and regions concentrate a large number of employees in their structures or have at least access to a pool of researchers via their members (e.g. SafeTRANS via firms like Bosch, Daimler, Airbus, etc.). In contrast to centres of excellence for example, the portion of non-scientific or technical staff seems to be much higher in industrial and regional clusters. Non-technical staff may be active in administration, marketing, supply, public relation or business networks, etc. The large number of staff in the Cluster University Network in contrast accounts for the many students at universities and has importance with respect to education, human resources, mobility and exchange of knowledge inside and across clusters.

Again, the clusters with a large number of **actors** or units (composed of large firms, SMEs and public units) are industrial and regional clusters. However, not all these clusters actively integrate SMEs. For example, the virtual cluster SafeTRANS consists of a few number of large firms and public research centres only. On the other hand, all physical clusters comprise a large number of member units or at least are located such, that access to SMEs can be guaranteed.

For example, centres of excellence integrating a limited number of actors profit from their proximity to industrial or regional clusters. Consequently, the importance of **external cooperations** for these centres becomes obvious as can be seen in the cases of MINATEC and the region of Grenoble or DIGITEO and System@tic, both located in the region of Paris. External cooperations are even more important for **virtual clusters** in particular Universities but also the Fraunhofer VμE, which are also characterised by a limited number of actors and have a strong horizontal character (i.e. they do not cover the whole value chain in contrast to physical clusters).

With respect to the different **types** of clusters a clear picture shows up in the sense, that physical clusters are able to cover the whole value chain (vertical) and are characterised by a large number of actors and staff (apart from the three centres of excellence with horizontal orientation and limited actors and staff but local access to SMEs and industry). **Physical clusters** are also in a mature state of their life cycle, visible for customers and provide a stable economic and competitive basis, access to global markets and trust for business relations.

Types of specialised or focused clusters compared to clusters with broad thematics are more difficult to classify. This is not at least due to the lack of a uniform definition of how a specific and broad range of topics has to be understood, as discussed in chapter 3.2.3. Principally all combinations of thematically focused or broad clusters with vertical, horizontal, virtual or physical, etc. clusters can be found. For example, Aerospace Valley focusing on aeronautics, space and embedded systems and SafeTRANS focusing on safety and transportation systems are each active in rather specific market sectors but are differently set up and composed clusters. On the other hand, the region of Dresden has shaped its profile as "Silicon Saxony" being active in the semiconductor industry for several years. Today Dresden is known as one of the strongest industrial locations for Nanoelectronics. However, Grenoble seems to have a broader profile with activities in micro- and nanoelectronics, information technology and software but also in the energy and biotechnology sectors, for example. To conclude, specialisation seems to be important in clusters with industrial participation and a broad range of research topics is more pronounced in basic and applied research centres.

Finally, **SME integration and spin-off/start-up creation** are found to be closely related to each other and play a dominant role in physical clusters. In virtual clusters this is principally not relevant. However, the industrial cluster SafeTRANS and the Fraunhofer VμE may support creation of start-ups and spin-offs via their members, but not in their form as virtual clusters. The centres of excellence MINATEC and IMEC explicitly stress their role in the creation of start-ups and/or spin-offs, which can be explained by the applied orientation of research and strong cooperation with local industries.

Table 4: Analysis of cluster ecosystems

Framework		Cluster - Dimension	state		staff		actors				type			correlation			
		Indicator	age	stage/phase	researcher	total staff	total units	large firms	SME	public units	vertical or hori-zontal	virtual or physi-cal	specific or broad thematic	SME integration	SME creation	external coop-erations	virtual vs. physi-cal
		Information	year	1, 2, 3, 4	number	number	number	number	number	number	V, H	V, R	S, B	Y/N	Y/N	Y/N	V/R
Link to		**SME integration**		x	x	x	x	x	x		x (V)	x (P)	x (S)	X			
		SME creation		x	x		x		x		x (V)	x (P)	x		X		
		external cooperation								x	x (H)	x (V)	x (B)			X	
		virtual vs. physical			x	x	x	x	x	x	x	x					X
Cluster	**No.**	**Case**															
Industrial Ecosystems	1	Aerospace Valley	2005	3	8.500	55.000	500	21	n.n.	114	V	V/P	S	Y	Y	N	V/P
	2	SafeTRANS	2003	3	300	>300	13	7	0	6	H	V	S	N	N	Y	V
	3	Systematic	2005	3	50.000	102.000	340	80	100	160	V	P	B	Y	Y	Y	P
Centres of Excellence	4	MINATEC (Grenoble, France)	2006	3	3.000	4.000	>18	0	>0	18	H	P	B	Y	Y	Y	P
	5	DIGITEO (Paris, France)	2007	2	<1.200	1.200	6	0	0	6	H	P	B	N	N	Y	P
	6	IMEC (Leuven, Belgium)	1984	4	~1.000	1.600	1	0	0	1	H	P	B	N	Y	Y	P
	7	FhG VµE (Germany)	1996	4	<1.600	1.600	12	0	0	12	H	V	B	N	N	Y	V
Regions and Cities	8	Cork (Ireland)	2004	3	n.n.	n.n.	n.n.	n.n.	n.n.	n.n.	V	P	B	Y	Y	N	P
	9	Grenoble (France)	1999	4	n.n.	>38.500	>500	~500		~50	V	P	B	Y	Y	N	P
	10	Dresden (Germany)	2000	4	n.n.	35.000	265	n.n.	n.n.	n.n.	V	P	S	Y	Y	N	P
Universities	11	Cluster University Network	1990	4	11.000	146.500	12	0	0	12	H	V	B	N	N	Y	V
	12	EECI	2006	2	35	63	>6	n.n.	n.n.	6	H	V	S	N	N	Y	V
	13	INL	2005	1	n.n.	n.n.	1	0	0	1	H	V	S	N	N	Y	V
	14	ICGEE - International Center	2007	2	n.n.	n.n.	13	0	0	13	H	V	B	N	N	Y	V

5 Conclusions

Our analysis shows that an optimal setting of the KICs within an EIT should integrate the favourable elements of different types of cluster ecosystems to create a Europe-wide visible and functional network. Such a network would have to include the advantages of clusters with preferable economic performance like **industrial ecosystems** or **cities and regions**, which are able to develop existing SMEs and to improve their innovation skills and to attract new SMEs but also integrate complementary factors, which are underrepresented in these kinds of clusters. Such underrepresented factors are typically programs or activities supporting the mobility of employees and thus enhancing the scientific, technological (knowledge) transfer through the exchange of human capital as done in **university clusters**. A further factor is the intense cooperation with external partners, e.g. within the same field of research, leading to new insights and innovative ideas. **Centres of excellence** represent a "mixed model" between the virtual university networks and physical industrial and regional networks and profit from the advantages of both constellations. Excellent research becomes possible by interdisciplinary and intercultural exchange. The transfer to applications is supported by intense collaborations with industries in the vicinity, based on efficient TT schemes and Intellectual Property management according to Commission Recommendation on the management of intellectual property in knowledge transfer activities and code of practice for universities and other public research organisations[6].

However, with respect to the KICs, centres of excellence are in general claimed by individual countries and cannot be the preferred choice for an international operating structure due to questions of neutrality and equal rights for the European member states. This is one reason why the establishment of a physical EIT has been criticised.

Without any doubt, the most suitable constellation would be a combination of the above described cluster types with an appropriate dose of important elements like SME integration, elements supporting SME creation (i.e. start-ups, spin-offs), elements supporting development of existing SMEs (efficient TT schemes between academia and existing SMEs, financial support for this TT for example by venture capital institutions, supporting access for SMEs to norms and standards)external cooperations and the adequate combination of virtual and physical cluster structures. In order to make these elements and their relevance to an EIT and its KICs more concrete we discuss their different aspects independently and in more detail.

6 EC COM (2008) 1329 10.04.2008

SME integration is realised best in physical clusters like industrial ecosystems or cities and regions. SMEs are attracted by the visibility and stability of such local or regional clusters with at least several years of experience and history and established innovation culture. These clusters provide access to global markets producing trust to establish sustainable cooperations. The integration of SMEs into such physical clusters leads to a further dynamic growth and attraction of even more technological infrastructures (research institutes, firms, etc.) along the value chain and other actors (business, venture capital, local authorities, public and private transfer offices, supplier and demander, etc.). The focus on a specific market sector is of interest, since clear and operational supply and demand structures have to be built up. On the other hand, broad scientific and technological research and development and the contact to public institutions (research centres, universities) helps to generate further knowledge, innovative ideas and potential new applications.

Thus, SME integration is strongly linked to and achieved best in geographically concentrated, vertically structured (along the value chain), and specifically oriented or focused clusters.

Consequently, **SME creation** is also linked to physical clusters with a vertical structure. This is due to reasons of stability and proximity to local industries and infrastructures again. In addition it is important to differentiate between "normal" start-ups and spin-offs from universities, research organisations or industrial enterprises. The latter are created under a "security framework" of their mother organisations that limits the risks associated with the start-up stage. Accordingly, physical clusters allowing and favouring spin-offs are important. On the other hand start-ups and spin-offs are typically based on scientific and technological breakthroughs or inventions and are generated at universities and in particular applied research centres. For the dynamic creation of start-ups and spin-offs firstly, a dynamic and open environment with opportunities for exchange of ideas is of importance. Virtual structures enabling such an exchange by mobilising people inside and outside a cluster are favourable instruments. Secondly, the direct access or at least close collaboration with industry is important, as chances for market success will be significantly enhanced.

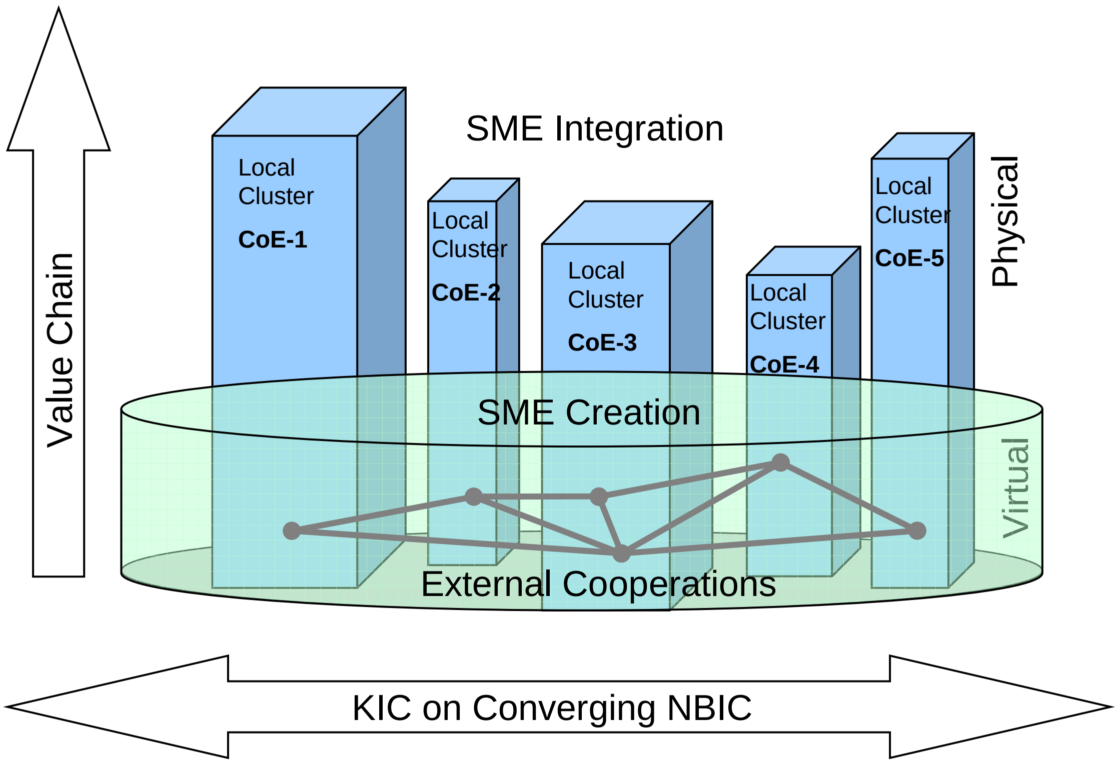
SME creation is therefore somewhere in-between physical and virtual as well as horizontal and vertical structures and is supported best in an environment with a broad and interdisciplinary thematic orientation.

External cooperations have minor importance for physical clusters. Of course, global cooperations with industries and customers are essential, but not intercluster cooperations as understood in this context. The exchange of ideas and knowledge helps to strengthen international collaborations and not the least enhances the trust between countries, cultures and eventually firms and industrial sectors. In today's clusters, external cooperations are established and deepened best in virtual networks with horizontal orientation. Exchange programs for students and young researchers have often proved their advantage and led to long lasting professional contacts.

External cooperations can be understood as relevant at the basis of each value chain and are clearly relevant to virtual and horizontal networks with a broad technological scope. They may serve to sustainably interconnect the different nodes of local clusters.

The role of **virtual and physical clusters** has been discussed for SME integration, creation, and external cooperations with different relevance to each aspect. The strong dependence of all aspects among each other has become obvious, however.

Figure 3: Elements and structures relevant for the KICs of an European Institute of Technology (EIT). CoE: Centre of Excellence; NBIC: Nano-, Bio-, Information technologies, Cogno-Sciences



To conclude, the different types of clusters with different actors and elements defining their structure enable a specific kind of performance which is shown in Figure 3. A future EIT with its KICs should be designed as a virtually and European wide operating structure providing programs for external cooperations and connecting different physical nodes. These physical nodes are standalone clusters building on existing strengths as represented by centres of excellence with strongly vertical orientation (along the value chain) and a focus on specific markets. Within these clusters the creation of dense institutional and personal networks will be an important factor for improving the performance and supporting the sustainability of these structures. Such networks need to be closely linked to the respective local territories thus pointing to an important role of cities and regions. The added value of the virtual structure besides the support to strengthen collaborations is a much better knowledge transfer on a broad thematic basis leading to new kinds of interactions, more trust among the actors of the network and in particular the creation of innovations (e.g. start-ups, spin-offs, improvement of existing SMEs' innovation skills)). Openness with respect to new topics, cooperations but also new members in order to optimise the structure is essential.

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