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Cluster Dynamics and Innovation

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ABSTRACT

The present paper presents the concept of cluster, what they are, which benefits they offer, the various types of clusters, the main elements forming a cluster, and a tentative model for explaining the dynamics of clusters and innovation. Clusters are "geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities" (Porter, 1998:199). Clusters' most known and/or perceived benefits are the *positive effects of agglomeration*, such as the proximity between firms facilitating collaboration and triggering rivalry among companies, a significant R&D environment and a high degree of interaction and knowledge sharing to sustain a culture of entrepreneurship and innovation.

Seeking to understand how industrial clusters can foster innovation and vice versa, the perspective taken in the present paper is the *innovation system* view on clusters (gupta et al., 2008). The four main elements defining a cluster are the *cluster members*, their *interaction*, the *knowledge and innovation* generated, and the *economical impact* of the cluster activities.

To understand the dynamics of clusters, a *conceptual model* is proposed, highlighting the main forces driving an industrial cluster and its underlying mechanism. Central to the cluster are innovations, firm growth and formation, and cluster attractiveness, which are supported by market growth, business and social interactions, entrepreneurship, competence and tacit knowledge, knowledge sharing, education and R&D. These forces are then put together in a system driven by five mechanisms: *cooperation and rivalry*, *interactions*, *knowledge development*, *technology development*, and *market development*. The model is tested on a maritime cluster perceived as very innovative. This model can be used for: 1) illustrating the interrelatedness of each cluster element, and show their relative importance, 2) scenario planning, to predict negative effects of particular decisions, or events, as well as to point out the necessity of specific ameliorations, 3) monitoring performance, by providing a sort of check-list to develop a cluster and assess performance over time. However, there are several limitations to the model, and the fact that it does not take into account external obstacles not necessarily related to the cluster's drivers. These can be:

- Culture, such as firms' resistance to change, reluctance to knowledge sharing
- External forces, like constraining regulations
- Financial constrains: such as high costs of applying new technology
- Cluster's resources, such as available labour force

To improve the usefulness of the proposed model, further development could focus on testing it on a series of other industrial clusters, correct it and develop it further. Systematise it and improve its exploitability, by introducing weight to each driver and enable performance measurement and benchmarking among clusters.

KEYWORDS	ENGLISH	NORWEGIAN
GROUP 1	Cluster, maritime cluster, innovation	
GROUP 2		
SELECTED BY AUTHOR		

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Cluster Dynamics and Innovation

"*Firms are not islands but are linked together in patterns of co-operation and affiliation*" (Richardson, 1972).

"*The reasonable man adapts himself to the world; the unreasonable one persists in trying to adapt the world to himself. Therefore, all progress depends on the unreasonable man.*" Shaw (1903).

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Clusters, innovation, structure, dynamics, performance, maritime clusters.

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1. Abstract

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2. INTRODUCTION

This paper aims at uncovering some ambiguities related to the concept of cluster and propose a framework for describing cluster dynamics and innovation.

For a long time, industries were seen as a set of individual companies competing against each other. Over the last two decades, the concepts of *networking* and *cluster* have gained considerable interest in both academic and industrial worlds[1]. The importance of access to resource as source of competitive advantage, as well as the need to share risks and create long-term competitiveness have lead to the formation of a multitude of partnerships, network based businesses, and the formation of successful industrial groups of companies, where organizations, their suppliers and customers are all working together for achieving mutual benefits.

From a broader industrial perspective, clusters represent pools of related organizations and competence, or related industries driven by both cooperation and rivalry (e.g. the Silicon Valley), among which some will create multiple partnerships and establish specific project-oriented clusters (e.g. the Maritime cluster in Møre og Romsdal, Norway).

Cluster is also an important concept for policy makers, especially in the context of regional development, for which they turn to be a source of attraction for foreign investment (Smith and Ibrahim, 2006; Lagendijk, 1998).

Yet, some authors have criticized the value added of cluster approach, the way cluster studies have been performed, and the excessive interests of policy makers in clusters (Benneworth and Henry, 2004; Malmberg and Maskell, 2002; Mc Donald et al., 2007); others have highlighted the ambiguity in the use of the concept (Gordon and Mc Cann, 2000), or demonstrated the relevance of multi-perspectives around the concept of clusters (Gupta et al. 2008; Pickernell, 2007; Smith and Ibrahim, 2006).

Silicon Valley, Boston's Route 128 are among the most famous and studied industrial clusters, but there are a many other clusters that have been subjects to academic research, including the North Carolina's Research Triangle in USA; the Italian Emilia-Romania cluster; the aerospace cluster in Derby, UK; the biotech cluster in Uppsala, Sweden; the Dutch Maritime cluster, NL; the Ceramic tiles cluster in Modena and Reggio provinces, Italy; to name a few.

Although all are qualified as clusters, their structure, orientation, internal mechanisms, performance, and historic development differ from one to the other.

The purpose of the present paper is not to speculate on the existence of clusters, but rather to understand the relation between cluster, industry performance and innovation. Indeed, not only for policy makers, but also for other institutions and for economic agents, it is interesting to see how industrial clusters contribute to national competition, and how (innovation at) cluster (level) can be managed.

[1] In the database EBSCO*host* Electronic Journals Service, as of July 2009, out of 783 articles with "networking" in the title, published in academic journals since 1965, 259 were published between 1990 and 2000, and 501 after 2000. Similarly, out of 1585 articles (from academic journals) with "cluster" in title, 286 were written 1990-2000 and 1161 after 2000.

3. The concept of Cluster

3.1 Definition

M. Porter, systematically cited in cluster studies, defined a cluster as a "geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities" (1998:199).

Cluster analysis focuses on vertical dimension (complementary functions), and horizontal dimension (competitors on a given discipline) on a value-chain. In addition to economic advantage, cluster can be studied from the perspective of socio-cultural factors and territorial agglomeration (Karlsen, 2005). Indeed, trust, locally embedded knowledge, and proximity are all factors facilitating knowledge and competence development in a specific territory.

Clusters are characterized by the following commonalities (Altenburg and Meyer-Stamer, 1999; Carpinetti, 2007):

- Forward and backward linkages between firms
- Information exchange between firms and other cluster members
- Institutional infrastructure supporting the activities of the cluster
- A social cultural identity with common values
- Shared focus
- Entrepreneurship attitude, aiming at value-creation and innovation
- Most important is agglomeration, either geographic, economic, cultural, sectoral

Looking specifically at the cluster's raison-d'être and dynamics, Håkanson refers to cluster as: "clusters consist of and are defined by the value-adding activities in a set of linked companies and institutions" (2005:443), and Parto offers to view clusters as "groupings of interrelated firms that innovate and generate economic growth" (2008:1006).

3.2 Various perspectives on cluster

One should note that the concept of clusters is used in distinct cases: for industry analysis, country analysis, or more specific as a particular regional business networks working in partnership towards a particular service/product delivery.

To alleviate some of the confusion around the study of regional clustering, the seven perspectives identified by Gupta et al. (2008) are particularly helpful (see figure1).

Clusters have been studied by a number of researchers, many of whom defined and identified them from *Geography and Neo-Geography* perspectives, in which clusters are driven by cost-advantage of geographic proximity, but also are supported by informal know-how spill-overs. Firms become more embedded, more dependent on their cluster membership. The *Diamond and Neo-Diamond* perspectives seem to overtake when it comes to analyzing cluster comparative advantages and expansions decisions. The *Regional and Global Innovation Systems* perspectives seem more suitable for identifying the benefits of clustering and the synergies created through intra-cluster interactions. In this perspective, attention is drawn on the externalities that such interfirm relationships generate and the way they innovate. The *Transnational Value-Chain* perspective, appeared more recently, emphasizes spill overs and collective learning as critical to the cluster. This perspective views the cluster as shaped by a lead firm and supported by local institutions.
The perspective adopted in the present paper is the "Innovation System" perspective, which seems most appropriate for studying internal mechanisms supporting innovation.

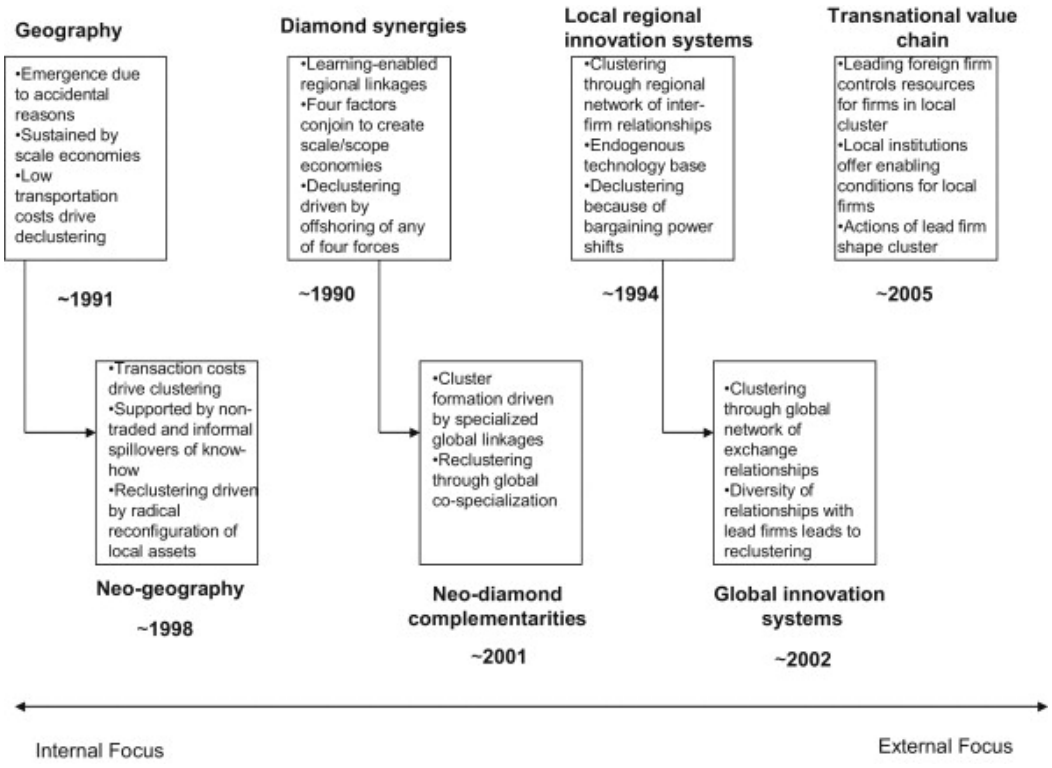


Figure 1: Seven perspectives on clusters, and years of (Source: Gupta et al., 2008)

A more recent variant could be the *Knowledge-Hub* perspective. More recently the idea of value creation through innovation has overdrawn the importance of production optimization and cost minimization. Focus has switched from tangible to more intangible resources as source of competitive advantage, and knowledge has become the gold of today's "knowledge economy".

While the traditional geographic and industrial approach to cluster is obviously the most used model, especially for identifying and describing a particular cluster, efforts are being made for developing new ways of understanding clusters and re-think cluster models in which knowledge should be placed at the centre as the main driver of development. In particular, Reve (2008) is working with models which will convert industrial cluster into "global knowledge hubs"[2], in order to ensure continuous value-creation through clusters.

According to Reve (2006), while a cluster is defined as a *geographical concentration of related companies*, a Global Knowledge Hub is characterized by a geographical concentration of; top league universities and R&D milieus; international expert firms and their R&D activities; competent venture capital and investors; an innovative culture;

[2] Here the term "global" should not be confounded with "international", as it refers to the broader scope of the cluster, expanding above industrial borders, and covering the totality of actors, public or corporate, contributing to knowledge development. The term *hub* connotes less geography-dependence than *cluster*, and less "scatterness" than *network*, therefore conveying the aspect of concentration, as a central network node.

The London Maritime Cluster is an excellent example of what could be called a Global Maritime Knowledge Hub. With about 1800 companies, it is considered the leading maritime service cluster. It is service-focused and driven by knowledge development, characterized by close ties between academia, education, and industrial actors, but also industry association, and maritime service providers within insurance, finance, consulting etc.

excellent infrastructure and global knowledge networks; highly attractive living conditions and great cultural environment.

To become a global knowledge hub, a cluster needs to; invest in world class research and education; be a strategic location for R&D functions of multinationals; attract world class talents and experts; provide excellent infrastructure; offer key industrial meeting places; create intensive knowledge interactions (Reve, 2008).

3.3 8 types of Clusters

There is no one way of classifying cluster types, as focus can be on distinct aspects of clusters, like its structure (firm size, interfirm relations, internal/external orientation; Markusen, 1996), or driving process (agglomeration, industrial complex, social network; Gordon and Mc Cann, 2000).

Generally, cluster identification is based on the following common elements (DTI study; 2001; Smith and Ibrahim, 2006):

- Stage of development (cluster life cycle)
- Cluster depth (industry linkages, embeddedness)
- Employment dynamics (growth/decline)
- Geographic significance (focus, national/international)
- Value-creation (annual turnover)

Still, in practice, there are numerous forms of clustering, distinguished by their members, thei motivation, the nature of the clsuters' activities, its governance system, etc. Pickernell et al. (2007) propose eight basic types of clusters, based on a review of literature covering distinct approach to cluster description and overlapping definitions. This classification is very relevant because it gives an updated and overview of distinct types of clusters; besides, this review includes among others the work of Markussen (1996), Gordon and Mc Cann (2000), Parr et al. (2002), Granovetter (1992) and Styles and Goldsworthy (2002), and can therefore be seen as the most exhaustive review available.
The elements used for categorization are the following:

- *Structuring of cluster members*: horizontal (internalized activities or cross industries) or vertical attributes (external activities within an industry)
- *Type of interaction*: formal or informal type of clusters
- *Reason for success*: transaction, agglomeration, or relational
- *Return sought*: cost and/or knowledge
- *Participant goal*: individual and/or collective survival
- *Participant behavior*: control, collective action and/or cooperative learning
- *Nature of Relationships*: transactions, cognitive trust, and/or teamwork
- *Management focus*: start-creating, surviving-connecting, and/or sustain-developing
- *Learning process*: doing things better (cost focus), doing things differently (process innovation), and/or doing different things (product innovation)

The reason why this paper focuses on Pickernell's classification is because it gives a simplified and easy-to-use framework for identifying a type of cluster, giving more precision to a particular cluster analysis.
The proposed eight types of clusters are described below (based on Pickernell et al. (2007), and Markussen (1996)), and are presented as a useful framework for apprehending a cluster.

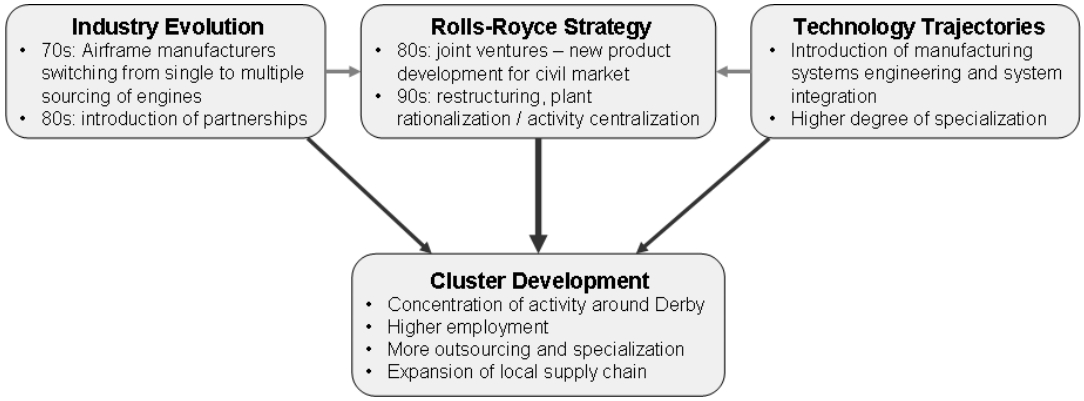
CLUSTER TYPE	Short description	Structure / Business type	Nature of interaction	Reason for success	Return sought	Participant goal	Participant behavior	Type of relationships	Management focus	Learning process
Industrial Complex (state-anchored)	Local business controlled by a government-institution (university, military) served by suppliers/service firms.	Vertical (Supply chain based relationships, local suppliers)	Formal (Loyalty primarily to institutions)	Transactional (Limited to trade-relationship between the public entity and the suppliers)	Cost (Minimize cost of distance)	Individual survival (Agglomeration of small firms, or technological spill-overs)	Control	Transactions (Low commitment, weak trade associations)	Start-creating (Many small firms to serve the public entity)	Doing things better
Hub and Spoke district	Group dominated by few large firms on which depends the economic activity of many smaller firms and ancillaries.	Vertical Strong activity with/among suppliers in/ outside the cluster	Formal (No trade associations)	Relational (Significant links outside the region)	Cost / knowledge	Collective survival Long term contracts	Collective action (Large firms' strategies shaping the cluster)	Cognitive trust (Cooperation, but not among competitors)	Survive-connecting	Doing things better / differently
Marshallian	Large group of locally owned SMEs benefiting from special labor and services, with strong institutional support.	Vertical (Similar industry, forward and backward linkages)	Informal	Agglomerational (much interfirm trade and collaboration)	Cost	Individual / collective survival (Long term contracts)	Control / cooperative learning (Strong information spillovers)	Transactions / cognitive trust (Strong local trade)	Start-creating / sustain-developing	Doing things better
Italianate district	Large group of small firms benefiting from special labor and services, with strong local government role.	Vertical (Similar industry, forward and backward linkages)	Informal (Business partners personal exchange)	Relational (Strong trade associations)	Cost / knowledge	Collective / wider survival	Collective action / cooperative learning	Cognitive trust / teamwork (Risk-sharing cooperation)	Survive-connecting / sustain-developing	Doing things better / differently , and different things (High innovation)
Urban Hierarchy	Common infrastructure, utilities, services in a geographical area.	Horizontal (Various industries)	Informal	Agglomerational	Cost	Individual survival	Control	Cognitive trust	Start-creating	Doing things better
Social Networks	Relationship-based with informal ties.	Horizontal	Informal	Relational (Trust-based relationship)	Knowledge	Wider survival	Cooperative learning (spatial benefit of networks based on weak ties)	Teamwork (Act in a group for common benefits)	Sustain-developing	Doing things differently and different things
Virtual Organizations	Relationship-based virtual large organization of group of SMEs.	Horizontal	Formal (Joint-venture type)	Relational	Knowledge	Collective survival	Collective action (spatial benefit of networks based on strong ties)	Cognitive trust	Survive-connecting	Doing things better / differently, and different things
Satellite industrial platform	Branch plants of medium and large externally-based firms.	Horizontal (e.g. industrial parks)	Formal (little interfirm trade and networking)	Transactional	Cost (Strong governmental incentives)	Individual survival (External labor markets and specialized services)	Control (few link to local firms)	Transactions (Short-term and no cooperation)	Start-creating	Doing things better

Table 1: Pickernell's classification of eight types of clusters and their characteristics (modified).

East Midlands Aerospace & Rolls-Royce: example of hub-and-spoke cluster

An example of **hub-and-spoke cluster** is the **East Midlands Aerospace** cluster in the UK, studied by Smith and Ibrahim (2006). The cluster's *anchor* firm is the engine manufacturer Rolls-Royce, surrounded by its many second and third tier suppliers and other SMEs. The activity generated by Rolls-Royce in the region is primarily triggered by international markets. Most of the company's operations are located in Derby where the company employed 12000 persons in 2006.

As for the dynamics of the East Midlands Aerospace cluster, Smith and Ibrahim (2006) described how Rolls-Royce's strategy has been fostering the cluster's development, together with industry evolution and technological trajectories. This is briefly illustrated in the figure below:



On the importance of anchor firm and its international orientation for the success of such clusters, Smith and Ibrahim (2006:374) concluded that "since hub firms can be significant contributors to regional development, policymakers should target policies designed to shape the competitive position of the industry in which the hub firms are located and invest in public infrastructure that will support them and facilitate their continued development and growth".

3.4 Role of cluster in the economy

- **Clusters foster Innovation:**

One highly recognized outcome of clusters is innovation (Porter, 1990; Reve and Jakobsen, 2001; Enright, M.J., 2003; Isaksen, 2008). Innovation often emerge as result of interaction, in the form of business relation, collaboration, or social interaction, between competent suppliers, demanding customers, competitors and rivals that possess complementary knowledge and skills (Porter, 1990; Waxell and Malmberg, 2007).
Innovation is generally stimulated by both competition and cooperation, and facilitated by intense knowledge and capability development. In practice, this should not be taken for granted. Indeed, in a study of the Quebec Costal Maritime Cluster, Doloreux (2008) confirmed that innovation, R&D and training is higher for clustered firms, but also reported a low level of collaboration and knowledge sharing, as well as an "innovation paradox" (Oughton et al. 2002), i.e. a mismatch between demand and supply of innovation related services. This phenomenon underlines the importance of sharing, improving

exchange and networking to ensure common vision/ strategy for the cluster, and the development of common knowledge.

- **Benefit of Clusters:**

The main benefits of operating in a cluster are higher productivity, higher value-creation, capacity of innovation and technology development, reduction in transaction costs, higher growth and new business formation, higher salaries, lower costs of learning, external economies based on specialized labor force and dedicated suppliers, and agglomeration of enterprises (Porter, 1990; Reve and Jakobsen, 2001; Storper, 1995; Parto, 2008). All these elements contribute to secure competitive advantage for the cluster and its members. But these benefits should not be taken for granted and depend on the cluster be sufficiently well-functioning. Success factors of clusters include (Reve and Jacobsen, 2001):

- Employee mobility
- Broad, numerous communication areas
- Competent consultant to entire cluster
- Proximity to demanding customers
- Effective competition in all markets
- Collaboration among clusters' companies
- Competent suppliers nearby
- Significant research environment with international contacts
- Well developed infrastructure
- Entrepreneurship and market-oriented culture

A fundamental element of clustering is the synergy created through complementarities and knowledge diffusion among the cluster members. These synergies can be referred to as *collective efficiencies* (Carpinetti et al., 2007), which consist of:

- external economies: cost-reduction advantages derived from common pool of suppliers, specialized workers, dissemination of knowledge
- cooperative joint actions: vertical and horizontal business cooperation

Examples of "active collective efficiency" are trade fairs, joint development of resources, supplier base, or joint actions towards stakeholders (NGOs, unions, etc.)

One negative aspect of cluster can the dependency that cluster membership represents. The lock-in effect of cluster participation, although necessary for interaction and synergies, can also increase the vulnerability of its members or force them to follow the cluster's direction although not always compatible with their own strategy. In this context, the risk of been locked out might become greater than the market opportunity in a firm's strategy.

- **Clusters in the Global Economy**

As underlined by Wijnolst and Wergeland (2008), the increasing focus on cluster testifies of the importance given to innovation and competititiveness through cooperation, and as the inevitable way to compete in the global economy. Nevertheless, it is important to understand the role and challenges of regional clusters in a globalized economy. As pertinently noted by Gupta et al. (2008:371), "the globalization of the value chain puts older regional clusters characterized by local, vertical value chains across multiple connected sectors, at a significant risk". Firms operating within the local regional clusters need to develop new generic strategies and new bases of competitive advantage in response to the growing outsourcing within the regional cluster". Further, the geographical

aspect of cluster competitiveness is nuanced by two contradictory trends: international division of labor and the utilization of economies of knowledge (Theodoropoulos, 2006).

3.5 Example of successful clusters

The Silicon Valley high-tech cluster and the Boston biotech cluster have been attracting interest from both academicians and practicioners for a long time. Although different in their historical development, they present some commonalies to which their renowned success can be attributed: favorable markets, supporting institutions, strong link university-research-industry, available capital, role of cluster leader, force of entrepreneurship, spin-off / firm creation, proximity, mobility, rivalry. Both clusters are briefly presented below.

3.5.1 Silicon Valley (entrepreneurship and the strength of trial-and-error)

- **History:**

Located in the San Francisco bay area, the Silicon Valley is known as a power house for entrepreneurship within high-tech and software development, supported by strong social network. Origin of the integrated circuit and micro-processor, the Silicon Valley got its name from the use of silicone in the manufacture of transistors.

The interest of the Silicon Valley lies in its agglomeration effect not motivated by cost reduction through proximity (as in industrial clusters), but to a non-common aggregation of rivals close to each other.

The Valley's success recipe consists of: concentration of brain, entrepreneurial culture, infrastructure supportive of high-tech and entrepreneurial activity, and an academic core to boost economic development in the region (Adams, 2005).

- **Analysis of the Silicon Valley model:**

The main Studies of the Silicon Valley are:

- Saxenian (1994) focused on role of institutional and social networks in fostering innovation.
- Kenney (2000) underlined the role of institutional infrastructure supporting start-ups.
- Leslie & Kargon (1996) focused on the role of Stanford, F. Terman and US government.

The Silicon Valley is a "clustering of entrepreneurial firms that develop new technologies in high risk, high return, high growth markets" (Sako, 2003:85).

Favorable markets for the model of the Silicon Valley are IT, software, and biotech. These markets share a need for high R&D and marketing expenditures, possibility for high network externalities, and are characterized by short product cycles and frequent innovations (Sako, 2003). These markets also favor small start-ups, due to high frequency of technology change and knowledge-intensiveness of the products/services, which small firms take advantage of through quick decision-making and avoiding large investment.

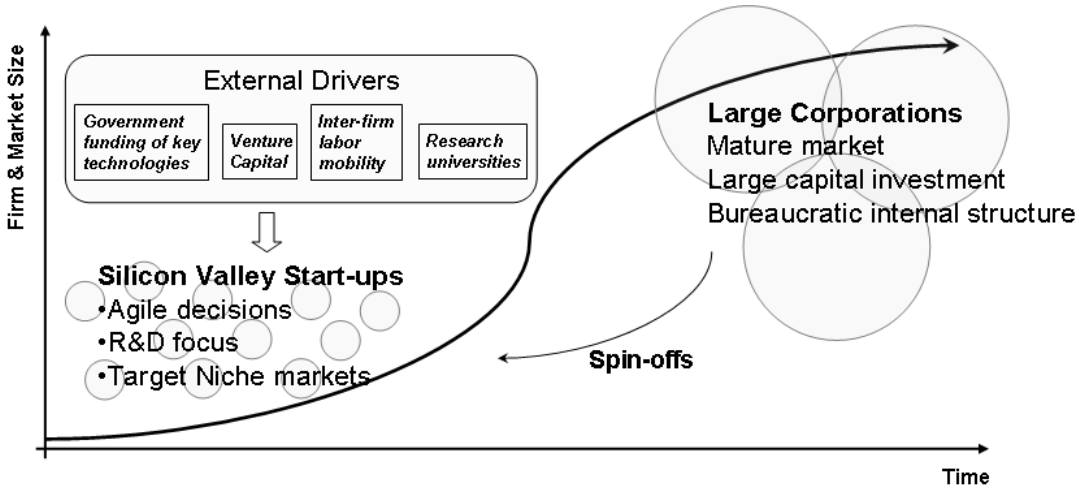
In these specific markets, four main **institutions** facilitate the emergence and sustainability of entrepreneurial firms (Sako, 2003):

- Corporate governance: venture capital providing finance, advice, management…
- Labor market: high-skilled, mobile, flexible people enabling more information and knowledge flow at lower cost.

- Education and Training: high level education and entrepreneurial mindset
- Inter-firm relations: long-term and trust-based partnerships, in a context of high level of outsourcing and diversification of production (importance of informal networks and trust between entrepreneurs and business people like venture capitalists…)

Locality is a key element in successful relationships between venture capitalists and entrepreneurs, industry and research universities, and buyer and supplier. Geographical proximity also reduces the cost of maintaining relationships.

Silicon Valley **start-ups** differentiate themselves from **large corporation** by their phase of development (e.g. HP and Intel Microsoft were once Silicon Valley start-ups), and therefore are not in direct competition with them. Start-ups target niche markets while the larger firms operate in mature markets (Sako, 2003). Coexistence is also ensured by the fact that many of Silicon Valley start-ups emerged as spin-outs of large corporations. External drivers and institutions played a significant role for the development of Silicon Valley start-ups (Sako, 2003). This is summarized in the illustration below.



The interplay between **industry, government and university** has been acknowledged as successful configuration for high tech clusters. From this perspective, Adams (2005) explored the crucial role of Stanford University in the success of the Silicon Valley, which main elements are: strong link between companies and Stanford, either as start-ups created by students/professors, or as companies using Stanford's technologies; and brains and capabilities initially developed by Stanford through relations with large companies not necessarily localized in the Valley. In fact, while the early success of the Silicon Valley is attributed to the concentration of entrepreneurship behavior, the development of the high-tech cluster is attributed to Stanford having established successful relationships with robust international organizations (Adams, 2005), which resulted in agglomeration of economies around the University. These relationships were facilitated by Stanford's four industry-oriented programs (Honor Cooperative, Industry Affiliate, Industrial Park, Stanford Research Institute) originally aimed at attracting funding from large companies to the university. In parallel, the US government has also served as a major source of funding.

As noted by Adams (2005), the Silicon Valley's start-ups in the 60's originated mostly from spin-out of outside companies, and it was not before the 80's that entrepreneurs from Stanford (students, professors) contributed to the start-ups proliferation in the Valley.

Properties of the Silicon Valley Cluster (Zhang, 2003) are:
- First mover advantage: early start grants longer survival
- Path dependence: firm creation becoming a driver of more firm creation in the region

- Clustering of entrepreneurship: entrepreneur culture expressed through constant trial and error and continuous firm creation.
- Clustering of innovation: extensive R&D coupled with imitation resulting in effective learning and higher productivity.

To conclude, conditions for the cluster's successful development (Zhang, 2003) have been:

- High quality research institute
- Knowledge spill-over
- Star-up funding (government and large companies)
- A visionary entrepreneur (e.g. Terman)
- Constant learning and the value of trial and error

3.5.2 The Boston Biotech Cluster (cooperation and the role of the university)

Among the world's three main biotech clusters, Boston is "home to one of the largest concentration of dedicated biotechnology firms in the world" (Porter et al., 2005:262). The main activity of the Boston cluster is medical science and it is composed today of independent biotech firms, venture capitals, and public research organizations such as research universities, research hospitals, and medical research institutes. As of 2002, Boston regrouped 275 biotechnology firms employing over 26000 people (Breznitz et al., 2008).

Historically, the end 1970s marked the beginning of the cluster, and the 1980s were characterized by few venture capitals, while public research organizations in collaboration with some small firms played a crucial role in the development of biotech in the region. This evolution has been supported, among others, by the US Congress "allowing US universities to retain intellectual property rights to the commercial application based on basic research funded by federal grants" (Porter et al. 2005:262). The 1990s saw the cluster grew through the proliferation of start-up firms, strongly supported by venture capitalist seeing great opportunities in the biotech industry. Since 2000, some leading pharmaceutical multinationals (Pfizer, Novartis, Amgen) have established in the Boston cluster (Porter et al., 2005).

On of the success factor of the Boston biotech cluster has been the active but constructive scientific competition, "enabling researchers and clinicians to build on the accomplishments of others" (Porter et al., 2005:288). Complementarily, one unique asset of the cluster has been its well-educated human capital and strong scientific knowledge pool. Furthermore, founded on MIT's top educational system, the cluster has benefited from the University's ability to promote entrepreneurship and technology transfer. MIT spin-offs have been a driver of the success of the Boston biocluster (Breznitz et al., 2008).

❖ The role of MIT

The MIT has fostered entrepreneurship and pragmatism. The university model, created by W.B. Rogers, was founded on a link between the university and the industry.

The various forms of industry-university linkages, founded on business relationships as well as friendships, covers (Porter et al., 2005:264):

- the movement of university graduates into commercial firms;
- consulting relations between faculty and companies;
- licensing of university technologies;
- industry gifts supporting university research and student training;

- faculty entrepreneurship leading to the founding of new companies;
- faculty involvement on scientific advisory boards;
- co-patenting between university and industry scientists;
- Formal contractual partnerships to pursue joint R&D, product or prototype development, and clinical trials.

The MIT has stimulated firm creation through two main mechanisms:

- *Academic entrepreneurship*: MIT's extensive company-based research and been enabling technology transfer, lead by researchers and academics. (Breznitz et al., 2008).
- *Lead by examples*: entrepreneurship culture based on numerous examples of company created by students and faculty members, which in turn motivates and encourage others to do so.

MIT has always been involved in promoting economical development in the region, emphasizing on applied research, as well as generating and sharing knowledge, supporting technology transfer (Breznitz et al., 2008), notably through the establishment of supporting institutions, like the Technology Licensing Offices, the Sloan School Entrepreneurship Center, and the Deshpande Center for Technological Innovation.

To conclude, there are several feature of the Boston cluster that have made it unique and not an obvious model for other clusters. Not only does the high value of biotechnology makes its particularly attractive for venture capitalists, but the importance of interpersonal relationships in the Boston area, among researchers, universities, hospitals, and firms, has been decisive for the cluster's prosperity. Finally, contrary to the Silicon Valley, the early development of the Boston biotech cluster has been fostered and enabled by the MIT University, while the role of Stanford in the development of the Silicon Valley came in later stage.

Learning from the Silicon Valley or Route 128 models?

While clusters like Silicon Valley or Route 128 have been greatly successful and seen as role models, one should not aim at replicating them literally in other countries or industries without understanding their key success factors. As The Economist cleverly noted, "without the right soil and the right climate, nothing will grow" (March 29, 1997; cited in Sako, 2003). Juxtaposing for example the Silicon Valley cluster with maritime clusters may be biased by the fact the type of industry (high tech) has played a crucial role in the success of the high tech clusters. Nevertheless, assessing the role of external institutions and of entrepreneurship in the development and viability of any industrial cluster is necessary. When it comes to the role of entrepreneurs, even though it cannot be denied that firm creation has nurtured and reinforced these clusters (facilitated their organic growth), Feldman et al (2005) argue that the Silicon Valley and The Route 128 are not clear examples of the model of entrepreneurial type of cluster, and were indeed strongly fostered (initially) by initiatives to create / develop strong research institutes and strong university-industry interaction. Furthermore, the cultural element of a region's development cannot be denied, and even with all similar ingredients, it cannot be assured that a successful cluster in a part of the world will function as well in another region. Finally, replicating a model has proven to be difficult when one consider elements like proximity and interaction; it has been shown that cluster stability depends mostly on interactive learning, which demonstrates the importance of network effect and knowledge development (Vicente and Suire, 2007).

4. Framework for studying Cluster performance and innovation

4.1 Cluster structure

To understand the relationship between cluster and innovation, one must start by identifying the main components of this cluster and the mechanisms driving its activity and development. The four main elements defining a cluster are the **actors / cluster members**, their **interaction**, the **knowledge and innovation** generated, and the **economical impact** of the cluster activities; these four elements metaphorically compared to those driving a human body (its organs, arteries, blood, and health) by Kamarazulzaman and Norhashim (2008), but also often referred to in cluster literature, and can therefore been seen as main components for studying cluster structure.

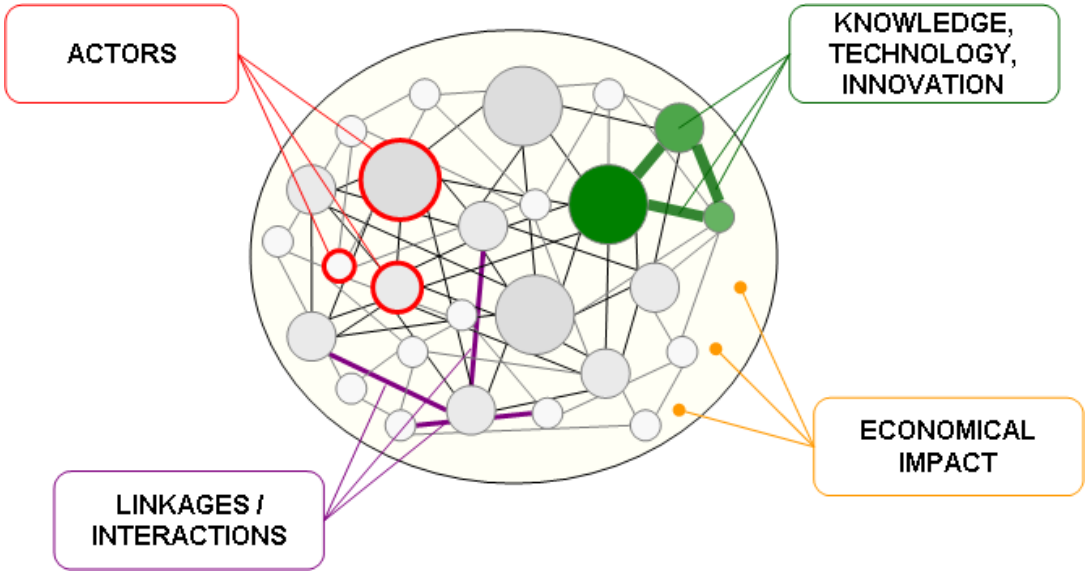


Figure 2: Components of Clusters.

These are described below, based on an broad literature review.

4.1.1 Cluster actors

The main actors / members of a cluster are:

- **Industry actors**, enterprises - rivals, customers, suppliers -, are the entities at the core of the cluster (leading field), directly serving its industrial activity.
- **Complementary service providers**: financial service providers (venture capitalists), consultants, etc.
- **R&D and education** institutions: public and private research centers, consultancies, universities
- **Supporting organizations**: government, trade associations, network facilitators

All stakeholders are important in the formation of a cluster, for providing it with the necessary independency to make it attractive and sustainable.

Entrepreneurship is at the core of innovation in a cluster. Entrepreneurs have the ability to perceive opportunity, accept challenges and organize resources in accordance (Feldman et al., 2005). “Entrepreneurship shapes the local environment through active learning and experimentation, the reinvestment of profits and expertise, the extension of relationships

with universities and government laboratories, the working associations and the subsequent pull of new group of actors to the region" (Feldman et al., 2005: 130).

Innovation may occur without entrepreneurship (firm creation), but entrepreneurs play an important role in self organizing and generating new activity in a cluster.
It is important for entrepreneurs to receive support from their environment, including from supporting institutions (R&D, educational system, good communication and infrastructure, and strong local government support) as well as a good management/organization of the cluster itself (e.g. a cluster facilitator).

4.1.2 Cluster Linkages and Interactions

From an economic geography point of view, clusters are interesting because they are in the heart of the paradox between growing globalization and importance of geographic location. As argued by Håkanson (2005) the value of clustering should be sought in the professionals / individuals engaged in the cluster's activity. Based on valuable tacit knowledge acquired overtime, local practitioners create a dynamic entrepreneurial activity (development of new services/products or similar to those of the current employer but targeted at new customer groups, etc.), high rate of new firm formation, which is argued to be the key to cluster growth and prosperity (Håkanson, 2005). "Most new firms are set up by people who have gained experience by working for others firms, in the same or related industries" (2005:451-452). Linkages consist of trade/business relationships (forward / backward) as well as social relationships.

Although argument of localization as factor of success is not very supported in empirical studies (Håkanson, 2005), the interaction necessary to foster innovation is enabled by the proximity between actors. Besides geographical proximity, cognitive (similar mental maps / context understanding), organizational (interaction among professionals through contract or face-to-face), social (interaction among people) and institutional proximity are also very important for creating necessary exchange and development of common mindset (Onsager et al., 2007; Boschma, 2005). Proximity, reflected in face-to-face interaction, short cognitive distance, common language, trustful relations, observation or immediate comparison, is highly beneficial for knowledge creation and innovation, through the sharing of knowledge and experience (Waxell and Malmberg, 2007).

Despite the importance of geographic proximity, internationalization and external orientation are necessary for attracting activity to the cluster (this is a typical aspect of the hub-and-spoke system, as illustrated by the East Midlands Aerospace in chap 2.3). Based on the case of the Trondheim city, Onsager et al. (2007:565) concluded that "the firms have thus become strongly integrated in global production systems, reflecting the fact that the international owners often are important suppliers to their firms in the clusters". Finally, link to other related industries is necessary for sharing competent workers and advanced technologies.

4.1.3 Cluster activity: Knowledge, technology, innovation

Clusters are basis for social interaction and agglomeration economies. Just like network, clusters give their members access and control over resources and information, as well as tacit knowledge.

The tacit knowledge and know-how developed in cluster derives from two main mechanisms (Bell 2005):

– *Common knowledge* transmitted informally (managerial network, informal ties) and common understanding developed overtime, resulting in cluster specific capacity, and ability to exploit knowledge and innovate.

– *Observation* (more access to industrial news, industry association etc.), facilitated by proximity and enabling mimetic behavior, and innovation, notably through trials or failure to replicate).

Knowledge and capabilities are key to competitive advantage. "Knowledge is created by processes of interactive learning and transferred via networks of actors able to absorb, understand, and manage the knowledge in question" (Waxell and Malmberg, 2007).

❖ **Knowledge development and sharing:**

Knowledge exchange is critical for cluster functioning and performance. Transferability of knowledge among firms depends on the type of knowledge (Tallman et al., 2004):

– *Component* knowledge (specific, technical, definable, acontextual, codified) is easier to transfer, but require absorptive capacity (ability to acquire, assimilate, adapt and apply knew knowledge (Cohen & Levinthal, 1990)). Provides short-term competitive advantage.

– *Architectural* Knowledge (knowing, tacit, complex, embedded, organization specific, routines, resources, core competencies, capabilities), difficult to transfer. Provides sustained competitive advantage. Tacit knowledge: typical knowledge that can only be acquired through practice and experience (particularly through trial and error); and tacit knowledge acquires generally through involvement in local networks. (Håkanson (2005).

While component is easily transferable and reproducible, also outside a cluster, architectural knowledge develop over time, through interfirm relationships and routines, common interest and geographical identity, fostering the cluster's absorptive capacity and establishment of non-replicable and cluster specific resources.

To summarize, "component knowledge moves around the cluster on "rails" laid by communal, cluster-level architectural knowledge" (Tallman et al, 2004:266; Brown & Duguid, 2001).

Regarding how learning affect the cluster evolution, Vicente's (2007) analysis of ICT clusters (in the Silicon Valley, USA and in Paris, France) revealed that informational externalities and observational learning affect cluster formation while network externalities associated with interactive learning affect cluster stability.

❖ **Cluster and innovation**

Innovative clusters build on strong knowledge and know-how, and lead by new and innovative firms focusing on niches and screening new market opportunities. (Feldman et al., 2005).

In line with the argument that firms are not isolated islands (Richardson, 1972; Granovetter, 1985), they do not innovate or expand alone.

Innovation and technology development in cluster, in the form of new products, new services, but also new firms, is mostly triggered by the *diversity of actors* enabling creative exchange of ideas and complementary and increasing knowledge creation, *interfirm competition* pushing forward the search for competitive solutions, and sufficient *R&D activity* enabling the sufficient exploration and trial-and-error.

"Collocation and proximity increase the awareness of emerging trends and reduces uncertainty for firms" (Feldman et al., 2005)

The relationship between cluster and innovation is explored by Onsager et al. (2007), looking at knowledge-intensive industries in peripheral regions in Norway.

According to the study, innovation being complex and a part of a learning process, it requires cooperation and collaboration among individuals and among firms, mainly for sharing ideas, experience and knowledge (primarily tacit and firm specific). Therefore innovation is dependent on well-functioning networking and clustering (exchange and access to knowledge and information), but also on individuals (entrepreneurship culture), firms, knowledge and support organizations in these local networks.

The innovation system of the four clusters studied by Onsager et al. (2007) is based on abundant and varied knowledge, institutions and firms, which find their innovation partners and information source among subcontractors, customers, R&D and academic institutions, consultancies and competitors.

4.1.4 Cluster value-creation and economical impact

Typical cluster activities include (Sölvell et al., GCIS, 2003)**:**

- Research
- Networking
- Cluster expansion
- Innovation and technology development
- Education and training
- Commercial cooperation
- Policy action

Clusters are believed to create economic activity (jobs), competitiveness, and wealth and have been used as a tool for strengthening local economies.

Cluster performance measurement system (Carpinetti, 2007) is composed the four following categories:

- **Economic and social results**: economic growth, gross product and employment, considered the primary indicator of cluster importance (Smith & Ibrahim, 2006).
- **Firms' performance**: growth and competitiveness (productivity, cost, profit…), triggered by easier access to valuable resources and services, as well as high customer quality requirements (Sölvell et al., 2003).
- **Collective efficiency**: external economies and actions of cooperation, including innovations and new firm creation (through FDI or spin-off from existing firms and institutions).
- **Social capital**: cultural values like trust and cooperation.

So, in addition to creating an innovative environment for firms, the cluster directly contribute to regional growth and value-creation, believed to be higher than in other non-clustered economic regions, due to the consequent exploitation and sharing of knowledge (Myklemyr, 2009). Although collective performance is also valid at long distance, through network (Tallman, 2004), but not as efficiency as within local clusters.

4.2 Cluster Creation, Development, Management

The main phases of a cluster life cycle (Feldman, 2005) are:

1. Emergence (entrepreneurial innovation, supported by exogenous events)

2. Self organizing (interaction among entrepreneurs, enterprises, institutions and resources)
3. Maturation (well functioning and rich innovative entrepreneurial system)

Clusters are path-dependent, meaning that its future development depends on its past evolution (Karlsen, 2005). The past creates both constraints (e.g. restriction to a specific field, economic activity anchored in the region), and opportunities (like top competence, talents, supporting services developed over time and supporting entrepreneurship).

Further, an important element in cluster development is the generation of spin-offs, most often firm creation through replication of a service/product based on experienced gained in an existing firm (Håkanson, 2005).. Typical spin-offs are based on value-chain disintegration (horizontal / vertical), either through diversification (new customers or new products), vertical specialization (core focus), or through the development of supporting functions / services in a value chain.

Spin-offs often closely located to their "origin" (another firm, a university, social network, professional network, etc.), which naturally create agglomeration of economies (Håkanson, 2005). Håkanson underlines that "most new firms are set up by people who have gained experience by working for other firms" (2005: 451), which reminds us that innovation is not technology-dependent only, but first and foremost enabled by human competence.

"Economic activity does not occur in a socio-political vacuum" (Parto, 2008:1013). Exogenous forces like research universities, venture capital, and social network are all parts of institutions supporting the development and success of industrial clusters (Feldman et al., 2005). As noted by Parto (2008), governments play a crucial role in shaping the institutions surrounding cluster development, especially in developing countries.

While historic coincidences and country comparative advantage are difficult to control and seem to be the more natural causes of cluster development, national institutions and policy are exogenous factors of strategic importance to the well development of a cluster and stimulation of innovation (Isaksen, 2008). Despite some critics to the extensive and systematic reference to clusters when talking about regional and industrial economic performance (Mc Donlad et al., 2007), it is a fact that, many governments have encouraged actively the establishment of industrial clusters in many regions.

Concentration of experience and knowledge in a region, favorable business environment (as defined by Porter's Diamond (1990)), condition for competition, low entry barriers, skilled labor force, efficient suppliers, appropriate infrastructure, favorable geography, supporting legal framework (Thedoropopoulos, 2006).

Cluster development is dependent on several parameters like innovation, knowledge creation and sharing, but cluster creation is often driven by the initiative of few central firms or professionals willing to increase cooperation and knowledge sharing. This requires a ground for cooperation and a managing organ, focusing on marketing of the cluster and establishment of joint projects, and therefore clusters need a well functioning management organization (Myklemyr, 2009). In an interesting article on *network builders*, Myklemyr pointed out the special role of the cluster leader, like a facilitator who stimulates joint activity and motivates companies to explore for opportunities outside their daily work.

Even if, very often, the motor of a cluster is identified as a company (Rolls Royce in the hub-and-spoke Derby cluster), a public institution (Stanford and MIT for the Silicon Valley and Boston Biotech clusters), or an association (Oslo Teknopol, non-profit regional development agency, founder of Oslo Maritime Network), it is not uncommon that the

founder and leader is a particular person. Examples are: Norway: Sunnmøre / Idar Ulstein, Møre / Per Erik Dalen, Silicon Valley / Fred Terman.

Network leaders exhibit the following characteristics / skills:

- Network builder with big own network of industrial actors, research institutions, public sector, financial institutions
- Experience
- Knowledge in industry, various industries
- Good leadership model, focusing on flexibility, dynamic capability informal communication and quick innovation.
- To be neutral

The management tasks of such a leader consist of: establishing common projects, creating link among firms and promote business networking, image and brand building, internationalization strategy, technological knowledge development, educational programs.

To do so, they use promotional tools like fairs and conferences, brochures, promotional movies, presentations, and investment in high level education.

Their network-building work is challenged by the difficulty of defining projects that are valuable enough to find interest among cluster members, finding enough support and resources, but also by the rivalry among firms and competition for resources in the cluster, as well as ethical issues and risk of discrimination.

4.3 Cluster Dynamics / Innovation

Understanding of the dynamics of cluster and their innovation mechanism is important for various purposes, including:

- To benchmark competitiveness at industrial level, compare clusters and countries.
- To be able to monitor performance of a particular cluster
- To identify the importance of cluster in an industry's performance and improve the cluster strategy

Innovation is defined as the "development and implementation of new ideas to solve problems" (Van de Ven, 1986; Dosi, 1988; Bell, 2005). Innovation focus can be on new product and services (novelty on features) or on new processes and systems; innovation process can either be incremental / continuous innovation (do what we do better) or radical / disruptive innovation (do what we do differently) (Carpinetti et al, 2007).

Although innovation is a central element of cluster dynamics, other internal factors like knowledge development and diffusion, or business interactions and complementarities are also central for cluster performance. Exogenous factors stimulating cluster success are resources, infrastructures, demand and market growth, and external competition (Tallman et al, 2004). Furthermore, important external forces supporting cluster development are national/local policies (public support) as well as network facilitators/managers.

Several authors have provided very insightful models or framework for understanding cluster dynamics. A sample is given in the table below.

Author	Focus	Purpose
de Langen (2002)	Analyze cluster performance	Look at cluster structure and governance and their impact on cluster performance.
Håkanson (2005)	Cluster dynamics in a open economy	Highlight the various forces (external and internal) and mechanisms that contribute to

		cluster growth.
Carpinetti et al. (2007)	A conceptual model of a performance measurement system of a cluster	Provide support for managing continuous innovation and performance of SME clusters.
Pickernell et al (2007)	Cluster identification	Highlight cluster structure and processes relevant for cluster classification.
Kamarulzaman and Mariati (2008)	A holistic framework for understanding key cluster dynamics and performance	Provide playground for policy makers' work supporting sustainable cluster development.
Beerepoot (2008)	Knowledge and skills diffusion	Show how labor force contributes to learning in clusters.
Trippl and Tödtling (2007)	Structure of regional innovation systems	Show the interaction between knowledge generation/diffusion, knowledge application/exploitation, and policy support

Table 2: Selected publication on cluster dynamics

The intention in the present section is to propose a model that summarizes the mechanisms of cluster dynamics and innovation.

Based on the review of the main cluster components (chap. 3.1) and of cluster development (chap. 3.2) and of the various models given in the literature, particularly the one proposed by Håkanson (2005), the following model (illustrated in figure 3) is proposed.

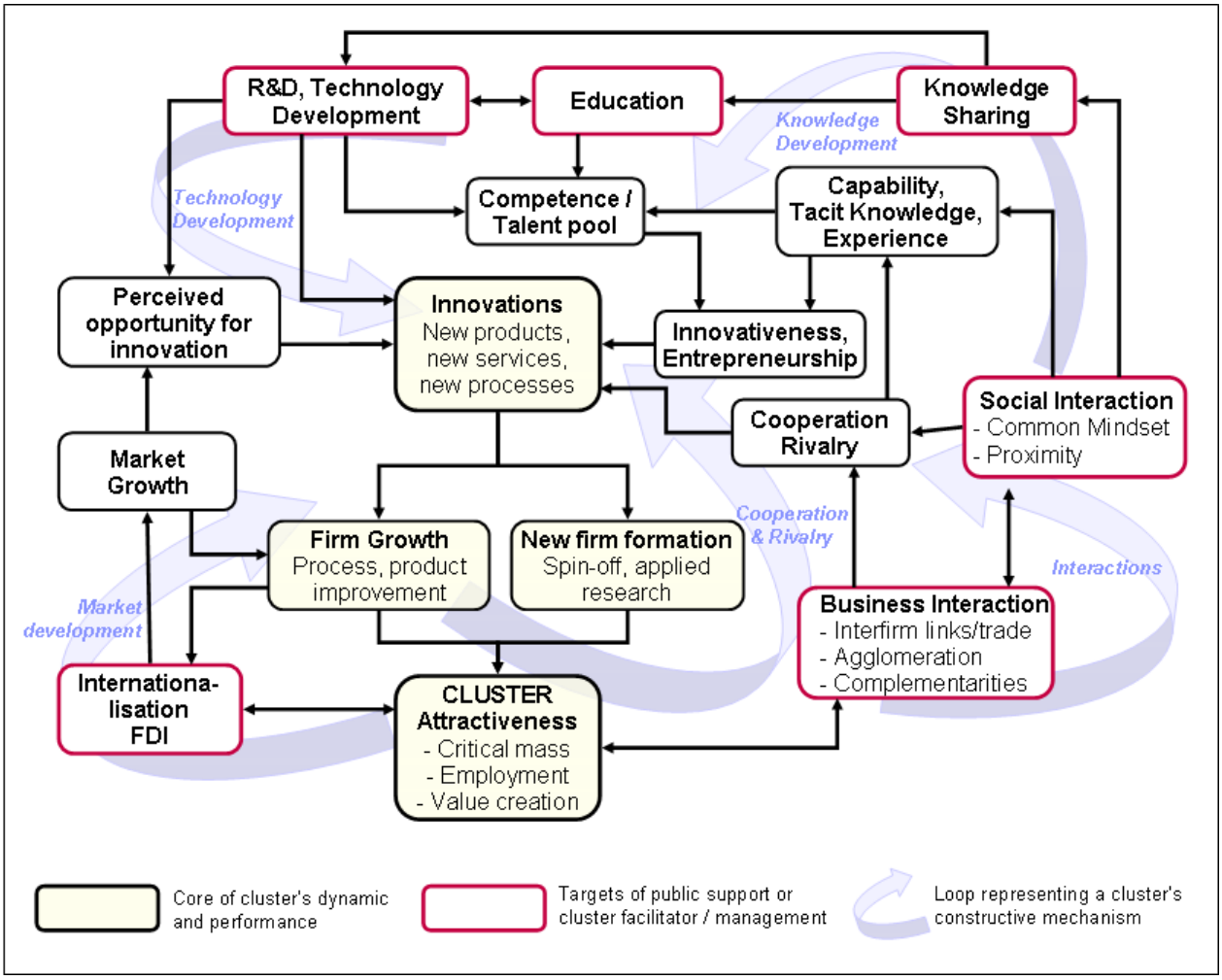


Figure 3: Model of cluster dynamics

Explaination of the logic behind the proposed model

Innovation can be seen as core of cluster dynamics. The essence of a cluster are firms, and their dynamic is expressed in terms of *firm growth* (in size and diversification) and *new firm creation* (as spin-off of larger firms, of universities or R&D institutes). These two central elements are dependent on *innovations*, as new products, services or processes. In turn, firm growth and new firm creation foster what can be called the *cluster attractiveness*, measured in number of players (critical mass must be reached), employment and value-creation (annual turnover). This dynamic is represented by the four yellow boxes at the centre of the figure.

Around these core elements, there are five main mechanisms that drive, directly or indirectly, innovation and cluster attractiveness.

One mechanism is ***technology development*** (upper left in the figure). Extensive and adequate R&D activity (both a research institutes and internally in companies), facilitated by efficient knowledge sharing in the cluster, increases the likelihood of new technologies and perceived opportunities for innovations. This results in innovations being implemented.

A second mechanism that influences innovation directly is ***cooperation and rivalry***. Not only the cluster develops through firm's growth, diversification, new firm creation, but these firms become more and more embedded in a network of complementary and competitive organizations, driven by interdependent relationships. Business interactions among various parts of a common value chain increase, and agglomeration of firms continues. Often, through these interfirm trades, firms become animated by rivalry but also cooperation for exploring new ideas and develop new products. This in turn reinforces the degree of innovation inside the cluster.

A third mechanism is the one of ***interactions***. Triggered by an increasing number of firms and agglomeration effect, interfirm links are intensified. These business interactions generate more social exchange among firms' representatives, enabled by geographical proximity. In addition, cognitive proximity (due to similar background or history of doing business together) facilitates the development of a common mindset in the region. This in turn stimulates more knowledge sharing. These two forms of interaction, social and business, activate each other overtime.

A fourth mechanism in cluster dynamics can be identified as ***knowledge development***. Primarily developed through education and R&D activity, knowledge is also created by interaction and exchange among competent and experienced cluster members. While R&D and education generate mostly tangible knowledge, competence and talent, business activity and social interaction create more capabilities and tacit knowledge based on experience and trial-and-error. Both competence and capabilities contribute to increasing innovativeness and entrepreneurship culture in the cluster, which in turn result in innovations.

A fifth mechanism is the one of ***market development***. Market growth fosters firm growth by increasing directly the level of activity or by creating more opportunities for innovations and results in concrete innovations. Firm growth and new firm creation increase the cluster attractiveness which generates more FDI and facilitate internationalization of the cluster's firms. Eventually, this internationalization effect (also intensified through the firms' growth processes) generates more market development and opportunity for the cluster abroad.

Finally, there are several forces of cluster dynamics which can be controlled/activated externally. In the purpose of stimulating innovations and business development, *local authorities* as well as *cluster managers/facilitators* work on supporting education, R&D, knowledge sharing, social interaction and business interaction, and FDI in the region.

Utility of such a model

The proposed model may be used for several purposes:

1. For illustrating interrelatedness of each cluster element.

To show the importance of each driver, either controllable or not.

For instance, the impact of the economic crisis in 2009 on local economies can be described in part using the proposed model. The downturn in market development results in less firm growth or in bankruptcies, which directly affects a cluster's strength and attractiveness, and in turn reducing the level of external investment in a given region. This situation also leads to less business interactions (obviously limited by fewer market opportunities and firms' struggle to survive), which further have a "slowing" effect on knowledge sharing and on firms' engagement in rivalry or cooperation type of activity (mostly because more focused on cutting-down costs, refocusing and resizing the company).

This market downturn also affects directly the perceived opportunities for innovation and reduces the level of innovation. In addition, in period of recession, firms tend to limit their R&D activity and investment in education, which indirectly can impoverish the cluster's competence.

Still, clusters do not necessarily cease to exist in period of recession. Explanation can be found in the cluster's surrounding institutions, which are bounded by other forces than the market only: the education and R&D system, and the government and regulation system on one side, and social bonds and business culture on the other side. One could say that the lock-in effect and risk of high dependency related to clustering (as mentioned earlier) is in a way counterbalanced by the fact the these institutions would remain strong in period of crisis. For instance, social bonds would remain tight and help to avoid complete dissolution of well-functioning business relations.

2. For scenario planning.

To predict negative effects of particular decisions, or events, as well as to point out the necessity of specific ameliorations.

The proposed model can be used to describe specific cause-effect scenarios, like in the case of the economic crisis mentioned above. Doing so, one can identify signal posts for avoiding a specific situation and point of actions to be taken in specific circumstances. This is especially related to the forces that can be acted upon by external actors (governments, cluster managers), marked in red colour in the diagram in figure 3.

In situation of crisis, or facing a poor culture for clustering (e.g reluctance to share), external facilitators can investment in or establish strategies for ensuring that R&D, education, knowledge sharing are sustained, as well as , business relations (by organising conferences, fairs, etc), and seeking to attract investment in the region (either from venture capital or internationalisation).

3. For monitoring performance.

To provide a first list of the important puzzle pieces to be put in place when developing a cluster (like a check-list), and to assess performance over time.

Regions, local industries, countries recognising a certain form of clusterisation and wishing to develop it can use such a model in order to:

- Pre-assess the situation and evaluate the cluster
- Take note of missing denominators and remediate to it.
- Monitor the cluster's evolution by conducting regular audits so as to identify negative trends and risk elements.

Limitations

There is a certain number of missing elements or element not wholly treated by the proposed model.

It should be noted that the model does not take into account obstacles and negative forces. In fact, this suggested way of presenting cluster dynamics is done in a simplistic way, where each arrow in the diagram represents a triggering effect, by which the first element affects positively the next one. Negative effects are simply assessed by assuming a negative trend or performance of the identified drivers, such as market growth vs. decline, well-functioning R&D vs. poor R&D activity, sustained social interactions vs. lack of social bonds, etc.

In addition, the model does not treat negative forces like "snags" or system failures, which are not necessarily related to the cluster's drivers but hinder its mechanism. Such obstacles might be related to:

- Culture, such as firms' resistance to change, reluctance to share knowledge and information
- External forces, like constraining regulations
- Financial constrains: such as high costs of applying new technology
- Cluster's resources, such as available labour force

5. Study of a Norwegian Maritime Cluster

5.1 Maritime Clusters

As commented by de Langen, ''the maritime industry does not consist of clearly economically related activities. Some activities are tightly interwoven, while others (…) are more stand-alone" (2002:214). It is argued that the potential independency of most of the maritime segments is not beneficial for networking and knowledge sharing, and does not create the necessity to establish closer partnerships building on complementarities for targeting new business opportunities (Doloreux, 2008). However, clusters like the Norwegian and the Dutch maritime industries are example of good business networking and cooperation.

❖ **Composition of Maritime Clusters:**

- The major maritime clusters in Europe are composed of the following main sectors: *Shipping, Shipbuilding, Marine equipment, Offshore, Inland navigation, Dredging, Ports, Maritime services, Fishing, Yachting, Royal Navy*
- Affiliated sub sectors: *Yacht & shipbuilding, Ocean surveys, Seafood processing, Marine renewable energy, Education & training, Research & development, Security & safeguarding from terrorist or piracy activities, Vessels & equipment for underwater activities in large depths,* Marine *aquaculture.*

The core (de Langen, 2002) of a maritime cluster varies from region to region, depending on the main segment served by the cluster's members. For instance, in Norway, while the NCE [3]Maritime (in the Møre og Romsdal region) covers the entire value-chain (from ship-design to ship operations) of the offshore market, the NCE Subsea (in the Hordaland region) is oriented towards subsea oil and gas exploitation.

❖ **Previous studies on Maritime Clusters**

The maritime industry has been the focus of a number of cluster-related studies, most of which on country basis, but some look at particular regions, at clusters that fall into the hub-and-spoke, Marshallian, or Italianate categories of clusters. A sample of maritime cluster studies is given in the following table.

Author	Country/Region	Main findings / Aspects analyzed
de Langen (2002)	Netherlands	What are the advantages for firms to locate in a cluster? and second, what cluster specific factors influence the development of maritime clusters?
Jakobsen et al., Dutch Maritime Network (2003)	UK, Germany, the Netherlands, Denmark and Norway	Determining industry long term performance, attractiveness, and competitiveness through an analysis of characteristics and sophistication of companies, industry dynamics, policies and regulations, and past performance of the maritime industries in the selected countries.
Karlsen (2005)	Norway	Insights into the industrial dynamics within regional contexts, through an analysis of shipyards and related maritime industries, the dynamics leading to cluster formation and upgrading, as well as industrial fragmentation,
Wijnolst, Maritimt Forum, Norway and Dutch Maritime Network (2006)	Netherlands, Norway, Germany, Italy, Denmark, France, UK.	Maintaining European Maritime competitiveness, through strengthening the maritime clusters from within, as well as at the economic policy level.
Reve (2006)	Norway	Focusing on competence as competitive advantage
Smith and Ibrahim (2006)	East Midlands Aerospace cluster, UK	Typical example of hub-and-spoke cluster, in which the economic activity is first and foremost dependent on and stimulated by Rolls Royce.
Isaksen (2008)	Norway	Analysis of innovation dynamics in six regional clusters (Norwegian Centers of Expertise), revealing the great importance of strong Norwegian

[3] Norwegian Centre of Expertise. The accreditation is attributed by a program run by The Norwegian Research Council, Innovation Norway and the Industry Development Fund, aiming at stimulating the best-in-class clusters in Norway.

		innovation systems in the maritime and oil and gas industries in underpinning the innovation dynamism of these clusters.
Doloreux (2008)	Canada	Explores the nature of innovation activities in the maritime industry, and the impact of firms size, knowledge intensity, and location within a cluster, on these innovations
Theodoropoulos (2006)	Europe, Netherlands, Germany, Greece	Factors of cluster creation and performance measurement.
Westvik (2008)	China, Japan, Korea, Singapore	Shipbuilding, Ship Repair, Maritime Services, Port Operations, Oil and Gas, R&D.
Oterhals et al. (2008a)	Møre og Romsdal Maritime Industry (Norway)	Cluster activity strengthened by internationalization of offshore activity. Tremendous growth, based on a strong power of innovation, but disparities among firms in terms of spill-overs and productivity.

Table 3: Selected studies of maritime industries and clusters

5.2 The Møre og Romsdal Maritime Cluster

The purpose of this study consists of reviewing a particular maritime cluster and apply the conceptual framework exposed in this paper (cluster identification, cluster structure and cluster dynamics and innovation), in order to assess the usefulness of such models as well as to identify some inexplicable or cluster-specific aspects in the cluster of focus.

The cluster selected for analysis is the maritime cluster located in the **Møre & Romsdal** region of Norway, a cluster representing an integrated value chain serving the offshore market.

5.2.1 History and evolution

In a very insightful and well-documented paper, Karlsen (2005) provided valuable information on the evolution of maritime activity in the region and explanation of its successful development of the maritime cluster.

The regional industrial activity studied by Karlsen covers shipping, shipbuilding, equipment suppliers and related services. With about 5% of the country's population and 10% of coastline, the Møre og Romsdal region plays a crucial role in Norway's maritime industry and is "considered to be the most entrepreneurial region of Norway" (2005:315).

At the end of the 19's century, advanced maritime technologies have developed in the region to support growing fishing activity (as a result of limited access to cultivated land).

Entrepreneurship in the region has developed in parallel with the industrialization from fishing activity to manufacturing of marine equipment and shipbuilding dedicated to hard-condition fishing. The development of shipbuilding activity has been supported by long-term market knowledge and innovation based on copies and experimentations. The first steel vessel was built at Ulstein in the 30s (2005:321).

Over time, the region specialized in shipbuilding because the combination shipbuilding / maintenance did not offer sufficient margins and was rather complicated in practice. And this, in spite of the higher cyclicality and risks related to shipbuilding. The region has made

good use of these variations in economic activity, through systematic investment in innovations (2005:322).

The agglomeration towards a well-connected industrial region started in the 30s. Diversification in marine equipment (in periods of overcapacity in shipbuilding) enabled by competence and strong business networks, resulted in the establishment of a set of key suppliers and sub-suppliers serving both regional and international markets. Thanks to good collaboration between yards and suppliers as well as among yards, competence and capacity was strengthened, and the region developed a flexible and low-bureaucratic cluster. Challenged capacity in terms of size of ships motivated shipyards to focus on new vessel types and new markets. The 60s were a period of prosperity and growth for the region (2005:323-324).

Focus on core competence, innovative attitude, entrepreneurial culture and strong bonds between well-established firms have contributed to the region successful strategies. By 2000, shipbuilding activity in value was almost as high as shipping (2005:327).

A factor that enabled strong integration in the region has been the local market (most of new shipbuilding contracts are given to regional shipyards); in turn, this well-integrated set of shipyards and suppliers have been able to expand to other regions, sectors and international markets (2005:328).

Innovation in the region has been triggered by demanding customers and competition intensity. Good collaboration has developed due to both proximity of customers (local market) and durable relationships which facilitated the understanding of their requirements. Competition in national and international markets has resulted in important investments at yards, to reinforce production capacity, equipment and personnel. Local rivalry and cooperation have been a stronger driving force rather that rough competition. Cooperation has been facilitated by geographical proximity of yards and customers. Besides, regional associations have fostered exchange and the further promotion of a common culture (2005:328-330).

R&D activity has been sustained in the region, also through collaboration with other regions. New products and services account for most the region's income (2005:331).

Shipbuilding requires a network of supporting activities, and strong and multiple linkages among yards, shipping companies, shipping engineers, equipment suppliers, have facilitated improvement of industrial activity in the region (2005:331).

At the end of the 20th century, large multinationals have started to take control of a part of the family-driven activity in the region. This has created culture mismatch and management tensions. More recently, the tough international competition (Asia) mainly based on lower labor costs, but also on rapid competence development, resulted in an outsourcing of hull production to Eastern Europe and Far East. As a result, the strong and well-coordinated regional cluster in Møre og Romsdal has been challenged (2005:331). However, strong will, long-term competence and extensive market knowledge enabled the cluster to focus on high-value product and services, and take advantage of the strong linkages among local partners.

5.2.2 The cluster today

The strongest competitive advantage of the Møre og Romsdal maritime cluster is a common innovation force and the ability to deliver new products to a demanding market (Oterhals et al. 2008a).

The weakness of the cluster lies in the difficulty to compete on costs and to get access to high-competent work force.

In 2007, the cluster was composed of 13 shipyards, 159 equipment producers and other suppliers, 12 marine and design consultancies, and 17 ship owners; in addition, the region had a fleet of 72 deep-sea fishing. For 2008, the cluster's turnover was budgeted at about 50 billion NOK, twice as big as in 2005; employment in the cluster has increase by 30% during the period (Oterhals et al. 2008a). In 2007, shipyards delivered 50% of their product and services to local shipping companies, while accounting for almost 30% of the result of equipment suppliers in the cluster.

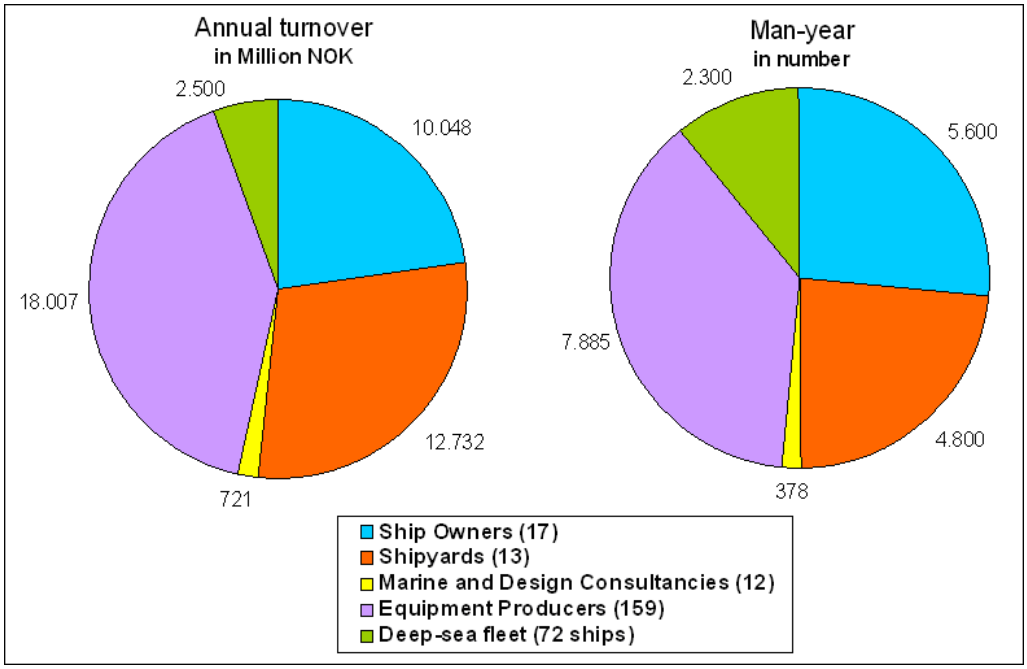


Figure 4: Annual turnover and man-year of the Møre og Romsdal Cluster, 2007 (data source: Oterhals et al. 2008a).

Today, thanks to a strong and sustained demand on the offshore market, the maritime cluster has become bigger, stronger, and developed self-reinforcing mechanisms and scale advantages, supported by a strengthened capital base of ship owners (Oterhals et al. 2008a). Interaction and trade among the cluster's members has increased, and closer relations among companies have lead to a significant increase in design activity and development of new ship concepts. Work force and competence have been increasing in response to growing activity, but improvements are needed for making the region more attractive to a competent and diversified work force (Oterhals et al. 2008a; Hildre, 2009; Almestad, 2009).

The global financial crisis started in 2008 may have consequences on the cluster's development, but strong linkages among companies give the cluster a good position in delivery of high-value and integrated services for niche offshore segments, at regional,

national and international level. Internationalization of offshore activity has contributed strongly to the cluster's development (Oterhals et al. 2008b).

❖ Innovation in the Møre og Romsdal Cluster

Risk-taking and continuous search of new concepts have been drivers for innovation in the maritime cluster. This has been supported by close cooperation among designers, yards, and equipment suppliers, and good business relations. Local ship owners ordered primarily ship design and equipment from the cluster, even for ships produced in lower-cost countries (China, Spain, and Eastern Europe) (Oterhals et al. 2008b). Innovation has also been stimulated by tough market competition, increasingly from international firms. The demand for more sophisticated and tailor-made offshore vessels for both Norwegian market and new international offshore fields is growing, and the cluster must work to keep its leading global position, notably within design and ship equipment as well as quality control of foreign yards. R&D activity has been reinforced over the past years, notably through the establishment of the NCE Maritime (Norwegian Centre of Expertise in Ålesund).

❖ Role of local authorities

The role of local authorities is to create an environment favorable for business activity and facilitate the link between the industry and public institutions.
The **South-Sunnmøre** region has developed a robust infrastructure and transport network, which has benefited greatly to the working region, also attracting a complementary work marked thanks to shorter commuting time.
Other initiatives taken by the **Sunnmøre** region (Goksøyr, 2009), for establishment of a joint growth strategy for the region, include:

- Strengthen maritime research and education, based on closer cooperation between communes and industry
- Inter-regional link and cooperation, to attract more workforce and competence
- Strengthen cultural life and top-level athletics.

❖ Key success factors of the Cluster

The main success factor of the Sunnmøre region has been **innovation**, as pointed out by Hildre from NCE Maritime (Goksøyr, 2009)
The main asset of the region is its world leader cluster within advanced maritime operations, a cluster comprising 200 companies, accounting for a turnover of 50 billion NOK, and employing around 21000 people. The maritime industry is vital for the region, and the Sunnmøre cluster contributes to the world offshore market with 60% of the design, 50% of equipment /outfitting, and 35% of ownership (Goksøyr, 2009).

❖ A vision for the Maritime Cluster

Ulstein, one of the driver of the cluster's successful development, envisions the maritime cluster to be "an attractive growing region with high living standard and quality of life built on a dynamic, international-oriented and knowledge-based business life" (Ulstein, 2009).

❖ Knowledge and Competence: the gold of the cluster

Some ingredients for fostering competence development through a good learning environment (Goksøyr, 2009) include:

- Good employers
- Research environment and education system
- Life-long learning culture
- Human capital
- Competition and cooperation among firms
- Attractive living environment (culture, sport,)
- Communication (among people, among places)

❖ **Challenges**

Growth and new markets lie outside Norway, and the cluster must retain its first-class competence in offshore market, including design, prototype development, equipment and integrated systems, and must ensure that its long-term competence within shipbuilding continue to create value through involvement in foreign yards. In order to sustain a necessary level of innovation and competitiveness, the cluster is facing several challenges:

Recruitment, education and training have been pointed out as critical factors in the cluster's development (Oterhals et al., 2008; Goksøyr, 2009; Hildre, 2009; Ulstein, 2009; Almestad, 2009). Attracting talents and strengthen competence and knowledge in the public and private sector is necessary. This requires to promote more actively Møre og Romsdal as a dynamic and exciting industry, as well as an attractive region in terms of culture and sport (Hildre, 2009).

Education should be strengthened, focusing more on attracting more and qualified students with an entrepreneur profile and increasing the interaction education/industry.

Research must be intensified in order for the cluster to become a knowledge and innovation centre in maritime operations. While the while the cluster benefits from a strong link between research and industry, the public support is insufficient and recruitment of researchers difficult (Hildre, 2009). The industry's relevance and competence must also be better integrated in research activities (Almestad, 2009).

Infrastructure must become more efficient. Despite the good development in one part of the region (South-Sunnmøre), the network of internal and external connections still needs improvement (Hildre, 2009).

5.2.3 Analysis

❖ **Types of cluster**

The classification proposed by Pickernell et al. (2007) to identify the type of cluster that corresponds the most to the Møre og Romsdal Maritime Cluster (shortened to M&R).
First, reviewing the clusters' short description, an initial selection of adequate cluster types is made, and then each aspect of the cluster type is reviewed to identify which type suits the M&R region best.

Initial selection:

Industrial Complex. This type is driven by a government-controlled institution, which is not the case of the M&R cluster, and thus does not qualify as relevant type.

Hub-and-Spoke District. This type is dominated by few large firms on which depend a series of SMEs and may well suit the M&R cluster.

Marshallian. This type consists of a large group of SMEs with access to specialized labor and services, with strong institutional support. It may qualify as relevant type.

Italianate. This type is similar to the Marshallian, but exhibits more exchange between buyers and suppliers, cooperation between competitors to share risk, high innovation, strong local associations to build shared infrastructure and strong local government. Although the local government has not been at the origin of the M&R cluster development, it definitely works for facilitating good economic development. The Italianate qualifies as a relevant cluster type for M&R.

Urban Hierarchy. The M&R cluster enjoys common infrastructure due to strong development efforts from the local authorities, but this infrastructure is not what defines the cluster primarily. Therefore the M&R cannot be called a urban hierarchy.

Social Network. Thanks to substantial effort from NCE Maritime in Ålesund, but also individual initiatives (e.g. Ulstein leading joint industrial innovation projects), the M&R cluster definitely is home for a well functioning social network.

Virtual Organization. Given the significant number of interactions, joint projects, deliveries of integrated services locally and abroad, the M&R cluster shows clear signs of a virtual organization, defined as a relationship-based virtual large organization of SMEs.

Satellite Industrial Platform. Despite the increasing presence of international players, the cluster does not resemble a set of branch plants of multinationals. It rather has a long history and family tradition.

This quick review leaves us with four potential types of clusters to define the M&R Maritime Cluster: the hub-and-spoke, Italianate district, social network, and virtual organization types.

Looking at the other aspects of cluster classification, the following can be said:
Structure / Business type. The M&R cluster definitely is vertically oriented, given that it covers the entire value-chain serving the offshore industry, including ship design, shipbuilding, ship equipment, and shipping. Therefore, the social network and virtual organization, horizontally oriented, do not seem appropriate types for defining the M&R region.

Nature of interaction. The hub-and-spoke type is driven by formal interactions while the Italianate is mostly informal. The M&R cluster is supported by associations (e.g. NCE maritime) ensuring good relation and social interaction. Without saying that interactions are purely informal, one can note that from this perspective, the Italianate and social network types suit the M&R best.

Reason for success. It is difficult to say whether success is due to relational or agglomerational forces, given that both can contribute to better knowledge sharing and innovation. Yet, the M&R region is known for its extensive interaction and close cooperation. From that point of view, all four selected cluster types may qualify.

Return sought. As stated by Karlsen, “economic and social success is widely respected in the local communities [of the Møre og Romsdal region]” (2005:330). This conveys the idea that knowledge might not be the first driver inciting firms to being part of the cluster, but cost might be. However, the leading position of the cluster in terms of high value creation, high quality products and innovations makes it attractive also from a knowledge and competence point of view. Consequently, the hub-and-spoke and Italianate types are most appropriate types for the M&R cluster.

Participant goal. The presence of firms in the region is mostly due to the presence of other firms serving the same industry with complementary or competitive services/products, as well as a pool of competent work force. Rivalry inside the cluster is expressed as "I shall not crush my neighbor, but I shall become better than him" (Karlsen, 2005:330, quoting Karlsbakk 2003: 86). Their goal seems therefore more collective survival, based on good relationships and long-term contracts than individual based on contract outside the cluster. The hub-and-spoke, Italianate, and virtual organization are therefore potential cluster types according to that criterion.

Participant behavior. The cluster is stimulated by collective action, and also by strategies of the large players, shipbuilders. On the other side, it is difficult to tell to which degree local firms operate independently. Therefore, it is difficult to judge which of the hub-and-spoke, Italianate, or virtual organization types best suits the M&R cluster.

Type of relationships. Relationships are primarily based on cognitive trust and team work, rather than pure transaction, both in the form of local trade and risk-sharing cooperative actions. It is less obvious how much of this cooperation happen between competitors. Still, the Italianate type seems to qualify best the M&R cluster.

Management focus. Unlike high-tech clusters characterized by extensive firm creation, the M&R region is less focused on *start-creating*, and more of the *sustain-developing* and *survive-connecting* types. Indeed, the leading shipbuilders in the region have a long history and family tradition. The equipment suppliers are located were innovation occurs and depend on successful business connections for securing their own development. From that perspective, the Italianate model suits the cluster best, but hub-and-spoke and virtual organization may also qualify.

Learning process. The M&R region is referred to as one of the most entrepreneurial region in Norway (Karlsen, 2005), and a maritime cluster of top-class and innovative products and services for the offshore market. Still, the industry served is not similar to the biotech or software industries, characterized by constant and quick innovations and short product life-cycles. Still, the M&R cluster focuses on new concepts and prototypes developments, and seems to be oriented to all three aspects of learning, doing-things-differently, doing-things-better and doing-different-things. From that point of view, the Italianate district and virtual organization seem most appropriate cluster types.

From the above review and the previous introduction to the Møre og Romsdal Maritime cluster, one can conclude that this cluster corresponds to an Italianate district. Although the hub-and-spoke district qualified for many of the aspects, what differentiate the two types is the dominance of a few large firms in the hub-and-spoke district, as well as absence of trade association, while the Italianate district serves one main industry, and is based on geographically generated external economies of scale in labor, specialized services and information spill-overs, driven by large intra-district trade between firms, personal exchanges, cooperation between competitors, strong trade associations and high innovation. Although the cluster types share the aspects of vertical integration, specialized services, cooperation and long-term contracts, and a strong local government, the aspects that point at the Italianate district as suitable type for the Møre og Romsdal cluster are its high level of innovation, high degree of personal interaction, and support from of trade association.

This is not a quantitative multi-criteria analysis, but rather an attempt to apply the classification offered by Pickernell et al. (2007), including both qualitative and objective judgments, to identify a cluster type corresponding to the M&R region.
The identification is not straightforward, and the classification could have benefited from additional elements, such as type of industry and historical development. Nevertheless, the eight-clusters-classification is helpful to approach cluster analysis in a more systematic manner and to understand better the internal functioning of those clusters.

❖ Dynamics of the Møre og Romsdal Maritime Cluster

To apply the proposed model of cluster dynamics to the Møre og Romsdal maritime cluster, it is necessary to consider the past evolution of the region until its present activities.

Starting from the core of the cluster, firm growth and new firm creation, new firm creation is not obvious to measure, due to the fact that figures on number of firms do not include firms that were created then disappeared. However, the industrialization period started in the 30's during which a substantial number of ship equipment suppliers established, demonstrates well the dynamic of new firm creation. On the other side, firm growth has been characterizing shipbuilders, from the small family-owned enterprises to today's large and renowned international players (as results of several mergers among local firms).

This business development has been and is still nurtured by constant innovations, including improved products and services, but also diversification to new attractive markets. At the beginning of the 20th century, advanced maritime technologies emerged to support a growing fishing activity. In the 70's innovations were turned toward the offshore oil and gas market. Today, the cluster is very attractive for businesses thanks to its high level of activity and top quality of products and services, good employment opportunities, high and growing value-creation (50 billions NOK in 2008, twice as much as in 2005).

However, it is recognized as a challenge for the region to attract more talented people to secure a sustainable competence pool and be able to answer future demanding growing markets.

The Møre og Romsdal cluster is driven by several forces, which can be seen from the perspective of the mechanisms described in the figure 3.

Technology development has been and is one of the cluster's strengths. In the 50's challenged capacity in terms of size of ships motivated shipyards to focus on new vessel types, which required a certain level of R&D. Overtime and still today. While R&D is mostly triggered by learning-by-doing, the cluster's firms engage in R&D in collaboration with research institutes locally and nationally, particularly with the technology milieu in Trondheim (NTNU, SINTEF, MARINTEK).

The ***cooperation-rivalry*** mechanism is also one driver of innovation in the M&R cluster. Business interactions are numerous; approximately 50% of the cluster's activity is created by trade between firms inside the cluster. Good collaboration has developed thanks to proximity of customers (also enable by improved infrastructures) and long-term relationships. Both cooperation and rivalry are recognized as dynamic forces, not only due to stimulating interactions among firms, but also supported by the NCE Maritime, helping the cluster establishing joint innovative projects.

The process of ***interactions*** is not limited to interfirm trade, and the cluster is also built on social interaction. Encouraged by the NCE Maritime, the cluster engages in social networking and idea exchange, both in the context of interfirm trade and during conferences, fairs, etc. These collaborative exchanges are at the heart of new business ideas and innovations. As underlined by Karlsen, "innovative capabilities are rather to be found in the relations and interactions between firms than in the R&D function within the single firms" (2005:335).

The maritime industry in Norway is knowledge-based (Reve and Jacobsen, 20001), and the industrialization process in the Møre og Romsdal's maritime industry has been enabled by competition and practical knowledge (Karlsen, 2005). The cluster has developed a sort of locally embedded knowledge (unique to the cluster) as well as absorptive capacity (capability to learn and apply new knowledge). Knowledge exchange is enabled by various interaction channels, and by interactive learning. Not only goes knowledge transfer from ship owners to shipyards, but among all actors in the value-chain, including designers, equipment suppliers, marine services, supporting institutions. All this ***knowledge and capability development*** contributes to foster the entrepreneurship attitude in Møre og Romsdal, which in turn generates innovations.

Market development has always been the motor of the development of the maritime industry in the region: in the 30's, when the shipbuilding capitalized in modernization of the offshore fishing industry; in the 70's, when they diversified towards the offshore oil and gas market (Ulstein producing the first supply vessel) while remaining loyal to their core business – shipbuilding; and since the turn of the century, while the offshore market has switched from the Northern and Norwegian seas to international markets[4] including Brazil, Australia, the Mexico gulf, and West Africa. The market development has generated more business for the cluster's firms and stimulated their growth and diversification. On the other side, the high-quality and high level of competence present in the region have been attractive factors fir FDI (an example being the establishment of Rolls Royce in the region during the 90's). More striking in relation to market development is the extensive internationalization activity of both shipping companies and shipyards.

Finally, it seems that the cluster has all the winning cards to be a successful and integrated cluster: competence, communication, capital, critical mass, strong cooperation industry/research institutes, innovations, internationalization.

The model reflects quite correctly the dynamic of the Møre og Romsdal maritime cluster, and may therefore be considered for further analysis of other clusters. Other types of clusters might point at elements not covered in the model, as well as similarities. One aspect that is missing for the model to fit the Møre og Romsdal cluster is the recourse to foreign labor force, which technically cannot be seeing as a driving force of cluster development, but rather as a sign of weakness and a risk to become dependent on outside resources. On the other side, this shows the high degree of flexibility exhibited by the cluster and its ability to adapt to market changes. Another aspect that should be more directly treated in the model is the external forces that support the cluster integration.

[4] In 2002, the Northern and the Norwegian seas represented 66% of the market for offshore shipping activity of the region, lower to 56% in 2006 (Oterhals et al., 2008b)

6. Conclusion

The present paper aimed at presenting the concept of cluster, what they are, which benefits they offer, the various types of clusters, the main elements forming a cluster, and a tentative model for explaining the dynamics of clusters and innovation.

To understand the dynamics of clusters, a conceptual model is proposed, which highlights the main forces driving an industrial cluster as well as its underlying mechanism.

The the proposed model may be used in various purposes:

- For illustrating interrelatedness of each cluster element.
  To show the importance of each driver, either controllable or not.
- For scenario planning.
  To predict negative effects of particular decisions, or events, as well as to point out the necessity of specific ameliorations.
- For monitoring performance.
  To provide a first list of the important puzzle pieces to be put in place when developing a cluster (like a check-list), and to assess performance over time.

Such a model might serve to various users:

- Governments and local authorities responsible for regional development.
- Cluster managers and facilitators for monitoring the cluster's evolution.
- Firms wishing to evaluate their position in a given economic system and weighting the pros and cons of engaging actively in a cluster.
- Education, by giving a first insight on the dynamics of clusters.

Limitations

The model presented is principally based on desk study, and is obviously not pretended to be universal or immediately applicable. There is a certain number of missing elements or element not wholly treated by the proposed model. The model does not take into account obstacles and negative forces. Such obstacles might be related to:

- Culture, such as firms' resistance to change, reluctance to knowledge sharing
- External forces, like constraining regulations
- Financial constrains: such as high costs of applying new technology
- Cluster's resources, such as available labour force

Further work

To improve the quality and usefulness of the proposed model, several actions can already be taken:

- Test it on a series of other industrial clusters, correct it and develop it further. Not only should such a model be validated by existing clusters, but it should also be improved based on comparison between disctinct type of clusters. Indeed, it is not obvious that a same model would apply for any type of industries and any type of clusters.
- Systematise it and improve its exploitability, by introducing weight to each driver. This would help to measure a cluster performance in a more quantitative way and to benchmark distinct clusters more easily.

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