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Emergence of clusters: by chance or by design? The rise of the Oslo Cancer Cluster

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Abstract

The paper develops an analytical framework to explain the emergence of regional clusters. The framework consists first of some pre-existing conditions that have to be present if specific clusters are to evolve in some places. Secondly, it points at the need for triggering factors that cause clusters to emerge in just some particular places that have the necessary conditions, and factors that first of all stimulate entrepreneurship. The framework also distinguishes between pre-existing conditions and triggering factors at the micro, meso and macro level. The framework turns out to be a useful tool in order to explain the emergence of new entrepreneurial biotech firms in Oslo in the late 1990s and early 2000s, which makes up the rise of Oslo Cancer Cluster. Important pre-existing conditions in this case are the long-term creation of a regional R&D system specialised in cancer diagnostics and research in Oslo and latent entrepreneurs. Triggering events are in particular national regulatory changes and the inflow of new knowledge of commercialisation. The framework is highly relevant for small, science based clusters as Oslo Cancer Cluster, however, it is in principle also applicable to other types of regional clusters.

Introduction: the middle ground between chance and design

We have witnessed a large scholarly and political interest in regional clusters the two last decades. A main focus has been on why clusters exist, the main characteristics of functioning clusters, and how clusters can be supported by policy initiatives. Recently more interest has also been devoted to the life cycles of clusters; how clusters emerge, change and develop over time.

The cluster life cycle approach is, however, discussed. One topic under debate is how new clusters emerge, and why clusters grow up in some particular places. Feldman and Braunerhjelm (2006: 1) maintain that ‘there is little understanding of how successful clusters come into existence’, and Ter Wal and Boschma, (2011: 921) claim that the cluster literature has paid little attention to the question ‘about where clusters come from and about why they emerged as they did’. Two main views on cluster emergence can be distinguished. These correspond mainly with the three approaches of regional path creation by Martin and Sunley (2006: 424-428). We join the first two of these approaches which see path creation as random and as a mix of limiting conditions and chance events. The third approach by Martin and Sunley (2006) is path creation resulting from successive regional paths that may include a large element of purposive agency.

The first main view underlines that new clusters often ‘start out in a particular location more or less by chance’ (Maskell and Malmberg 2007: 612). Krugman (1991:35) likewise observes that highly localized industries within the US ‘can be traced back to some seemingly trivial historical accidents’. Crespo (2011: 2026) discusses ‘the evolution of technology clusters, i.e. clusters that are in the cutting-edge position in the evolution of the technological field’. Although initial conditions in a region influence the emergence of technology clusters, they mostly arise by largely arbitrary location decisions. The idea is that no externalities exist in the emergence phase of clusters; thus, ‘each actor decides individually’ (Crespo 2011: 2034), and the places where pioneering firms ‘chose to locate are uncertain and unpredictable’ (op. cit.: 2035). These views resemble the approach of windows of locational opportunity (Storper and Walker 1989) which states that new or renewed, fast-growing industries have a large degree of locational freedom. The location freedom is explained by the fact that new and renewed industries often demand new skills and work habits, and new types of input factors which make such industries less bounded to location factors found in the old industrial centres. Additionally, fast-rising industries have often high profits, ‘which allow them to attract the resources and labour that cannot be created at the new site’ (Storper and Walker 1989: 74).

The second main approach maintains that the emergence of clusters relates to previously developed local capabilities, routines and institutions (Boschma and Frenken, 2011). New industries grow out of existing technology and industrial structures through regional branching processes which include spin-offs and new firm formations. New industries emerge when an existing industry mutates and diversifies into technologically related areas or when knowledge and skills from several industries are combined to form a new industry. In the first case specialisation in one industry or value chain in a region may facilitate knowledge spillover and learning among firms that lead to new economic relevant knowledge. In the second case ‘it is argued that diversity and variety foster cross-fertilization of knowledge and technology between diverse industrial sectors’ (Strambach and Klement 2012: 1845), which stimulates the generation of new knowledge that may provide the basis for new economic activity.

Following the second main approach clusters emerge in places that hold some specific, local conditions, ‘for example a strong scientific base or political support, which give the emerging cluster the potential to reach a critical mass’ (Menzel and Fornahl, 2009: 225). With the use of the regional innovation system (RIS) approach, the rise of clusters is shaped by the configuration of the RIS. New clusters depend on historically evolved competences and pre-existing RIS structures. Based on a study of the emergence of fuel cell technology Tanner (2011: 24) concludes that ‘even in the case of radical technology development, knowledge production is also highly cumulative and builds on pre-existing localized scientific and technical knowledge recourses, which implies that the emergence of radically new industrial paths is highly place dependent’. Tanner (2011) regards two mechanisms to be of particular importance in an early phase of radical technological development; first, that a minimum level of relevant scientific and technical knowledge exists in firms, and, second, proximity to

university research and researchers that can assist in developing a new knowledge base. Because of geographical bounded knowledge spillovers localities with existing knowledge and skill in a particular technological field will often nurture new related industries through branching processes.

This paper forwards a middle ground between these two approaches through recognizing the significance of pre-existing, regional conditions that make it possible for specific industries and clusters to evolve in some places, and at the same time emphasising some triggering factors that cause clusters to emerge in few particular places. This approach may contribute with new knowledge as Wolfe and Gertler (2006: 250) observe that ‘the way antecedent conditions are transformed by trigger events into the genesis of a cluster is precisely what is missing in prevailing cluster formation theories’. The next part of the paper develops this approach on to an analytical framework for studying why and how clusters come into being at specific places. The paper then discusses the relevance of the framework in an empirical analysis of the emergence of the highly research based Oslo Cancer Cluster (OCC). OCC received the status as Norwegian Centres of Expertise in 2007, a status which is reserved for the internationally most competitive clusters in Norway. The cluster organisation consists of about 70 members including research institutes, global biotech and pharmaceutical firms located in Oslo and beyond, established and venture based Norwegian firms, hospitals and patient organisations. The paper aims to uncover which assets and which triggering events that have been most important for the emergence and initial growth of Oslo Cancer Cluster, in particular the growth of a number of small firms in the 2000s. The last part of the paper discusses what more general theoretical insights about cluster emergence that can be drawn from the analysis of OCC.

Theory: pre-existing conditions and triggering events

This paper develops a framework consisting of two initiating conditions for the rise of a new cluster; first, certain pre-existing conditions or assets present in a locality prior to the emergence of the cluster; and second, triggering events that stimulate entrepreneurship (Isaksen 2011). Thus, Ter Wal and Boschma (2011: 924) state that ‘regions may have to fulfil generic conditions such as infrastructure, a local labour force and the like in order to be a potential candidate for new industry’, while Feldman and Francis (2006) point to the fact that entrepreneurs and new-firm formations often spark the emergence and growth of clusters. Entrepreneurs are often ‘home-grown’ and have some location inertia; they establish firms based on previous experience, knowledge and local assets. The emergence of a new industry mainly rests on where the pioneer firms of the industry arise (Ter Wal and Boschma 2011). New industries often emerge through spin-off dynamics and processes of imitation. A new industry tends to arise from existing, related industries, either one particular industry or from combinations of knowledge inputs from a variety of industries. Such factors lead to spatial clustering as spin-off firms tend to locate nearby their parent companies and imitation occurs more easily with geographical proximity to sources for brand new knowledge. One or a few anchor firms may be particularly important for the evolution of a cluster. ‘Whole clusters can develop out of the formation of one or two critical firms that feed the growth of numerous

smaller ones' (Wolfe and Gertler, 2006: 250). However, Ter Wal and Boschma (2011: 924) argue that many regions fulfil the necessary conditions to breed new industries, thus where new spatial clusters emerge 'is to a high degree dependent on chance events'. Crespo (2011) also argues that chance matters when the particular localization specifications that are vital for the emergence of a cluster in a new technological field are widely available in space. In summary, clusters do not emerge entirely by chance as cluster emergence requires some specific local assets. But nor can new cluster be 'designed' even if some basic assets may be created by policy initiatives, e.g. scientific knowledge in research labs, venture capital, and public demand for specific goods. Local assets also have to be turned into productive use by entrepreneurs.

The following discussion attempts to clarify what are possible regional preconditions and main triggering factors for the emergence of clusters in particular places. A main conclusion from cluster studies, however, is that clusters emerge in quite different ways (Belussi and Sedita, 2009). One distinguishing factor is the prevailing knowledge base or innovation mode of clusters (Trippel et al., 2014). To narrow down the subsequent theoretical discussion on cluster formation we focus on clusters dominated by an analytical knowledge base (Asheim and Gertler, 2005) and by the science based (STI) innovation mode (Jensen et al., 2007), which are clusters characterised by a comparatively high R&D input. Even if we then focus on one particular type of clusters 'no single determinant constitutes a necessary or sufficient precondition for the genesis of a knowledge-intensive regional cluster' (Sternberg, 2010: 316).

The discussion of main factors for cluster emergence is summarised in Table 1, which distinguishes two main groups of explanatory factors. The first group includes, as already said, the existence of certain prerequisites of assets prior to the emergence of a cluster, and triggering events that stimulate entrepreneurship. The events are 'historical moments through which social and institutional agency have influenced the nature and character of the emerging growth path' (Dawley, 2013: 108). The emergence of clusters is then based on 'the purposeful establishment and reinforcement of paths by actors' (Henning et al., 2013: 1351). The distinction between pre-existing conditions and triggering factors resembles the way empirical events are explained in the critical realist approach (Sayer 1992). This approach distinguishes between i) structures and mechanism with causal powers and ii) specific conditions that affect the working of the mechanisms. When applying this approach the evolution of a cluster depends upon some structural characteristics that are necessary for the emergence of a cluster and on 'conditions whose presence and configurations are contingent' (Sayer, 1992: 107), that is, found at certain places and times.

The second group of factors includes different levels wherein the initiating factors operate. Much theorising on cluster emergence focuses on entrepreneurs (micro level) that build on local sources of knowledge and local institutions (i.e. the meso level), thus theories focus on 'the importance of entrepreneurship as an endogenous process' (Feldman and Braunerhjelm, 2006: 7). *Macro* factors include the institutional and policy framework at the national level, in particular, that affect the formation of clusters. Macro factors that can contribute to the

emergence of science based clusters are in particular new technological knowledge that derives from research activities that are often supported by national means. It has become commonplace to regard radical innovations that change technological regimes as results of research activities. Universities and research institutes have been critical in the initiation and development of nearly all modern core technologies, and their research activities are often supported by ‘mission-oriented’, government supported technology programs, for example military-related R&D spending (Mazzucato 2013). However, government R&D policy contributes to cluster emergence in indirect rather than direct ways; regional clusters are rarely planned as outcomes of explicit government policy but rise as unintended results. Government R&D funds may trigger cluster building when funds go to places where there already exist relevant R&D capacity in the form of university research groups and R&D-institutes. ‘Policy, across multiple level of governance, can contribute to the accumulation of key assets in a specific location’ (Wolfe and Gertler 2006: 258). In some cases the rise of science based clusters are supported by geographical decentralisation in the form of movement of firms or R&D-organisations from metropolitan areas to other locations. Decentralisation of research activities has led to the fact that ‘Western Crescent is a perfect example of a state-dependent high-tech cluster’ (Sternberg, 2010: 306), and ‘Sophia Antipolis is almost exclusively attributable to measures of central government’ (op. cit.: 308).

Triggering events may also operate at the macro level in the form of new market opportunities, e.g. governments demand for technologically sophisticated products, and regulatory changes. The last event is exemplified by the emergence of the Capitol biotechnology cluster in Maryland, USA. According to Feldman (2007: 241) the emergence of this cluster can be traced back to ‘three exogenous sets of factors that sparked the nascent entrepreneurial talent in the region’. The first factor is, as underlined above, the presence of some large government laboratories and much R&D-funding in the region. The triggering effects were two other exogenous factors: new public actors designed to stimulate the commercialisation of research results, and new opportunities for the private sector to commercialise new technologies in cooperation with public sector organisations.

Table 1: Systematisation of explanatory factors for emergence and localization of science based, regional clusters

	Pre-existing conditions	Triggering events
Macro	New technological knowledge from ‘mission-oriented’, government research programs	New market opportunities, and regulatory changes
Meso	Functioning regional innovation system narrowly defined	New research results plus combinatorial knowledge dynamics
Micro	Latent entrepreneurs that are ‘created’ through former activity in a region	Considerable entrepreneurial activity caused by external shocks

The *meso* level points in particular to the importance of the existing regional innovation system (RIS) for the emergence of clusters. A RIS is seen as a specific framework in which

close inter-firm interactions, knowledge and policy support infrastructures and socio-cultural and institutional environments may stimulate collective learning, continuous innovation and entrepreneurial activity (Asheim & Isaksen, 2002; Tödting & Trippel, 2005). Several studies suggest that the configuration of RISs to a large extent affects what type of firms and clusters that evolves in a region. A core argument in evolutionary economic geography is that new growth paths 'do not start from scratch but are strongly rooted in the historical economic structure of a region' (Neffke et al. 2011: 261). The emergence of science based clusters is supported in particular by RISs defined in the narrow sense where the focus is on science based innovations (Lundvall, 2007: 98). Such RISs typically include advanced research activities in universities, research institutes and firms' R&D departments, venture capital funds, much knowledge exchange between academia and industry, and a pool of highly skilled workers. As much scientific knowledge is codified and widely available, science based entrepreneurs and firms may find their most relevant knowledge providers and innovation partners over long distances (Asheim & Gertler, 2005). However, entrepreneurs and firms also benefit from short geographic distance to R&D organisations, both to gain early access to new research results before they become widely published, and to recruit highly educated labour. Such conditions contribute to explain why firms in new, knowledge intensive industries often cluster close to some universities and research institutes (Cooke 2002: 130–131). Universities and research organisations 'perform as incubators which are then exploited in the form of new firms and more generally of the formation of a highly skilled labor force' (Orsenigo, 2006: 214). The meso and macro level back up each other: Government support programs and a regional knowledge infrastructure that can utilise the support to carry out advanced research is seen (by Sternberg, 2010) as the most important factor in the emergence of many science based clusters, e.g. 'the combination of MIT and state R&D expenditures was the decisive factor behind the genesis of this (i.e. Greater Boston) high-tech cluster' (op. cit.: 304)

The argument that functioning (narrowly defined) RISs often are the foundation for new knowledge based clusters stands out against the view that clusters emerge in particular locations by chance. However, the RIS has to produce some 'results' in order for a new cluster to evolve. The important results are research findings that lead to new firm formation, e.g. through academic spin-offs, and candidates who hold skills that are relevant for activities in an emerging cluster. Also other regional industries may provide valuable experience-based knowledge to commercialise and industrialise research results (Karlsen et al., 2011). Recent studies have demonstrated that firms innovate mainly through the integration and combination of varying knowledge bases, denoted as combinatorial knowledge dynamics (Manniche 2012). An important factor behind the combination of different types of knowledge is the need by firms 'for not only generating new knowledge but also for "pushing" and processing this knowledge towards commercial utilization' (Manniche 2012: 1834-35).

The *micro* level focuses on entrepreneurial activity, as entrepreneurs act as agents of change when starting firms. 'Entrepreneurs spark cluster formation' to cite Feldman et al. (2005: 130). Much empirical evidence points to the fact that entrepreneurs draw on existing resources in the local environment in their start-up process. Individuals start firms in the

location where they through studies and/or previous working careers have formed professional networks and have access to capital and other resources (op. cit.). This view points to the importance of pre-existing conditions and path dependence: potential entrepreneurs are ‘created’ by way of former and existing economic and research activity in a locality. As Menzel et al. (2010: 4) argue: ‘new firms in the biotechnology industry have emerged mostly at places where star scientists were located’, which means that biotechnology clusters tend to emerge where skilled persons trained in research or higher education organisations are already found. Entrepreneurs, however, also shape their local environment in several ways. They start firms which in some cases act as ‘training grounds’ for founders of spin-off companies, and they initiate organisations, such as venture capital funds, research institutes, and lobby organisations that further the interest of an emerging cluster (Feldman et al. 2005).

Potential entrepreneurs with relevant knowledge and access to critical resources make up a vital pre-existing condition for cluster evolution, while triggering events initiate series of new firm formations. A recurrent argument is that entrepreneurial activity is sparked by some exogenous events. The emergence of the biotechnology and ICT clusters around Washington, DC started to emerge when entrepreneurs were ‘created’ through pronounced downsizing of federal employment while outsourcing of the production of goods and services to the private sector created demand potential for new firms (Feldman et al., 2005). This case illustrates how some changes, more job insecurity for skilled workers and new market opportunities, drove latent entrepreneurs to start firms.

The relative importance of different pre-existing conditions and triggering events may vary among individual clusters, including the extent to which they operate at the macro, meso or micro levels. The paper will employ the analytical framework in Table 1 to investigate the emergence and early growth of Oslo Cancer Cluster. By that endeavour we intend to examine to what extent the framework is relevant in explaining the formation of Oslo Cancer Cluster, for analysing cluster formation more generally, and, if applicable, how the framework can be improved.

The data material to analyse the development of OCC includes secondary sources, such as a database (Purehelp) with key information of all firms in Norway, firms’ home pages and former studies. The primary data includes interviews with entrepreneurs and firms leaders in seven small start-up firms and in three support organisations (cluster organisation, venture capital fund and contract research organisation). The interviews focused on the entrepreneurial process and innovation activity in the firms and on the general development of the cancer related industry in Oslo. The primary data also includes a survey that collected key information about 21 entrepreneurs in 12 Norwegian based, recent start-ups belonging to Oslo Cancer Cluster.

Explanatory factors for the emergence of Oslo Cancer Cluster

About Oslo Cancer Cluster

Oslo Cancer Cluster is the name of the member organization consisting of organisations that in different ways are engaged with development and production of new cancer diagnostics and medicines. This paper focuses however on how the cluster as such, i.e. the different organisations, have come into being. The cluster was established in the late 1990s – early 2000s (Skålholt and Thune, 2013) when a number of firms that concentrate on the development of cancer treatment and medicine emerged in Oslo.

As seen in Table 2, Oslo Cancer Cluster includes about 20 knowledge and support organisations of different types and 40 biotechnology firms. Sixteen of the firms are Norwegian divisions of often very large pharmaceutical multinationals, which are the dominant players within the industry. These divisions represent the bulk of jobs among the members of Oslo Cancer Cluster. However, the cluster also includes a number of younger, independent and mostly small pharmaceutical firms. These are most often academic spin-offs but also industrial spin-offs or start-up companies with Norwegian entrepreneurs and venture capital. The firms are in general still in the clinical test phase of their first products or occupied with developing further a technological platform. Norwegian firms mainly develop cancer drugs in clinical phase I and II in Norway¹. In phase III these small firms often need to cooperate with international pharmaceutical companies due to the costs and lack of patient volunteers to carry out phase III testing in Norway. A few Oslo based firms have put patent protected products on the market under their own brand name or have license agreement with a global biotechnology company.

Table 2: Classification of members of Oslo Cancer Cluster in 2012

Sub system	Type of organization	Number of organizations	Median age of organizations	Ca. number of employees in Norway
Industry	Norwegian divisions of multinationals	16	1990	1,000
	Norwegian owned firms	23	2001	300
Knowledge organizations	R&D institutes	6	1998	600
	HEIs	4	1971	110
	CROs	4	1997	20
	Seed and venture capital funds	6	2007	50

Source: Key information of members of the Oslo Cancer Cluster from Purehelp.no and members home pages.

¹ The clinical stages are as follows: Pre-clinical: laboratory and animal testing; Phase I: 20–30 healthy volunteers to check safety and dosage; Phase II: 100–300 patient volunteers to check for efficacy and side-effects; Phase III: 1000–5000 patient volunteers used to monitor reactions to long-term drug use; and post-marketing testing (Bagchi-Sen and Lawton Smith 2008, 973).

The paper will examine how the industry focused upon cancer treatment and medicine emerged in Oslo. The paper examines in particular how and why about 15 entrepreneurial, venture based start-up emerged in the 2000s. The rise of these firms represents key causal episodes or historical moments that both are shaped by the former development of the cancer industry in Oslo and that shape the further development of this industry (Dawley 2013: 100).

Pre-existing conditions

Following the analytical framework in Table 1 we start by examining important pre-existing conditions for evolution of the cluster. An absolutely basic condition is the existence of specialised scientific knowledge of cancer in Oslo. The systematic development of this knowledge started when a special hospital for cancer treatment (the Radium hospital) was established in Oslo in 1932, which is one of first specialised hospitals for cancer treatment in the world (Table 3). The hospital had no State funding at the start, but was financed by fund-raising activities, contributions from The Norwegian Cancer Society and also significant private gifts (Skårderud, 2007). The hospital has been the centre for long term development of knowledge, which is described in this way in a review of the hospital's history: 'It has almost been an indisputably claim that newly hired assistant doctors are expected to take a PhD. It is been implied that one does not necessarily go home after normal working hours' (Skårderud 2007: 204, my translation).

In addition to the Radium Hospital as a cancer treatment unit, a comprehensive cancer centre was developed (Skårderud 2007). It consisted, firstly, of a Cancer Research Institute for basic research, clinical research and method development. It became established besides the Radium Hospital in 1954 as an independent entity, backed by the State-owned Norwegian company Hydro, as Norwegian Hydro's Institute for cancer research. The institute has since its start been central in Norwegian and international cancer research, and Norway has comparatively many scientific publications within cancer research (oncology) (Reve and Sasson 2012). Secondly, a cancer register aimed to register and monitor the development of cancer in Norway was established in 1952. The register was financed by private funds until the State took over the responsibility in 1979. All medical doctors in Norway are instructed by law to notify new cancer cases to the Cancer Register. The large amount of data and the unique personal identification number in Norway make the Cancer Register's data suitable, also internationally, for research.

The research at the Radium Hospital and related organisations has been a vital knowledge base for new cancer drug firms (Nicolaysen 2013: 71). The evolution of a research system in Oslo thus constitutes an important prerequisite for the emergence of Oslo Cancer Cluster (Table 3). The R&D system consists of the organisations mentioned above, the Radium Hospital, the Cancer Research Institute and the Cancer Register, but also a few other R&D institutes and higher education institutions (HEIs) (Table 2). Among these is the Centre for Cancer Biomedicine, which is a research institute focused on cancer research with about 100 employees located at the University of Oslo and Oslo University Hospital. The HEIs are

important both when it comes to providing employees, performing research, and as sources of several spin-off firms².

Table 3: Explanatory factors for the emergence of Oslo cancer cluster

	Pre-existing conditions	Triggering events
Macro	National dedication to treatment of and research on cancer through the creation of a specialised hospital, research institute and cancer register	Changes in the organization and division and labour in biotechnology research and commercialisation, and regulatory changes in Norway
Meso	Development of a regional research system in Oslo focused on cancer research	Development of a regional research and commercialisation system through the establishment of new, supporting organisations
Micro	‘Creation’ of potential entrepreneurs with relevant academic knowledge for commercialisation	Development of combinatorial knowledge bases when academic knowledge is supplemented with business experience

The development of an R&D system in Oslo is essential for ‘creating’ potential entrepreneurs with the scientific knowledge that are vital for starting new firms focused on developing cancer drugs. Ten of 12 Norwegian owned firms in OCC were started by individual entrepreneurs, the two others by a venture capital fund and existing firms. The ten firms have 21 entrepreneurs, and virtually all of these have a PhD. In nine of the 12 firms the core competence originates from research carried out by entrepreneurs at the Radium Hospital, in some cases in cooperation with researchers at Oslo University Hospital, the University of Oslo, and the Norwegian firm Hydro (see below).

Some of the founders are serial entrepreneurs. Algeta was established in 1997 by a doctoral student and a researcher who worked at the Radium hospital's lab and his supervisor who was a professor at the University of Oslo. Algeta entered a partnership agreement with Bayer Schering Pharma AG in 2009 regarding the development and commercialisation of Algeta's first product candidate, which was in phase III of clinical testing (Vesterbekkmo, 2010). Algeta was acquired by Bayer for 17.6 billion NOK (more than 2 billion euros) in 2014. The founders of Algeta established two new firms in 2009 and 2010 together with one and two other researchers, respectively. In two more cases entrepreneurs have established one additional firms. One of these are a spin-off from Photocure, which is one of few Norwegian owned pharmaceutical firms with marketed products and world leadership in a specific technology. Photocure also originates from the Radium Hospital in 1997.

Triggering events

Relevant academic knowledge is a key in starting highly research intensive firms like the cancer drugs firms in Oslo. Academic knowledge is however not a sufficient condition. The

² Table 2 shows the number of employees in what is deemed to be the most relevant departments in the four HEIs.

knowledge has to be turned into commercial use, and our next question is why and how this occurred.

We first point at two macro factors (Table 3). We can consider the emergence of new, small cancer drug firms in Oslo as one appearance of a transformation since the 1980s in innovation processes and division of labour in the pharmaceutical industry in general (McKelvey et al. 2004). A number of large multinational corporations controlled until the 1980s large parts of the value chain from basic research to marketing of pharmaceutical products. These corporations have met challenges in developing new medicines and have been focusing more on development of medicines in clinical phase III and on marketing and sales. This changed strategy of the large corporation enabled growth of numerous specialised new biotechnology firms (NBFs). 'They were primarily university spin-offs and they were usually formed through collaboration between scientists and professional managers, backed by venture capital' (McKelvey et al., 2004: 92). Many NBFs are started on the basis of a specific hypothesis and technique and are quite specialised. Large corporations, on the other hand, have the experiences and resources to do control testing, production and to bring a drug to the market.

The start-ups of new cancer related firms in Oslo were also spurred by two regulatory changes in Norway from 2003. A new law on employee inventions³ in Norway in 2003 meant that employers could claim the right to inventions made by workers transferred to them, while previously the employees themselves, e.g. researchers, had the rights to results and inventions that could be commercialized. The University and University College Law from 2003 also include a duty for these organisations to provide for the application of research results in industry. 'The new legislation imposes on us to help ensure that research results are used for product development. This marks to some degree a limit in that we now as an institution is obliged to consider the potential of research results. The University will now have to establish internal expertise and capacity to deal with the new situation' (interview with then-Rector of the University of Oslo in the university's Research magazine Appolon released on January 1, 2003⁴, my translation). The changes contributed to the build-up of stronger commercialisation units at the University of Oslo and the Radium Hospital, and it strengthened cooperation on commercialisation among other public actors like Innovation Norway, private actors as the Radium Hospital Research Foundation and the knowledge organisations responsible for commercialisation of a new idea (Nicolaysen 2013).

The regulatory changes contributed to transforming the regional research system linked to cancer research in Oslo into a regional research and commercialisation system (Table 3). The transformation is linked to the establishment of new organisations and to the development of experience based competence in commercialisation. Six fairly recently established seed and venture capital funds are part of the commercialisation system (Table 2). Included here is Innovation Norway which is the Government's most important instrument for innovation and development of Norwegian firms. The other funds are focused on supporting academic spin-

³ Law on employee inventions: <http://lovdata.no/dokument/NL/lov/2005-04-01-15>.

⁴ <http://www.apollon.uio.no/artikler/2003/tidsskille.html>.

offs and on life science start-ups. Inven2 is the largest actor within commercialisation of research in Norway, owned by the University of Oslo and Oslo University Hospital and particularly occupied with innovations from these organizations. A similar fund is the Norwegian Radium Hospital Research Foundation (NRHR), which is a pre-seed investor and project developer, aimed to strengthen cancer research at the Radium Hospital and also to invest in companies based on other leading Nordic research institutes. In mid-2012 the NRHR had invested in 13 companies with a total stock value of over 200 million NOK (about 27 million euro). Experienced entrepreneurs maintain that these capital funds have clearly improved the access to risk capital compared to the 1990s (Nicolaysen 2013).

Table 2 demonstrates that Oslo has a range of supporting organizations within cancer research, diagnostic and treatment. The new cancer drug firms in Oslo are small and dependent on cooperation with and knowledge from hospitals, research institutes, capital funds, industry, different specialists, and to recruit skilled workers. The contract research organisations (CROs), for example, provide a range of support, such as running clinical trials and developing documentation for products, to the pharmaceutical and biotechnology industries in the form of research services outsourced on contracts. Cooperation with many specialists and meetings are easier to organise when persons are in geographical proximity.

Another important triggering factor for the emergence of Oslo cancer cluster is creation of business expertise about firm start-up, clinical testing, contact with large pharmaceutical companies etc. (Table 3). Important business expertise was created and spread to entrepreneurs through the initiative by the large Norwegian industrial company Hydro to build up a pharmacy department from the end of the 1980s. Pharmacy was thought of as one of several new activity areas in the diversification strategy of Hydro (Lie, 2005). Hydro Pharma was established in 1986 and grew fast the following years through acquisitions. The research centre in Hydro (located in Porsgrunn about 160 kilometer from Oslo) discovered a substance that might possibly affect cancer cells and started collaboration with researchers at the Radium Hospital. Hydro 'also had a number of scouts who visited research centres where people could show their projects. I presented two projects which the scouts liked very much' (entrepreneurs of two cancer related firms in Oslo). Hydro Pharma focused a few years on the development of a cancer remedy, but the initiative failed when a clinical trial did not provide demonstrable positive results (Lie, 2005. 255). Hydro left the pharmaceuticals sector in 1993 already, also because the company's strategy changed to concentration on its traditional core areas of energy intensive activities.

Hydro's initiative is still seen by several key persons in the Oslo cancer cluster as very important for the evolution of the cancer drug industry in Oslo. Firstly, some firms have developed further projects and knowledge originally created in the 1990s in collaboration between Hydro and the Radium Hospital. There are cases in which patients that took part in clinical studies in the 1990s lived longer than patients who were not part of the studies, which are results that initiated further research on the original remedies. Secondly, Hydro contributed with industry experience, as did former employees of a few large Norwegian based pharmaceutical companies like Nycomed Amersham. Some have been involved in

several start-ups and product developments and have acquired business experience and skills in the development of pharmaceutical products. People with industrial experience were hired or employed in start-up firms, and they transferred industrial and commercial knowledge to start-ups (Nicolaysen 2013: 74). The short-term focus on pharmaceuticals in Hydro contributed to combinatorial knowledge bases in the Oslo cancer industry when analytical knowledge of researchers was combined with synthetic industry and business expertise.

Conclusion

This paper proposes an analytical framework consisting of pre-existing conditions and triggering events in order to explain the emergence of regional clusters. The paper also distinguishes between pre-existing conditions and triggering events found at both the micro, meso and macro level. The paper employs the framework to analyse the emergence of a number of small, entrepreneurial biotech firms in Oslo Cancer Cluster during the late 1990s and early 2000s. The analytical framework turned out to be a useful tool for empirical investigations of the rise of this cluster. This might reflect the fact that the paper analyses a small, science based cluster. The small number of organisations makes it possible to get a general idea of triggering events and key actors in the development of the cluster. As it is a science based cluster the pioneer firms have to build on scientific knowledge that takes time to develop and that often develops in organisations that carry out basic research. The analytical framework should in principle be equally relevant to study other types of regional clusters. It may, however, in practice be more difficult to detect pre-existing conditions and triggering events in larger clusters that mainly build on experience based knowledge.

The title asks if clusters emerge by chance or by design. Chance is out of question when specific pre-existing conditions are required for a cluster to emerge in a specific location, when it takes time to develop the conditions, and when these cannot be created in many places. In the OCC case the building of high quality capacity in cancer research took time and demanded much resources. The CEO of a small and young firm said for example that ‘the milieu is *here*, we could not have been located elsewhere’. But nor can new science based clusters be ‘designed’ even if some basic assets may be, and have been, created by policy initiatives, such as scientific knowledge in research labs, commercialisation units, venture capital funds, and public demand for specific goods like cancer medicine. Such assets also have to be turned into productive use by entrepreneurs. In the Oslo Cancer Cluster case the initiative by the large company Hydro to build new activities in pharmaceuticals seem to be *one* important triggering event that is difficult to see in advance and plan. Therefore, the framework with both pre-existing conditions and triggering events seems as a useful middle road between chance and design that is worth to test on several different types of regional clusters.

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