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the role of spinoffs in the early growth process

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Chapter 9

Emergence of regional clusters: the role of spinoffs in the early growth process

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1 Introduction

The literature on regional clusters has increased considerably during the last decade. Most of the theories focus on explaining their growth, internal dynamics and structure. The emergence and growth patterns are usually explained by such factors as unique local culture, regional capabilities, tacit knowledge or the existence of location-specific externalities (knowledge spillovers, networks, labour market pooling and specialised suppliers). However, these factors are not sufficient to explain the early formation of clusters, when it grows from one to many firms. The location-specific externalities are non-existing when there is only one company, that is, there are no labour market pooling externalities or knowledge spillovers. Additional firms have to enter the cluster before networks between employees working in various cluster-firms are formed, before knowledge spillovers occur and before firms can benefit from labour market pooling.

The dominant theories focus more on explaining ex-post dynamics of clusters than their early development. This chapter focuses on the early phase and uses an alternative approach to analyse the role of geography in the formation of clusters. Three key determinants are identified: (1) the geographical dimension of entrepreneurial activity, (2) spinoffs from successful firms and (3) new market opportunities. The chapter studies the evolution of the wireless communications cluster in Northern Denmark and compares it with the evolution of other clusters.

Section 2 presents the theoretical framework on the emergence of clusters with discussions of the geographical dimension of entrepreneurial activity, the role of spinoffs and market growth. Section 3 describes the methodology. The history of the wireless cluster is described in section 4. Section 5 gives an overview of the generation of new firms in the cluster. This evidence is discussed and compared with studies of four other clusters in section 6, followed by the conclusions in section 7.

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2 The emergence of clusters

The formation of clusters consists of several phases and the role of geography is changing during the evolution and over the industry life cycle. The process of clustering is not deterministic and might stop at various stages. The first firm in a cluster can, if successful, grow. It can be unsuccessful and close. However, a single firm is not a cluster. By definition numerous firms are needed. Firms can be attracted to the region, local firms can diversify from other industries, or new firms can be founded. The entry of additional firms is a key process in the emergence of clusters, where few firms grow to many. This process of early period evolution from a single firm to a cluster has, however, only received little attention in the literature.

Alfred Marshall (1920) observed that firms within the same industry often cluster in particular localities. He was among the first to provide rather detailed descriptions of the sources of concentration of specialised industries in particular localities. Based on his work, the emergence of clusters has been explained by the existence of location-specific externalities, such as (1) economies of specialisation caused by a concentration of firms being able to attract and support specialised suppliers, (2) economies of labour pooling, where the existence of a labour force with particular knowledge and skills attracts firms, which in turn attract and create more specialised labour, and (3) knowledge externalities, where knowledge and information flow more easily between actors located in a cluster than over long distances, which all lead to the existence of increasing returns to scale for firms located in clusters. Other factors have been added, such as unique local culture, regional capabilities, tacit knowledge, and favourable factor conditions. Porter (1998) explains the emergence by interaction between parts of his diamond (context for firm strategy and rivalry, factor conditions, demand conditions, and related and supporting industries) that are present in a location because of historical circumstances. He adds that chance events seen in its historical and locational context are important for the birth of clusters. As a result, the early growth process remains exceptional for each cluster.

Other studies have searched for the explanation in the founding of the first firm, with a focus on why the founder decided to set up a firm in a particular location. Accordingly, each cluster becomes a unique story, which makes it harder to generalise from anecdotal stories of founders' personal preferences, luck and 'foresightedness'. These studies often take a long look back in history. An example is the analysis of the French plastics injection-moulding cluster in Oyannax that can be traced back to the year 630, when the city was given a monopoly to make wooden combs (van der Linde, 2003). In the nineteenth century, they shifted from wooden to celluloid combs. In the 1930s, combs fell out of fashion and some unemployed craftsmen started production of plastics toys, and so on. In 1936, they adopted injection-moulding and became a French centre of plastics manufacturing. However, this story tells us very little about how and why the plastics cluster emerged. The problem with tracing back to the initial event that started a process that led to clustering is that the explanation often becomes colourful, but the causality remains blurred. In the case of Oyannax, the link between the regional industrial history of comb-making and the plastics cluster could be an effect of the

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geographical dimension of entrepreneurial activity, since entrepreneurs tend to start up their business where they live (Sorenson, 2003).

The distinction between what are the driving forces behind the emergence of clusters and what are related to the evolution of regional capabilities is not clear. According to Maskell et al. (1998), each region has a set of capabilities that consist of the institutional background, the structure of the industry, natural resources, knowledge and skills. These have been developed through a historical interactive process and further evolution relies on the creation, utilisation and reproduction of knowledge. Firms in an emerging cluster influence the region through creation of and demand for skills and knowledge, but the firms are also affected by the existing structure and institutions in the region (Storper and Walker, 1989; Storper, 1997).

Following this argument, the founding of the first cluster firm is often seen as being set in a particular geographical location by chance (Arthur, 1990). Historical and chance events would have provided a location structure; and that inherited structure combined with agglomeration tendencies would determine the future settlements in a region. New industries will be laid down layer by layer on inherited structures through the phases of development (Arthur, 1994). In an evolutionary perspective, agglomeration can be interpreted as the mechanism by which existing organisations breed the new ones founded by entrepreneurs.

This argument is quite similar to the cluster theories that focus on location-specific externalities to cause industries to cluster spatially. However, these ex-post dynamics can only exist when there are several firms located in a particular geographical location. The externalities may or may not be important for clusters, but they can not drive the emergence of clusters in the early phase.

The open window of locational opportunity (OWLO) model (Boschma and Knaap, 1999) distinguishes between two stages in the spatial evolution of a new industry. In the initial stage the location-specific externalities do not exist, while they may lead to clustering in the second stage. The OWLO model argues that the novelty and discontinuous nature of new industrial activities would imply that local supply of knowledge is unlikely to determine where the new industry would evolve. Some regions may provide some generic conditions that create a stimulating environment for new industries while others are non-stimulating, but the new industry may initially emerge in both types of regions (Boschma and Knaap, 1999). As a result, chance events become important for the spatial evolution. The new industry also relies on the creative ability to transform generic conditions into specific conditions. Thus, the new industry uses its creative ability to create the required labour and technological knowledge or to attract it from other regions (Storper and Walker, 1989; Boschma and Knaap, 1999). However, creation of the necessary labour through internal training and learning effects does not take place without firms. Likewise, skilled labour is unlikely to be attracted to a region with very few firms. The evolution from one to many firms is by definition a key process in the emergence of clusters.

Geography has a different role than proposed by much of the existing cluster literature that focuses on the location-specific externalities. Geography plays a role in the location decision of entrepreneurs

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because they may tend to found their new firms within close proximity to their previous employers or close to where they reside and have social contacts and family, and so on. It requires a considerable effort to obtain the information and resources needed to base a firm in another location (Sorenson, 2003).

This does not necessarily imply that firms always will be located within close proximity to their past employer and residence. There are many examples of founders who search for the most suitable location among regions that either provide access to a large local market or, perhaps more important, offer the best selection of resources to the organization. It is hard to argue that potential founders only have knowledge about their own local environment and the local entrepreneurial opportunities (Romanelli and Schoonhoven, 2001). Nonetheless, they argue that most new firms will be founded in the same region or very close to the firm that produced the entrepreneur, since social and economic forces will induce entrepreneurs to locate close to their origins, so they can maintain their social ties and continue exploiting their localised knowledge of venture capitalists, potential employees, and suppliers.

It requires a wide selection of resources and social commitments to found a firm (Stinchcombe, 1965). These resources, such as available technical personnel and financial resources, generally tend to be immobile and unevenly distributed across geographical space. Consequently, entrepreneurs are most likely to be tied to the region where they have useful social relations, even if another region is otherwise more attractive (Sorenson and Stuart, 2001). In general, we may expect that clusters of new firms in a particular industry continuously evolve in regions, where human and other resources are abundantly present and where entrepreneurs are 'produced' on a large scale in the incumbent firms (Sorenson and Audia, 2000). Geographical immobility of entrepreneurs would then make the existing structural base of a region a dominant source of clusters and create an agglomeration effect similar to the ones discussed by Arthur (1990, 1994).

Jane Jacobs (1969) described how clusters often are driven by employees leaving incumbents to start new firms. She described how an employee learns a craft by working in an organization and being taught by a master. Later, that employee may leave the firm and set up his own shop, employ new people, and teach them the craft. Jacobs argued that especially breakaways of able workers would be a source of regional development, since the entrepreneur would rarely leave the area, but stay in the place where he has the social connections. Jacobs's ideas are consistent with recent findings (some of which are reviewed below) that spinoff firms are an important engine of growth in the early phases of clusters. Experienced workers that leave a firm to startup their own firm in the same industry are a well-known mechanism for diffusion of knowledge. Historically, there have been many attempts to limit spinoffs and geographical mobility of employees in for example craft-based industries. Veblen (1912) colourfully described how entrepreneurs faced the death penalty if they left the area to start up somewhere else than in the cluster of glassmakers in Venice.

The transfer of routines and experience between a new firm and the previous employer of its founder has been analysed by organisational sociologists. Blueprints of the incumbent is passed on through the new firm's founders (Carroll, 1984; Brittain and Freeman, 1986; Hannan and Freeman, 1986). The

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relation between performance of the incumbent and the spinoff has also received attention in economics and management (e.g. Klepper, 2001, 2002a; Agarwal et al., 2004). Klepper (2001) proposes a model that combines the ideas of reproduction and inheritance with the notion of organisational routines. This notion was originally developed by Nelson and Winter (1982), assuming that firms to a large extent are governed by routines. A firm has separate routines for each of the different functions (R&D, marketing, management, etc.) and products. When a new firm is born, organisations will reproduce, because founders rely on routines they are already familiar with from their previous employment experience. The quality of these routines will determine the future success and performance of the new firm. Spinoffs may inherit more suitable routines than any other kind of start-up. This may on average enable spinoffs to outperform other startups.

Market growth as well as the industry and technological life cycles influence the emergence and evolution of clusters in a particular industry (Klepper, 2002a; Dalum et al., 2005). Market growth creates opportunities for additional firms to enter, and evolution of the industry opens new opportunities for market and application diversification for existing firms and spinoffs in a cluster.

Entrepreneurs may be motivated to found competing firms when the growth of their current employer indicates a substantial demand for its products and services. High growth can indicate the presence of unmet demand and great market opportunities (Romanelli and Schoonhoven, 2001). In these cases, employee learning becomes important since spinoffs can exploit the opportunities of their parents by entering with a similar product. Consequently, they either compete directly or more narrowly with one of the parent's activities (Franco and Filson, 2000).

Application diversification and innovations relate closely to the activities of parents and grow out of research undertaken there. Spinoffs will occur when employees pursue new technological discoveries made in their own firm. Wiggins (1995) and Anton and Yao (1995) add that the innovations are likely to be path-breaking and opening new sub-markets within the industry. The work of new firms and organisations is related to activities of parents and is in some cases innovative by introducing new products or services. Entrepreneurs bring knowledge and skills from their past working and educational activities that may be valuable in searching for new business areas and opportunities as well as in the daily life of running a firm (Shane, 2000). Founders are likely to bring specific knowledge about a wide range of issues to their new firm, such as customer demand, products, technologies, suppliers and competitors (Helfat and Lieberman, 2002). This may also include knowledge about how to exploit new knowledge and technological developments based on unmet supplier or customer demands or prior scientific and technical training (Roberts, 1991).

Growth in the number of firms within a particular industry in a region is by definition the most important process in the emergence of clusters. However, the emergence may stop at various stages, even when the necessary conditions seem to be present. Three key mechanisms are central determinants in the early growth phase of clusters: (1) the geographical dimension of entrepreneurial activity, (2) spinoffs from successful firms, and (3) new market opportunities. It is in the interaction between these three mechanisms that a particular industry may grow from a single firm to become a cluster. Geography obviously plays a role in the interaction between the first two determinants, but

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the new market opportunities relate more to the industry life cycle and the growth of markets outside the region. Location-specific externalities might emerge as the cluster evolves from a single firm to many. However, in the early phase it seems unlikely that these are attracted to a non-externality region. Internal circumstances may cause a spinoff process to stop. Jacobs (1969) describes how Rochester, New York, used to 'produce' a high number of breakaways within precision manufacturing and optical products, but turned into a company town, since the successful Eastman Kodak company started fighting breakaways and acquiring competitors. Sometimes a successful company does not 'produce' spinoffs but grows large on its own. Then a regional agglomeration within a particular industry consists of one or a few large firms.

A successful incumbent can spawn new firms that are more successful on average because their founders bring knowledge from the incumbent. Success will breed success in this respect. This spinoff mechanism is not necessarily geographic in its nature, but since most entrepreneurs found firms near their past employers, local success is more likely to generate success in the same region than elsewhere. The opportunities for application diversification and market diversification increase when the market grows. These three mechanisms put together can be the main driving forces of geographic clustering of economic activities, because a single successful incumbent can lead to well-performing spinoffs, which later on can spawn other new firms. To a large extent this is because entrepreneurs are likely to stay where they are, and because they are able to rely on the success they experienced while being employed at the incumbent. Furthermore, the firms in the cluster develop new applications of the initial technologies and seek out new customers. Location-specific externalities might become important as the number of firms in the cluster increases, but not in the early growth phase.

3 Methodology

The case study presented below has been developed using detailed information about the founding events and organisational backgrounds of each individual entrant in the cluster until 2003. The collection of this information has involved extensive work to trace the founders of every firm. First, we need to identify all firms that at any point in time have existed in the region. We have identified the name of the firm, the year it was founded, and the year that it closed, if this has been the case. The second step is to identify the founders and where they worked previously. The data are presented in a table in Dahl et al. (2003) with the names of all companies, year of entry, year of exit (if any), name of founders, their organisational background, and main events in the history of the firms, such as acquisition and bankruptcies. Dahl et al. (2003) also presents a more detailed description of the history of the cluster.

The information was collected from existing historical studies (Gelsing and Brændgaard, 1988; Dalum, 1995), the cluster's own organisation, NorCOM, founded in 1997, newspaper articles, information

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from the Internet, and a number of interviews and casual conversations with key actors.¹ An earlier version of this chapter was presented at a NorCOM Association meeting, where many key actors were present. Many of these have been employed at the early firms and have experienced the growth of the cluster. The comments from key industry and university participants at this meeting have been a valuable source. All information has been double-checked to make sure that the information is accurate using multiple different sources.

4 The emergence of a wireless communications cluster

The case to be studied in detail is the emergence of a cluster of high-technology based firms in the field of wireless communications (NorCOM) in the region of North Jutland. Defined narrowly, it consists of around 50 firms.

Simon Petersen founded S.P. Radio in 1948 as a radio and later TV manufacturer in Aalborg. This industry faced increasing competitive pressure in the early 1960s, which fuelled a shakeout. Meanwhile, Simon Petersen had noticed opportunities in the market for maritime radio communications equipment for small vessels. Consequently, S.P. Radio managed to diversify into maritime communications from the mid-1960s and became one of three world leaders within half a decade up to the early 1970s. In 1966, the company had reached 150 employees.

In 1973, the first spinoff firm, Dancom, was founded by three engineers from S.P. Radio. One of them had been the head of R&D at S.P. Radio for four years. Dancom was active in the same markets as S.P. Radio, producing maritime communications equipment. Two former Dancom engineers founded the second spinoff, Shipmate, in 1977. Their first product was a radio phone for maritime use, which competed directly with both Dancom and S.P. Radio. Their breakthrough came in 1980, after they developed a satellite navigation system (application diversification). At that time, the firm only had one employee besides the two founders. Shipmate successfully developed and produced radiophones and navigation equipment for maritime use. Five years later, the firm had reached 200 employees. Dancom went into financial difficulties in 1980. The firm started to explore the possibilities of using the firm's capabilities and advantages from maritime communications in an emerging market of onshore personal communications (mobile phones). Shortly after, the firm started activities in producing personal mobile phones and changed its name from Dancom to Dancall Radio.

In the early 1980s, some of the cluster firms and spinoffs diversified into an emerging technologically related area of personal mobile communications equipment. This opened new opportunities as the mobile communications market opened with the introduction of the common Nordic standard for mobile telephony (NMT). When the market boomed during the 1980s, these firms were among the

¹ Such as Erik Rauff (co-founder of Shipmate, former employee of S.P. Radio and Dancom/Dancall), Henrik Langkilde (CEO of Dancall in the 1980s), Niels-Christian Gjerrild (co-founder of T-Com, CEO of Dansk DECT/Ericsson, former employee of Dancom/Dancall), Jens Hansen (co-founder of RTX, former employee of Dancom/Dancall and Cortech) and many others, who have been employed at the early firms and/or been part of founding teams.

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world-leading producers of phones for this network. They were able to use the inherited and developed strong capabilities from the maritime radio communications. In 1985, Shipmate expanded into mobile phones with the new activities placed in a separate division, Cetelco. After two years, Cetelco had 25 engineers working with R&D. They developed and produced mobile phones for several European and East Asian markets.

The cluster firms experienced high growth because of the success of local firms that diversified into mobile telephony, and the North Jutland region became visible as a strong region in this industry. However, in the last half of the 1980s the market changed because of rapid technological development. The small firms were facing an international market with high development costs and production capacity demands, and intense price competition. The industry life cycle and market growth influenced the cluster significantly, but they also opened up new opportunities for diversification as the market and technology expanded further.

In 1987, seven experienced engineers from Dancall founded T-Com. The engineers disagreed with Dancall's overall market strategy and decided that they could do it better themselves. T-Com's strategy was to develop mobile phones just like its parent company, but differed by only focusing on R&D as a subcontractor. Other companies would then produce and market the phones under their own brands. In the same year, they developed their first mobile phone. In the last half of the 1980s, there were a total of 15 firms in the industry in Northern Denmark. One of the entrant firms had been closed, but new firms had continued to enter. The majority of these were spinoffs.

The common European standard for mobile telephony (GSM) was implemented as a new standard in 1992. The success of the NMT standard inspired the European telecommunications operators to create a common European system based on digital technology. A race began between the leading producers in the world to be the first to be able to produce a complete terminal for this network. The challenge of building a GSM mobile phone was seen to be a major economical and technical challenge for the mobile communications firms, since it was based on new digital technology. To cope with this, the two competitors Dancall and Cetelco formed a pre-competitive joint venture company, DC Development, with the purpose of building the basic modules of a mobile phone in close cooperation with Aalborg University.

DC Development was founded in 1988 and located at a new science park, NOVI, close to Aalborg University. DC Development succeeded in development of basic modules, and the parent companies were among the first in the world to produce a GSM mobile phone in 1992. This technological achievement increased the international visibility of the cluster and strengthened the region's reputation in wireless communications technologies. However, the new standard changed the market considerably as large multinationals continuously entered the promising GSM market. The consequence was increased competition, falling prices, rapid development and increased demand for volume production. The high development costs of GSM phones put Dancall and Cetelco into severe financial problems in the early 1990s, because they did not have enough financial backup to harvest their discoveries in this competitive market.

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As a consequence, Cetelco was gradually taken over by Hagenuk (Germany) in 1988-90. Dancall had more than 600 employees in early 1993. But they also had a troubled period. The newly produced GSM phone was too expensive compared to competitors and at the same time the export of NMT phones suffered from declining markets as the new GSM market grew. Consequently, Dancall had severe financial problems and was reconstructed again and sold to Amstrad (United Kingdom). During the next couple of years, the firm gained momentum and grew to become larger than before the reconstruction.

During the history of the cluster, Dancall and Cetelco have been the parents of numerous spinoffs. Many of these are clear examples of the market and application diversification that has been dominating the mobile phones industry. An example is RTX Telecom founded in 1993 by three experienced engineers from Maxon and four from Cortech. They founded the firm with the strategy of doing R&D for other firms. RTX based their designs on chipsets from National Semiconductor who had previously worked with Dancall and needed the knowledge on the future development of wireless devices to design their chipsets, and RTX needed the chipsets. RTX grew from seven employees in 1994 to more than 200 in 2003. Another example is ATL Research founded by engineers from Cetelco in 1996. While working at Cetelco, they often got enquiries from other firms in the industry who wanted to buy development aid for mobile phones. But it was not possible to follow this potential market within Cetelco. ATL cooperated with several chipset manufactures until Texas Instruments acquired the firm in 1999.

In the late 1990s, the mobile communications industry had high growth rates and the large multinational players in the industry were increasingly looking for new regions for their activities in order to access local pools of development engineers. As a result, many multinationals were attracted to the region.

The success of the first company in the NorCOM cluster, S.P. Radio, in the 1960s and 1970s as one of the world's leading producers of maritime communications equipment gave the employees who were the founders of the first spinoffs in the 1970s, the relevant capabilities and routines to become successful themselves. Market opportunities and market and application diversification were important in the evolution of the cluster. Some of the first spinoffs, Dancall and Cetelco, successfully diversified into mobile phones by using their experiences gained by the founders, while they worked at the parent, S.P. Radio. The growth of the mobile communications industry opened new opportunities that, coupled with the initial success of these firms fuelled, an intense formation of new spinoffs as the market grew, which developed the cluster as it grew from one to 50 firms during three decades. Application diversification and evolution of the industry life cycle have widened the knowledge base. The core competence is still wireless communications, but it has expanded from maritime communications to land-based radio, mobile phones, cordless phones, and many other wireless technologies. The maritime communications also led to radio-based navigation, satellite navigation, and fleet management systems.

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5 The role of spinoffs in the early growth phase

We have collected detailed information on every firm active in the cluster since the 1960s. They have been divided into different groups based on their prior experience: diversifying entrants (firms entering new or established markets unknown to them), parent spinoffs (new entities founded by established companies), joint ventures, entrepreneurial spinoffs (firms founded by experienced persons with previous employment in incumbent firms in the industry) and inexperienced entrants (founded by persons with no previous employment in the industry). The evolution of the population of firms, based on types of entry is shown in Figure 1. We have intentionally left out the two joint venture firms to keep the graph visible.

Figure 1 Evolution in the population of firms in NorCOM by main category (1970-2003)

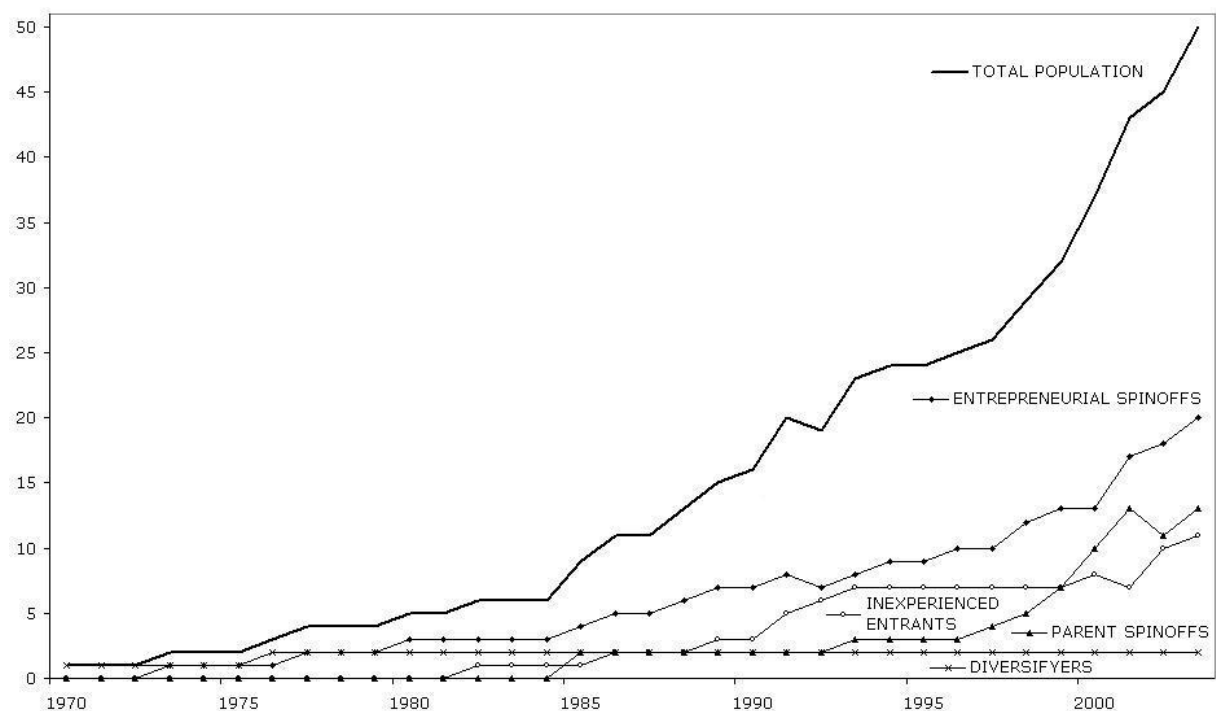


Figure 1 shows that the entrepreneurial spinoff firms represented a large share of the increase in the population. They were a driver of cluster growth during the entire period. They represent the largest group of firms. The total population has grown to more than 50 firms and the number exits is low. Several firms have, however, been rescued from exit on the verge of bankruptcy after being taken over, typically by multinational companies.

Figure 1 shows that the second firm entered in 1973 as a spinoff from S.P. Radio. A decade later the number of firms had increased to six of which three were spinoffs, two were diversifiers (including S.P. Radio) and a single inexperienced entrant. The introduction of mobile communications in Denmark in 1981 and the subsequent market growth influenced the emergence of the cluster. The success of Dancall and Cetelco and their growth in employment resulted in several spinoffs. From 1984 to 1990 the population of firms increased from 6 to 16. Spinoffs accounted for half of these. From

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1990 to 2003, the population increased from 16 to 51. In the early 1990s, several inexperienced start-ups entered the cluster and parent spinoffs enter in the late 1990s. However, the entrepreneurial spinoffs hold the largest share of the population of firms.

The growth in the number of parent spinoffs since 1997 represents the increasing international visibility of the cluster. At the introduction of the GSM system, where local firms were at the frontier of the technology from the beginning, the international focus on North Jutland's wireless industry has increased the number of parent spinoffs from three in 1996 to 15 in 2001. Before 1997, there were mainly local or national based players behind the parent spinoffs. Later, it was foreign companies, such as L.M. Ericsson (Sweden), Texas Instruments (United States), Motorola (United States), Siemens (Germany), and National Semiconductors (United States), which entered through acquisition of or investments in already established local firms. Multinationals such as Nokia (Finland), Lucent (United States), Analog Devices (United States), and Infineon (Germany) located activities in the region through green field investments.

The three large early firms, S.P. Radio, Dancom/Dancall and Shipmate/Cetelco have been the source of many spinoffs. In total, these three have been the source of 12 new spinoffs. Employees coming from Dancom/Dancall founded eight of these firms. Many of the founders had also been employed at S.P. Radio before going to Dancom/Dancall. This illustrates how important the three firms have been as a training ground for founders of new firms. The spinoffs gained the relevant capabilities, routines, and industry specific knowledge that helped them to become successful themselves.

6 Discussion

A successful company is not a sufficient condition for the emergence of a cluster. Two regions with similar initial conditions may develop quite differently. The Struer region in Western Jutland is an example of a region with a very successful company that never 'grew' into a cluster. It is a historical parallel to the NorCOM cluster in North Jutland. Initially they had some common features, but their development trajectories ended up being significantly different. The first firm Bang & Olufsen (B&O) grew large and became very successful in the manufacturing of high-end radios and television sets, but it only produced a few spinoffs, and Struer remained a 'one-company' town.

Peter Bang and Svend Olufsen founded B&O in 1925 in the small rural town of Struer. Olufsen was born there, while Bang was born in Copenhagen. Olufsen's family hosted B&O in the first years at the family farm. From the late 1920s, B&O grew considerably and was already in the 1930s an established radio manufacturer and experienced strong employment growth. The manufacturing activity was contained within one firm for many decades and a cluster never emerged in Struer. B&O experienced several spinoffs, but only two of these stayed in the region. The Struer development, which had gained significant international reputation already in the 1950s, never resulted in the creation of a cluster and had the character of single company concentration.

The emergence of the wireless communications cluster in North Jutland can hardly be explained by various location-specific externalities. S.P. Radio was the only company in the industry in the region

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for many years. It also seems unlikely that there was a unique local culture, climate or natural resources that, somehow, were ideal and designed for wireless communications technologies. Simon Petersen did not decide to found S.P. Radio in North Jutland to tap into tacit knowledge or to benefit from labour market pooling, knowledge externalities or specialised suppliers. Likewise, B&O located in Olufsen's hometown at his parents' farm and did not benefit from concentration of resources. Accordingly, the founding of both firms can be characterised as chance events driven by sociological factors rather than economic choices of optimal locations.

These new firms had an effect on regional industry structure, but initially it was a small effect. It did not start the path-dependent agglomerative processes that deterministically lead to a cluster. B&O was successful and experienced a large growth in employment. However, this success did not create a cluster. B&O managed to contain its radio and TV activity within one firm. During the history of the firm, it produced a few spinoffs, but these decided to locate outside Western Jutland, except for two in the 1980s. S.P. Radio existed for many years before it diversified into maritime radio communications. However, a growing number of firms in a cluster are by definition the most important process in its emergence. The second firm entered as a spinoff from S.P. Radio and in the early 1980s the 'cluster' consisted of six firms of which three were spinoffs. In the early 1990s, there were 16 firms working with wireless communications or related technologies, and spinoffs still accounted for half of the population. The strong employment growth in North Jutland occurred in the 1980s and 1990s, while the strong employment growth of B&O was already envisaged in the interwar period. However, the spinoff process pushed the early growth phase of the cluster in North Jutland, while Struer became a one-company town. Thus spinoffs are a key process in the emergence of clusters and it cannot be explained by interaction between parts of Porter's diamond that are present in a location because of historical circumstances. However, emergence of a cluster might suddenly stop at various stages, even though the necessary conditions seem to be present and spinoffs emerge. It is not a deterministic process.

In the early growth phase of the wireless communications cluster the role of geography was mainly confined to the limited mobility of start-ups. It was very hard to attract labour to the region in the early phase. An engineer who actually moved from Storno, a wireless communications firm in Copenhagen, and later founded a spinoff, confirms this. He claims that it was not attractive to move to North Jutland to get a job at Dancall in the early 1980s, because there were only a few firms to work for. However, as the market grew and additional firms entered the industry in the region and the pool of skilled labour increased, the role of geography changed. The increased market opportunities especially in mobile communications and the growing number of firms and labour also increased the breeding ground for spinoffs. It also opened the possibility for labour mobility between firms and subsequently the creation of social networks between employees working in various firms. In the 1980s and 1990s, the university had an effect through its growing supply of qualified labour and basic research in the wireless technologies. Later, firms were attracted to the region and entry by parent spinoffs. Thus, traditional cluster effects, such as knowledge spillovers, labour market pooling, and attraction of firms, can be found in the cluster at a later stage.

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The importance of entrepreneurial spinoffs is known from other studies of industry evolution. These studies focus on the role of entrepreneurial spinoffs in the evolution of particular industries that also created well-known clusters, such as semiconductors in Silicon Valley (Moore and Davis, 2001), wireless communications in San Diego (Simard and West, 2003), automobiles in Detroit (Klepper, 2002a), and tyres in Akron (Buenstorf and Klepper, 2005).

Many studies of evolution of the semiconductor industry in Silicon Valley have shown that entrepreneurial spinoffs and employee mobility have been important factors. Brittain and Freeman (1986) and Moore and Davis (2001) argue that entrepreneurial spinoffs were the main engine behind the rapid growth in Silicon Valley. In the early years, the semiconductor firms faced novel organisational challenges in aligning goals and designing the organisational structure that could establish and reach the technological demands of the industry. Working for incumbent firms was the best way to learn how to tackle those challenges. The most well known case is the many firms that spun off from Fairchild Semiconductor, often called the 'Fairchildren', such as Intel and AMD.² In general, engineers left established incumbents and started new firms that produced the capital goods and materials needed for semiconductor design and manufacturing.

Simard and West (2003) analyse the emergence of the wireless communications cluster in San Diego. Linkabit was founded in 1968 initially doing general military consulting, but later it diversified into secure military communications. In the 1980s, Linkabit spawned four spinoffs, Radyne, Tiernan, PCSI and Qualcomm. The latter was founded in 1985 and the founders saw an opportunity to adapt military communications technologies for civilian use. The timing of the market diversification coincided with the take-off in the mobile communications market. Qualcomm successfully developed CDMA technology that was approved as one of three standards for digital mobile communications in US in 1990. Qualcomm experienced a high growth during the 1990s. However, the increased market opportunities were coupled with a spinoff process from the first few firms in the emerging cluster. During the 1990s, the cluster became visible and in the late 1990s the major players in the industry was attracted to the region, such as Nokia, Ericsson, Siemens, Samsung, and Sony.

Studies of the evolution of the US automobile industry and the emergence of the cluster in Detroit also emphasise the importance of spinoffs (Carroll et al., 1996; Klepper, 2002b). The industry was characterised by a high rate of entry with more than 500 firms entering in its first 20 years. Eventually, the industry evolved to be an oligopoly dominated by three relatively late entering Detroit firms, Ford, General Motors and Chrysler. These three were all related to the first successful firm in the industry, Olds Motor Works, which was located in Detroit (Klepper, 2002b). These firms spawned 22 spinoffs. This growth in the number of firms and the emergence of a cluster were supported by the high growth in the market for automobiles. By the 1930s, Detroit firms dominated the industry.

Buenstorf and Klepper (2005) analysed the evolution of the US tyre industry. They found that the location and background of the entrants caused the industry to become regionally concentrated

² Fairchild Semiconductor was a spinoff from Shockley Transistor. The latter was founded in 1955 by the co-inventor of the transistor, William Shockley who previously worked for Bell Telephone Laboratories.

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around Akron, Ohio. The tyre industry evolved to be an oligopoly dominated by Goodyear, Goodrich, Firestone, and U.S. Rubber. These four firms accounted for more than 70 per cent of the market in the 1930s. Goodrich, Goodyear and Firestone were all located in Akron. The Ohio firms were distinctly successful and the production of tyres and inner tubes in Ohio accounted for two-thirds of total US production in 1935. The Akron tyre cluster emerged through a spinoff process as the market grew. The leading Akron firms spawned the most spinoffs and the performance of these was very much related to the performance of their parent. From a few early Akron firms related to the successful Goodrich, the Akron tyre cluster grew primarily through a spinoff process rather than through agglomeration economies (Buenstorf and Klepper, 2005).

The evolution of the semiconductor industry in Silicon Valley, the wireless communications industry in San Diego, the automobile industry in Detroit and the tyre industry in Akron illustrates the importance of the spinoff process in the early growth phase of clusters. The very detailed studies of the organisational background of entrants highlight the mix of a successful firm spawning successful spinoffs that stay in the region and are able to exploit new market opportunities. The role of geography is limited in the early phase and several regions might have had similar initial conditions. Likewise there do not seem to have been any given advantages in the regions, for example Detroit had historically been known for its production of flour and copper mines (Jacobs, 1969), North Jutland was dominated by agriculture, fishing, ship building, tobacco, textiles and construction materials, and military aerospace was San Diego's major manufacturing industry from the 1930s through the 1980s (Simard and West, 2003). New market opportunities seem to be important in relation to the growth of clusters. The opportunities and market growth of mobile communications supported the emergence of the wireless communications clusters in North Jutland and San Diego.

7 Conclusion

The dominant theories on industrial clusters focus more on explaining ex-post dynamics of clusters than the emergence of clusters. As a result many case studies often contain unique and colourful explanations as to why a particular industry became clustered in a particular location. One of the risks in these studies is that the intriguing chain of events that eventually lead to clusters clouds more general processes. Consequently, geography appears to be a very important factor in the emergence of clusters, because of the founder of the first firm's decision to locate in a particular region. In addition firms are shaping the regional environment through their demand for labour and knowledge and they are also affected by the existing structure of the region. However, we argue that the role of geography in the emergence of clusters is mainly limited to the geographical dimension of entrepreneurial activity, that is, entrepreneurs tend to found their firm where they live. The founding of the first firm can be characterised as a chance event, but a successful firm becomes a training ground for spinoffs that are able to exploit new market opportunities.

In the case of wireless communications in North Jutland, the success of S.P. Radio helped the spinoffs to gain routines to become successful themselves. The entry of these firms was a key process when the

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cluster grew from one firm to many. Spinoffs remained the dominating share of firms from the mid-1970s and onwards, but were particularly important in the early growth phase when there were no apparent location-specific advantages. The move into the emerging market for mobile phones in the early 1980s was important for further growth. The new market opportunities in the first and second generation of mobile phones and growth in demand sustained the employment growth in Dancall and Cetelco, and paved the way for additional spinoffs. This demand was not local, but initially Danish. During the 1980s the NMT standard was introduced in many European and Middle East countries in various versions and the cluster firms exported to these countries. The worldwide increase in demand for mobile phones also helped the emergence of the wireless communications cluster in San Diego. Spinoffs from the early firms, Linkabit, Qualcomm, PCSI, benefited from the market conditions and their inherited competences. Likewise, the clusters in Silicon Valley, Detroit and Akron emerged over the industry life cycle. Thus, the new market opportunities and increased demand facilitated their emergence. However, the process of clustering was not deterministic and could have been stopped at various stages, when technologies changed, new products failed, competition increased or the market changed. In the case of North Jutland, two of the seedbeds for many spinoffs, Dancall and Cetelco, experienced severe financial problems on several occasions and were taken over by foreign firms. If these had been closed down at an early stage it might have hampered the emerging cluster.

Local conditions do not appear to have been important in the emerging phase of the cluster in North Jutland. Later on, in the 1980s and 1990s, other factors supported the growth of the cluster, such as the university through its growing supply of qualified labour and basic research in wireless technologies. Thus, the role of geography changes after the clusters emerged. Studies of knowledge diffusion between engineers across firm boundaries in the cluster in 2001 reveal that they shared knowledge (Dahl and Pedersen, 2004), but these spillovers could not take place without several firms that emerged via the spinoff process.

The main finding in this chapter is that spinoffs have been a central mechanism in the early growth phase of the wireless communications cluster in North Jutland. This result is supplemented by the findings in semiconductors in Silicon Valley, wireless communications in San Diego, automobiles in Detroit, and tyres in Akron. Without the spinoff process, the NorCOM cluster would never have become a cluster, but only a single firm like B&O in Struer. This explanation for the emergence of clusters removes some of the uniqueness and historical and cultural specificity of clusters. Spinoffs are a key determinant when a cluster grows from a single firm to many firms. However, there are several unanswered questions concerning the spinoff process and the process of founding a firm. Why do spinoffs occur in some places and not in others? What triggers the separation process? What type of positions and functions do future founders have in the parent firm? Which types of routines are inherited? What is the link between the industry life cycle and spinoff process? Answers to these questions can give us much better knowledge about the process of spinning off and the emergence of clusters. Future studies of the emergence of clusters need to dig deep and study the organisational background of founders, the evolution of the industry and market opportunities.

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8 References

- Agarwal, R., R. Echambadi, A. M. Franco and M. B. Sarkar (2004). "Knowledge transfer through inheritance: Spin-out generation, development and survival." Academy of Management Journal **47**(4): 501-522.
- Anton, J. J. and D. A. Yao (1995). "Start-ups, Spin-offs, and Internal Projects." Journal of Law, Economics, and Organizations **11**: 362-378.
- Arthur, W. B. (1990). "Silicon Valley Locational Clusters: When do Increasing Returns imply Monopoly?" Mathematical Social Sciences **19**: 235-251.
- Arthur, W. B. (1994). Increasing Returns and Path Dependence in the Economy. Stanford, University of Michigan Press.
- Boschma, R. and G. A. v. d. Knaap (1999). "New high-tech Industries and windows of locational opportunity: The role of labour markets and knowledge institutions during the industrial era." Geografiska Annaler **81 B**(2): 73-89.
- Brittain, J. W. and J. Freeman (1986). Entrepreneurship in the semiconductor industry. Mimeo.
- Buenstorf, G. and S. Klepper (2005). "Heritage and Agglomeration: The Akron Tire Cluster Revisited." Mimeo.
- Carroll, G. R. (1984). "Organizational Ecology." Annual Review of Sociology **10**: 71-93.
- Carroll, G. R., L. S. Bigelow, M.-D. L. Seidel and L. B. Tsai (1996). "The fates of *de novo* and *de alio* producers in the American automobile industry 1885-1981." Strategic Management Journal **17**(Summer Special Issue): 117-137.
- Dahl, M. S. and C. Ø. R. Pedersen (2004). "Knowledge Flows through Informal Contacts in Industrial Clusters: Myth or Reality?" Research Policy **33**: 1673-1686.
- Dahl, M. S., C. Ø. R. Pedersen and B. Dalum (2003). "Entry by Spinoff in a High-tech Cluster." DRUID Working Paper Series **2003-11**.
- Dalum, B. (1995). "Local and Global Linkages: The Radiocommunications Cluster in Northern Denmark." Journal of Industry Studies **2**(2): 89-109.
- Dalum, B., C. Ø. R. Pedersen and G. Villumsen (2005). "Technological Life Cycles: Lessons From A Cluster Facing Disruption." European Urban and Regional Studies **12**(3): 229-246.
- Franco, A. M. and D. Filson (2000). Knowledge Diffusion through Employee Mobility. Research Department Staff Report, Federal Reserve Bank of Minneapolis.
- Gelsing, L. and A. Brændgaard (1988). Elektronikindustrielle Miljøer i Nordjylland. Aalborg, Institut for Produktion, Aalborg Universitets Center.
- Hannan, M. T. and J. Freeman (1986). "Where do Organizational Forms come from?" Sociological Forum **1**: 50-57.
- Helfat, C. E. and M. B. Lieberman (2002). "The birth of capabilities: market entry and the importance of pre-history." Industrial and Corporate Change **11**(4): 725-760.

- DAHL M. S., ØSTERGAARD C. R. and DALUM B. (2010) Emergence of regional clusters: the role of spinoffs in the early growth process, in R. MARTIN and R. MARTIN (Eds) *The Handbook of Evolutionary Economic Geography*, pp. 205-221. Edward Elgar Publishing, Incorporated, Cheltenham, UK
- Jacobs, J. (1969). The Economy of Cities. New York, Vintage Books.
- Klepper, S. (2001). "Employee Startups in High Tech Industries." Industrial and Corporate Change **10**: 639-674.
- Klepper, S. (2002a). "The capabilities of new firms and the evolution of the US automobile industry." Industrial and Corporate Change **11**(4): 645-666.
- Klepper, S. (2002b). The Evolution of the U.S. Automobile Industry and Detroit as its Capital. Mimeo, Carnegie Mellon University.
- Marshall, A. (1920). Principles of economics. London, Macmillan.
- Maskell, P., H. Eskelinen, I. Hannibalsson, A. Malmberg and E. Vatne (1998). Competitiveness, Localised Learning and Regional Development - Specialisation and Prosperity in Small Open Economies. London, Routledge.
- Moore, G. and K. Davis (2001). Learning the Silicon Valley way. Stanford Institute for Economic Policy Research.
- Nelson, R. R. and S. Winter (1982). An Evolutionary Theory of Economic Change. Cambridge, Massachusetts, Harvard University Press.
- Porter, M. E. (1998). On Competition. Boston, Harvard Business School Press.
- Roberts, E. B. (1991). Entrepreneurs in High Technology. New York, Oxford University Press.
- Romanelli, E. and C. B. Schoonhoven (2001). The Local Origins of New Firms. The Entrepreneurship Dynamic: Origins of Entrepreneurship and The Evolution of Industries. C. B. Schoonhoven and E. Romanelli. Stanford, California, Stanford University Press.
- Shane, S. (2000). "Prior knowledge and the discovery of entrepreneurial activities." Organization Science **11**: 448-469.
- Simard, C. and J. West (2003). The role of founder ties in the formation of San Diego's "wireless valley". DRUID Summer Conference 2003, Copenhagen.
- Sorenson, O. (2003). "Social Networks and Industrial Geography." Journal of Evolutionary Economics **13**(5): 513-527.
- Sorenson, O. and P. G. Audia (2000) "The social structure of entrepreneurial activity: Geographical concentration of footwear production in the U.S., 1940-1989", *American Journal of Sociology*, Vol 106, pp. 424-462.
- Sorenson, O. and T. E. Stuart (2001) "Syndication networks and the spatial distribuion of venture capital investments", *American Journal of Sociology*. Vol. 106, pp. 1546-1588.
- Stinchcombe, A. (1965) Social structure and organizations, pp. 153-193 in: J. G. March (Ed.) "Handbook of Organizations", Chicago: Rand McNally.
- Storper, M. (1997). The Regional World: Territorial Development in a Global Economy. New York, The Guilford Press.
- Storper, M. and R. Walker (1989). The Capitalist Imperative: Territory, Technology, and Industrial Growth. Oxford, Basil Blackwell.
- van der Linde, C. (2003). The Demography of Clusters - Findings from the Cluster Meta-Study. Innovation Clusters and Interregional Competition. J. Bröcker, D. Dohse and R. Soltwedel. Berlin, Heidelberg, New York, Springer Verlag: 130-149.

DAHL M. S., ØSTERGAARD C. R. and DALUM B. (2010) Emergence of regional clusters: the role of spinoffs in the early growth process, in R. MARTIN and R. MARTIN (Eds) *The Handbook of Evolutionary Economic Geography*, pp. 205-221. Edward Elgar Publishing, Incorporated, Cheltenham, UK

Veblen, T. (1912) "The theory of the leisure class: An economic study of institutions", New York: The Macmillan Company.

Wiggins, S. N. (1995). "Entrepreneurial Enterprises, Endogenous Ownership, and the Limits to Firm Size." Economic Inquiry 33: 54-69.