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Abstract:

How can the growth of regional clusters be explained? This paper studies in great detail the growth of the wireless communication cluster in Northern Denmark. Unlike the dominant theories, we argue that initial success of the first firms are the main driving force behind the generation of new firms that eventually lead to the formation of clusters. The success of the first firms tends to generate spin-offs, which become successful themselves due to the background of the founders.

Key words: Agglomeration, Clusters, Spin-offs, Knowledge Diffusion

JEL Codes: R10, O13, J60, L63

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1 Introduction

How can we explain the formation of regional clusters of economic activity? This has been one of the central questions on the research agenda in economic geography for decades. The work of Marshall (1919) has been particularly influential in explaining this question. Based on his work, the emergence of clusters has been explained by the existence of location-specific externalities (*Marshallian externalities*), unique local culture and favorable factor conditions, which all lead to the existence of increasing returns to scale for firms located in clusters. This gives firms a clear incentive to locate close to similar firms in order to achieve these returns. However, these ex-post dynamics given by the externalities and agglomeration economics can only exist once there are a significant number of firms in a particular location. Clusters may or may not have these dynamics, but the emergence of clusters cannot be driven by these factors from the start, as clusters tend to evolve out of individual firms. Studies have shown that there are not necessarily any increasing returns to scale associated by a location in a cluster (Sorenson and Audia, 2000). On the contrary, clusters might exist because of an above-normal production of successful entrepreneurs.

In the present paper, we use this alternative approach to study the emergence and growth of a wireless communications cluster around Aalborg in the region of North Jutland, Denmark (NorCOM). Recent studies have shown how capabilities of new firms are important for the evolution of industries over time. The main mechanism at work is that the capabilities of new firms are fundamentally shaped by the pre-entry experience of the founders (Helfat and Lieberman, 2002). Founders, which were previously employed at incumbent firms in an industry, will have a better performance with their new firm (spinoffs) due to improved capabilities. The aim of this study is to analyze the dominating forces behind the growth of NorCOM using detailed information about the founding events and organizational background of every individual entrant in the cluster. We focus on testing the argument that spinoffs are likely to be the engine of growth in the number of firms in the cluster.

We find that spinoffs have driven the evolution of the cluster. The early success of the first firms has been diffused through the mobility of personnel from old to new firms. Furthermore, we compare the evolution of this cluster with the evolution of other clusters, where the entrepreneurial background has been studied. The clusters have very similar stories, where spinoffs from successful early firms have been the key determinant. The theory is thus a powerful explanation of the growth of regional clusters.

The remainder of this paper is structured as follows. The theoretical framework is presented in Section 2 and 3 with discussions of the local production of entrepreneurs and spinoffs as diffusion of knowledge. The history of the present cluster is described in Section 4. Section 5 gives an overview of

the growth of the cluster in term of generation of new firms. This evidence is discussed in Section 6 followed by the conclusions in Section 7.

2 The local production of entrepreneurs

The phenomenon of the most successful entrants having ‘inherited’ significant amounts of experience from existing firms implies that entrepreneurial activity has a considerable geographical aspect, since the majority of entrepreneurs may tend to found their new firms in close proximity to their previous employers (Sorenson, 2003). The local ‘production’ of new entrepreneurs, thus, plays a vital role for regional development. New jobs are not only created in incumbent firms but indeed also by the formation of new employers through local spinoff mechanisms.

This does not necessarily imply that founders will only base their new organizations in close proximity to their past employer. There are well known examples of founders, who search for the most proper location among many geographic regions, that either provide access to a large local market or, perhaps more important, offers the best selection of resources to the organization. Today, 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). But the current geographical distribution of an industry places important constraints on entrepreneurial activity (Sorenson, 2003). Important resources for new organizations, such as abundantly available technical personnel generally tend to be immobile and unevenly distributed across geographical space. Thus, founders tend to base their new organizations close to previous employers, since they have detailed knowledge about and social connections to available resources in that particular region. 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). So in general, we might 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 at a large scale in the incumbent firms. If all of this is the case, the existing structural base of a region is a dominant source of the geographical concentration of industries and regional economic growth. But which factors determine where the initial activities of a new industry are located?

The initial activity is often seen as being located in a particular geographical location by chance (Arthur, 1990). This could be a single *de novo* entrepreneur or a single diversifying local organization. Arthur (1994) highlights the claims of Engländer (1926) and Palander (1935) that 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 upon inherited structures through the phases of development. In an evolutionary perspective, agglomeration can be interpreted as the mechanism by which existing organizations will breed new ones founded by entrepreneurs.¹ New firms in a region will mainly emerge from the existing ones as spinoffs.

The immobility of labor as a result of social and economic forces will induce entrepreneurs to locate close to their origins, so they can maintain their social ties and continue exploiting their localized knowledge of capitalists, potential employees, and suppliers. As a consequence, the quality of the new organizations and the future development potential in a region at a given time, will be a function of the quality of the stock of existing firms and past entrants (Klepper, 2003). This is in line with Romanelli and Schoonhoven (2001), who argue that most new firms will be founded in the same geographical region, or very close to it, as that of the firm that produced the entrepreneur. Entrepreneurs will be produced within the region itself by existing organizations. This means that a region's future will be closely determined by its present structure and profile.

3 Spinoffs as diffusion of knowledge

Organizational sociologists have considered the effects of the transfer of routines and experience between a new firm and its founder's previous employer for several years (Phillips, 2002). The argument that blueprints of a parent firm are passed on to new organizations through the offspring's founders (Brittain and Freeman, 1986; Carroll, 1984; Hannan and Freeman, 1986; Romanelli, 1985; 1989). This argument have recently received significant attention in economics and management (e.g. Klepper, 2001; 2002; Agarwal et al., 2004; Thompson, 2005; Klepper and Sleeper, 2005).

All 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). Thus, all entrants in an industry carry skills and routines embodied in the founders that are very likely to influence the new firm's future development and success. Often new firms enter the same industry in which their founders were previously employed. These cases are labeled spinoffs. Founders are likely to bring specific knowledge about a wide range of issues to their new firm, e.g. 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 (Shane, 2000) or prior

¹ Arthur (1994) have argued that similar organisations with a somehow different background and from other regions will be attracted by the growing presence of activities. This tradition goes back to Weber (1928).

scientific and technical training (Roberts, 1991). Consequently, more experienced founders with valuable industry specific knowledge should have a higher probability of success compared with less experienced entrants. So it becomes very likely that the success of a new entrant is based on the experiences of the founder.

Klepper (2001) exploits the metaphor of spinoffs as children and past employers as parents in his evolutionary account for spinoffs. He proposes a model that combines the ideas of reproduction and inheritance with the notion of organizational routines. This notion is originally developed by Nelson and Winter (1982) assuming that firms are to a large extent governed by routines. A firm has separate routines for the different functions (R&D, marketing, management, etc.) and products involved in its operation. Either the founders or the initial management team install these routines. Decision making at all levels will subsequently depend on them. When a new firm is born organizations will reproduce, because founders will rely on routines, which 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 startup, because of the experience of the founders. This may on average enable these spinoffs to outperform other startups. Eventually the longer survival and better performance of spinoffs will one day turn them into parents, since employees with access to better routines will be more likely to found new organizations (Klepper, 2001).

Successful and innovative firms with broader product lines are thus likely to spawn more spinoffs, since they form inspirational learning environments for their employees. Garvin (1983), Cooper (1985) and Cooper and Gimeno-Gascon (1992) argues that since spinoffs usually are of a small size initially, small firms will have higher spinoff rates, because they act as the most valuable lessons for their employees on how to start their own firms. They also argue that regions, which have many firms in a particular industry, will also have higher spinoff rates, because of the high supply of qualified labor in that industry.

4 History of the NorCOM cluster

The evolutionary approach outlined above is applied in the present section on the development of a cluster of high technology based firms in the field of wireless communications in the region of North Jutland, Denmark. Defined narrowly, it consists of around 50 firms, a science park (NOVI) and Aalborg University (AAU), which is one of the two major technical universities in Denmark with its Faculty of Engineering and Natural Sciences. The relative small size of the cluster has facilitated more

easy information access and has made it possible to study an entire cluster over more than three decades.

The case study presented below has been developed using detailed information about the founding events and organizational background of each and every individual entrant in the cluster until 2003. The tracing of founders is based on extensive research in the archives of local and national newspapers, technical journals, business reports, financial statements and existing historical studies of this cluster (Gelsing and Brændgaard, 1988; Dalum, 1995). Additionally, we have had several interviews and informal conversations with founders and other key actors in the local industry. An early version of this paper was presented at a NorCOM Association meeting, where many key actors were present. The comments from key industry and university participants at this meeting have been a valuable source of comments and historical facts. A more detailed description of the history of the cluster is presented in Dahl et. al. (2003).

4.1 Early success of S.P. Radio and its first spinoffs

The success of S.P. Radio (established in Aalborg in the 1940s) in the 1960s and 1970s as one of the world's leading producers of maritime communications equipment gave the employees, who was the founders of the first spinoffs in the 1970s, the relevant capabilities and routines to become successful themselves. S.P. Radio is usually acknowledged as the first company in the NorCOM cluster. Simon Petersen founded S.P. Radio as a consumer radio retail business in Aalborg around 1930. In 1949, the S.P. Radio began manufacturing the radio receivers themselves. The company had grown steadily since its establishment. But in the 1960s, there were more than 30 producers of consumer electronics in Denmark. Simon Petersen saw that the industry was reaching a saturation point facing fierce competition. Furthermore, he had noticed that the large producers had largely neglected the market for radio communication equipment to small vessels, so there was nearly no competition in this area. Consequently, S.P. Radio stopped producing consumer electronics and diversified into developing and producing maritime radio communication equipment in the mid-1960s. This became an almost immediate success. The equipment was technologically very advanced compared to its few competitors. S.P. Radio quickly became one of the world's leading producers of communication equipment to this segment. In 1966, the company had 150 employees and continued to expand its product line into the market for larger vessels.

S.P. Radio continued its success and grew in the 1970s and 1980s. 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

communication equipment. The second spinoff was founded in 1977 by two experienced engineers working at Dancom decided to found Shipmate in the laundry room in Sorensen's basement. The first product was a radio phone for maritime use, which competed directly with both Dancom and S.P. Radio. The product sold very well and funded the development of the next version, which was an even larger breakthrough for the company. In 1980, further success came after they developed a satellite navigation system. At that time the firm only had one employee besides the two founders. But they were able to develop a complete navigation system at only one-third of the price of the competitors after only one year of development. 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 founders were suspended from their duties as managing directors. The firm was reconstructed under the management of Henrik Langkilde, who was brought in by the creditors. Before that he had written a 300-pages report on the worldwide wireless communication industry as a consultant for Dancom. They wanted to explore the possibilities for using the firm's capabilities and advantages from maritime communication in an emerging market of onshore personal communication (mobile phones). Langkilde successfully reconstructed Dancom on a smaller scale focusing only on closed onshore mobile communication systems. Shortly after, the firm started activities in producing personal mobile phones. In 1982-83, Dancom changed its name to Dancall Radio and shortly after it went public on the Danish Stock Exchange.

4.2 The success in the first generation of mobile phones

In the early 1980s, some of the cluster firms and spinoffs (especially Dancom/Dancall) diversified into an emerging technologically related area of personal mobile communication equipment. These new firms eventually started the second wave of success. They diversified into mobile communications as the market opened by the introduction of the common Nordic standard for mobile telephony (NMT).² When the market boomed during the 1980s, these firms were successfully among the world leading producers of phones for this network. They were able to use the inherited and developed strong capabilities from the maritime radio communication equipment to diversify into mobile phones.

In 1985, Shipmate expanded into mobile communication with the new activities placed in a separate division, Cetelco (with one of Shipmate's founders as the technical manager). One year later, they had developed and produced their first mobile phone. The reason for establishing Cetelco was to produce

² In this first generation of mobile communication, most countries had their own system based on different standards. Only the Nordic countries had a common standard. This is often argued to be one of the reasons for the success of the Nordic mobile phone producers.

mobile phones, which had a fast growing market, but also to build up production capacity for mass production that could reduce the costs of the maritime products. 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 had high growth due to their successful diversification 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. The phones had undergone rapid technological development. From being relatively heavy, more or less portable (bag-like) terminals often installed in cars, the phones became much smaller and handheld. The small cluster firms were facing an international market with high development costs, production capacity demands and price competition. These developments strongly influenced the events of the cluster in the following years.

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 (produced and marketed by the French firm Alcatel). T-Com was very successful with their new strategy. The company was first sold to British C-Com in 1990, but only one year later Maxon (South Korea) acquired it.

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.

4.3 The success of the second generation of mobile phones

The third phase of success started when the common European standard for mobile telephony (GSM) was introduced as a new standard. 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-standard mobile phone was seen to be a major economical and technical challenge for the mobile communication 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 the Aalborg University. The companies should develop the rest of the phone (display, design etc.) themselves. T-Com/Maxon was also a part of the planning process, but decided not to join and continued to focus on the mobile phones for the old system.

DC Development was founded in 1988 and located at a new science park, NOVI, close to Aalborg University. They participated in the international GSM standardization and specification process, since the specifications were determined in parallel with the development of the terminals. DC Development succeeded in the development of basic modules, and the parent companies were among the first to produce a GSM mobile phone in 1992 in the world. In spite of the achievement and talks during this period of making DC Development a permanent establishment, the companies decided to end their cooperation. DC Development employed at the peak 30 engineers. The group was divided equally between the two firms after the closing.

The technological achievement of DC Development increased the international visibility of the cluster and strengthened the region's reputation in wireless communication 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.

As a consequence, Cetelco was gradually taken over by Hagenuk (Germany) in 1988-90. Cetelco continued to grow afterwards (from 100 to 250 employees), but had too high development costs compared to its income. This became a problem already in 1993 with their first GSM phones, which were expected to last 15 months in the market, but only lasted nine months. In 1995, when Cetelco launched the second version GSM phone, the development period was miscalculated and as a result the firm had downsized the production. The number of employees dropped to 150. During the late 1990s, Cetelco stopped producing mobile phones and was only an R&D division of Hagenuk (and later of Telital (Italy)).

Dancall had more than 600 employees in early 1993. But 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. In 1997, Robert Bosch (Germany) acquired it. Bosch used the acquisition to enter the GSM market and continued the expansion to 1400 employees in 1999.³

During the history of the cluster, Dancall and Cetelco have been the parents of numerous spinoffs. Many of these spinoffs are clear examples of the vertical disintegration that have been dominating the mobile phones industry. An example is RTX Telecom founded in 1993 by three experienced engineers from Maxon and four from Cortech.⁴ They founded the firm with the strategy to do R&D for other firms. RTX based their designs on chipsets from National Semiconductor and developed a very close cooperation with the US company. Later, National Semiconductor also acquired a share of RTX. National Semiconductor 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 inquiries from other firms in the industry, who wanted to buy development aid for mobile phones. But since Cetelco was a R&D department of Hagenuk, it was not possible to follow this potential market within Cetelco. ATL cooperated with several chipset manufactures until Texas Instruments (TI) acquired the firm in 1999. When this happened, a group of engineers headed by Ole Madsen left ATL/TI to found a local affiliate of Condat (Germany). This firm was also acquired by TI and merged with TI's other activities in Aalborg. This enabled the US company to develop an entire mobile phone by itself in Aalborg.

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, there were many investments by multinationals in the region from 1998 and onwards.

The history of the cluster illustrate, how the two first spinoffs, Dancall and Cetelco, became successful in mobile phones by using their experiences from maritime radio communications partly gained by the

³ In 2000, Bosch realized that it was too small a player in the industry and the firm decided to cut off its mobile phone activities. It ended up splitting the Danish division into two parts. Siemens (Germany) acquired the R&D department and Flextronics International (United States) bought the production facilities. During the transition period with changing ownerships many engineers moved to other local firms. Some of them also founded new spinoffs.

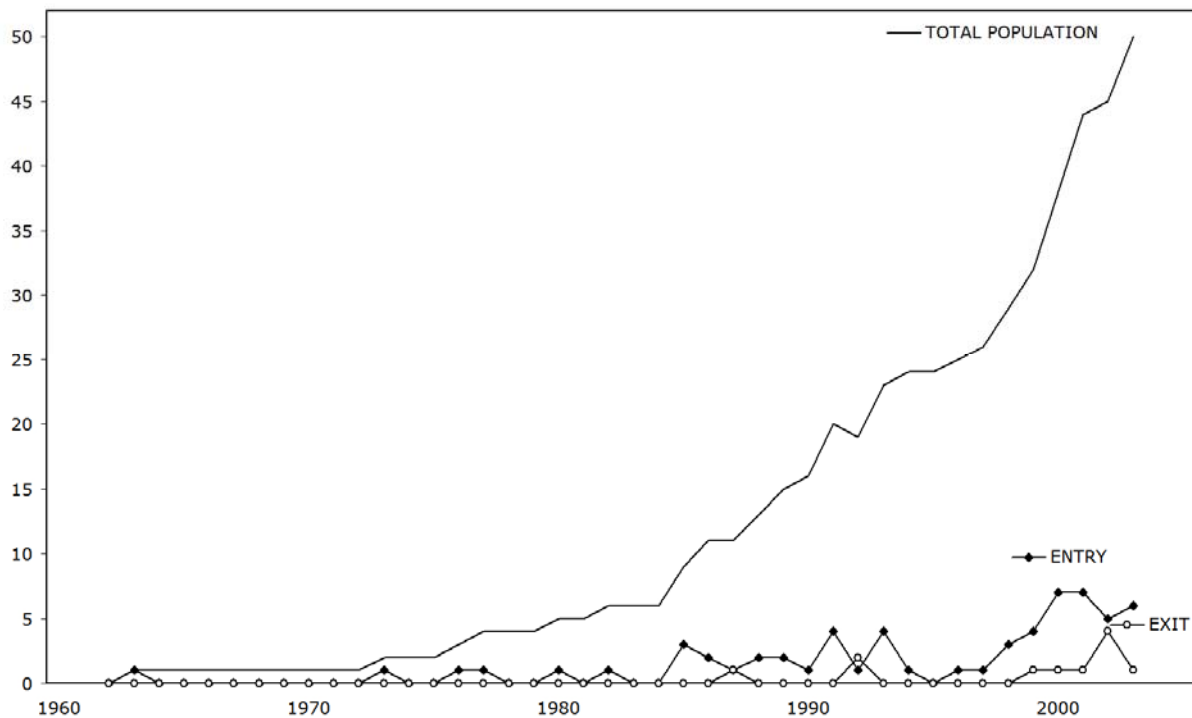
⁴ All seven had previously worked for Dancall.

founders, while they worked at the successful parent, S.P. Radio. The initial success of these firms fuelled an intense formation of new spinoffs, which altogether developed the cluster as it grew from one to 50 firms during three decades.

5 An overall look at the cluster

The overall evolution of the population of firms in the cluster is shown in Figure 1. This figure is based on the genealogical tree of the NorCOM cluster (shown in the appendix).⁵ Figure 1 show that there has been a steady, and even increasing, growth in the number of firms since the beginning. As a result, the number of firms is around 50.

Figure 1: Entry and exit of firms in NorCOM



The number exits has until now been remarkably low. The year 2002 has been the only year with more than two exits in a single year. Only 11 firms have exited through history. Several firms have, however, been rescued from exit on the verge of bankruptcy after being taken over by other firms, typically multinational companies. Three phases may visually be distinguished in Figure 1 in terms of different slopes of the total population curve. During 1973-84, the cluster grew from two to six firms, following the initial early success of the first parent, S.P. Radio. In the second phase, 1984-95, the

⁵ Further information on individual firm events is presented in Dahl et. al. (2003).

population of firms increased from six to 24 firms. In the third phase, 1995-2003, the population increased from 24 to 51 firms.

The main task of this study has been to construct a genealogical tree (shown in the appendix) based on detailed information on every firm being active in the cluster since the 1960s. Firms have been divided into different groups depending on the background of the founder or firm. There are different typologies of entrants based on their prior experience in the literature. In order to study the evolution of a particular case according to the different types of entrants and their background, it is necessary to select a relevant typology for distinguishing between different types. Based on Klepper (2001) and Helfat and Lieberman (2002), three main types of entrants can be identified: Diversifying entrants, parent-company ventures, and *de novo* entrants. (1) Diversifying entrants are firms entering new or established markets unknown to them, through acquisition or green field investment. (2) Parent-company ventures are new entities founded by established firms, either as joint ventures with other partners or as parent spinoffs. (3) *De novo* entrants are divided into two different types based on their level of previous experience in the industry: Entrepreneurial spinoffs are characterized as firms founded by experienced persons with previous employment in incumbent firms in the industry. Persons with no previous employment in the industry have established the inexperienced start-ups. The typology used in this case is shown in Table 1.

Table 1: Typology of new firm entrants

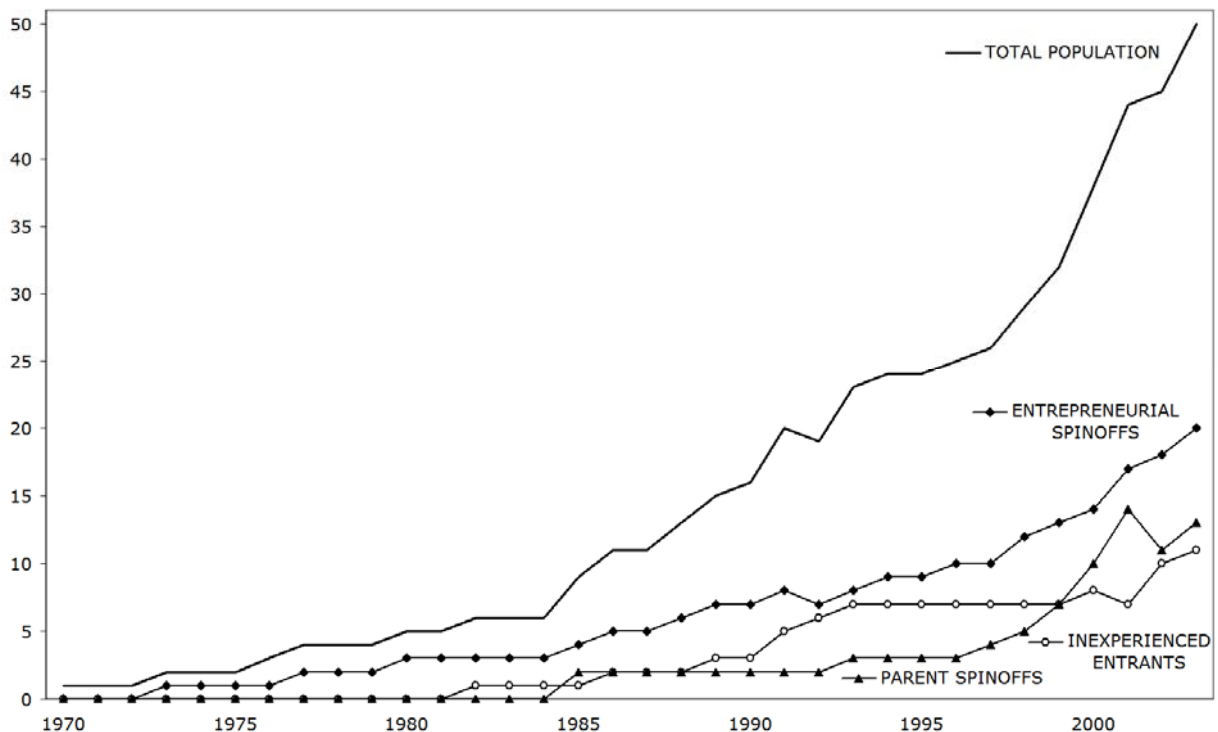
Entrant type	Relation to established firm	Parent company Ownership
(1) Diversifying entrant	Same firm	Full
(2) Parent-company activity	New firm as a separate entity	
- Joint venture	Founded by multiple established firms	Partial
- Parent spinoff	Founded by established firm	Partial
(3) <i>De novo</i> entrant	New firm as a separate entity	
- Entrepreneurial spinoff	Founder(s) previously employed in the industry	None
- Inexperienced startup	Founder(s) no prior experience or contacts in the industry	None

Source: Adapted from Helfat and Lieberman (2002, pp. 730-731) and Klepper (2001).

The evolution of the cumulative number of the three most frequent types of entrants is shown in Figure 2. The diagram indicates that the entrepreneurial spinoff firms have represented a large share of the increase of the population. They have been a driver of cluster growth during the entire period. It has been the largest group of firms throughout the history of the cluster. The growth in the number of parent spinoffs since 1997 represents the increasing international visibility of the cluster. After 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 1995 to 15 in 2001. Before 1995, 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), 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.

Figure 2: Entry and exit of new firms in NorCOM by main category



6 Discussion

The most powerful finding of this study is that entrepreneurial spinoffs account for the majority of the firm growth in the cluster. A key component in the growth of the cluster has been the early performance of the first entrant, S.P. Radio. Both technologically and economically, the firm was very successful and provided a good source of experience for the following entrants, spinoffs of S.P. Radio and Dancom/Dancall. Through the 1970s and 1980s, a series of new firms was founded as spinoffs, which became among the world leaders in mobile phones. In the 1990s, the activities of parent

spinoffs often founded by multinationals have added to the growth in number of firms. Often these have founded subsidiaries by hiring or head hunting experienced local employees to start the new firms.

In this process of industrial transformation, competencies from the past became highly relevant for the wireless industry from maritime to personal mobile communications through the NMT and later the GSM standards. The success of the maritime companies fuelled a series of confident entrepreneurial spinoffs often competing directly with the mother firms in maritime communication. As the mobile phone industry evolved, the spinoffs used their competencies and experience from maritime to diversify into the new industry. The original and successful organizational capabilities were inherited by the new organizations and then facilitated the overall basis for the formation of the cluster through rapid growth in the number of firms.

The dominating theories of economic geography and spatial agglomeration cannot sufficiently explain the emergence of clusters like the NorCOM case. The claims of the dominant theories about the initial factor conditions and overall regional attributes coupled with different externalities as the explanations of the evolution of clusters in general do not appear to be satisfactory. In the NorCOM case, these factors cannot explain why this cluster of high-technology and research intensive firms grew up in a region, which had been lagging behind the remaining part of the country for decades - and are dominated by farming, food processing, fishery and the process industries in mainly low growth manufacturing. Similarly, the local market conditions did not support the formation of the cluster very well, since it has been oriented towards foreign markets from the very beginning with a high degree of exports.

The initial location of first firm in the cluster can at best be characterized as a chance event. The entrepreneur Simon Petersen returned to the region after studying in another region. It could basically have been anywhere else in the country. Later, when the cluster had entered its initial growth phase, the local university was founded. But even in the years after that the firms had to rely on internal competence building and 'imported' employees from other Danish regions. In this early phase, the 'quality of the parents' played a major role as early seed beds for experience. In 1980s and 1990s, the university clearly had an effect through its growing supply of qualified labor and basic research in the wireless technologies of the cluster.

To illustrate how the theories of spinoffs can contribute to a better understanding of geographical clustering, we look at the evolution of three industries studied in such a context. The evidence from the

U.S. automobile, semiconductor, and tire industries reveals that pre-entry experiences and inherited firm capabilities can explain the performance of firms over time and the formation of clusters in these industries. The evolution of the three industries is very similar to the NorCOM case in how the geographical clusters grew over time. However, three very distinct clusters emerged as a result of spinoffs in the evolution of these industries.

First, the *automobile industry* was characterized by a large rate of entry with more than 500 firms entering in its first 20 years (Carroll et al., 1996). Eventually, the industry evolved to be a tight oligopoly dominated by three relatively late entering firms, Ford, General Motors and Chrysler. These three were all related to the first successful firm in the industry, Olds Motor Works, which happened to be located in Detroit (Klepper, 2002). These successful firms spawned 22 spinoffs that became successful. By the 1930's Detroit firms dominated the industry in number of leading makes. The new firms were able to rely on the superior performance of their parents to become successful themselves and dominate the entire industry. This cannot explain the initial location of the four large producers in Detroit and why they became successful, but given the chance of this occurrence, the theory of spinoffs can indeed explain, why the firms founded in that area in the following years became so successful.

Second, many studies of the *semiconductor industry* have shown that entrepreneurial spinoffs and employee mobility have been important factors in the evolution of this field. As Dosi (1984) notes, founders of new firms in the early years very often worked as scientists or managers in existing semiconductor firms. Brittain and Freeman (1986) and Moore and Davis (2001) even argue that entrepreneurial spinoffs were the main engine behind the growth in Silicon Valley. The most well known case is the many firms that spun off from Fairchild Semiconductor, often called the 'Fairchildren', such as Intel and AMD.⁶ In general, engineers left established incumbent firms in large numbers and started new ventures that produced the capital goods and materials needed for semiconductor design and manufacturing. The majority of the new firms were founded in Silicon Valley, where the technical expertise was already abundantly present, founders had the contacts to recruit talented employees, and where an effective venture capital system was ready to provide the critical early financial support for founding a firm (Romanelli and Schoonhoven, 2001). In the early years of the industry, the semiconductor firms faced novel organizational challenges in aligning goals and designing the organizational structure that could establish and reach the technological demands of

⁶ Fairchild Semiconductor was in fact itself a spinoff of Shockley Transistor. Shockley Transistor was also a spinoff. It was founded in 1955 by the co-inventor of the transistor, William Shockley. He previously worked for Bell Telephone Laboratories.

the industry. Working for incumbent firms was the best way to learn how to tackle those challenges. Consequently, spinoffs were uniquely able to perform well in the industry (Moore and Davis, 2001).

Third, a recent analysis of the U.S. tire industry has found that the location and background of the entrants caused the industry to become regionally concentrated around Akron, Ohio (Buenstorf and Klepper, 2005). Similar to many industries, the tire industry evolved to be an oligopoly dominated by four firms, Goodyear, Goodrich, Firestone, and U.S. Rubber. These firms accounted for more than 70 percent of the market in the 1930s. Goodrich, Goodyear and Firestone were all located in Akron, Ohio. The Ohio firms were distinctly successful and the production of tires and inner tubes in Ohio accounted for 67.1 percent of total U.S. production in 1935. The leading Akron firms spawned the most spinoffs and the performance of these spinoffs was very much related to the performance of their parents. From a few early Akron firms related to the successful Goodrich, the Akron tire cluster grew primarily through a spinoff process rather than through agglomeration economics (Buenstorf and Klepper, 2005).

The evolution of the automobile, semiconductor and tire industry illustrate very well how the success of early entrants in an industry and in a region can be starting point of a clustering process, where new firms founded as spinoffs are strongly influenced by the existing incumbents. The most successful early entrants located – basically randomly - in Detroit (autos), in Silicon Valley (semiconductors), and in Akron (tires), which started a reproduction process that determined the geographical distribution of these industries and created three notable clusters. Many other factors may or may not have been important in the history of the clusters, but nothing would have happened in these places without the spinoffs process, which increased the number of firms from one to many.

7 Conclusions

This paper has analyzed the entrepreneurial founder effect in the growth of a regional cluster in wireless communication. The location of a few early successful companies shaped the evolution of the cluster. The inherited capabilities of the spinoffs were decisive for the emergence, development and further growth of the cluster. The early successful performance of the first entrant was a key component and provided a source of experience for the following entrants. Through the 1970s and 1980s, a series of new firms was founded as spinoffs. They were among the world leaders in mobile phones. As the cluster evolved, the successful organizational capabilities were inherited by the new organizations. This facilitated the overall basis for the formation of the cluster through rapid growth in the number of firms.

The claims of the dominant traditional theories, where the initial factor conditions, regional particularities coupled with various location specific externalities explain the evolution of clusters in general do not appear to be satisfactory. These factors are not sufficiently explaining the early phases of growth. The initial location of first firm in the wireless communication cluster can be characterized as a chance event. In the emergence phase, the 'quality of the parents' played a major role as early seed beds for experience. Later on, in 1980s and 1990s, other factors supported the growth of the cluster, such as the university through its growing supply of qualified labor and basic research in wireless technologies. However, spinoffs have driven the evolution of the cluster and the early success of the first firms has been diffused through the mobility of personnel from old to new firms.

There are several open questions concerning the spinoff process and the process of founding a firm, which are still unexplored in this context. Why do spinoffs occur? What triggers the separation process? What type of positions do future founders have in the parent organization? How are spinoffs financed? These are the important unanswered questions, which can give us a much better knowledge about the process of spinning off. Several studies have already confirmed that this exact type of entry is an important source of economic growth and variety and technological change in industries. The background of founders can potentially explain the growth patterns of units at all levels – from individual firms, entire industries as well as geographical regions and clusters.

Clusters have become a desirable phenomenon in the minds of many public policy makers. Most of the efforts to obtain this are directed more generally at different levels. The main finding of this paper is that spinoffs have been the central mechanism in the evolution of a high-tech cluster. Furthermore it also has some policy implications. Little attention is paid on the public policies on employee contracts, which can have a strong influence on how clusters develop through a spinoff process. The employee's future possibilities for founding a new firm can be very limited, if the employing organizations use non-compete covenants or clauses in their employment contracts. This type of adscription of employees will evidently limit the evolution of clusters and hinder employment growth through new firm formations.

8 References

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9 Appendix

The Genealogy of the Wireless Communications Cluster in North Denmark (NorCOM) - 1963-2003

