The role of universities in cluster emergence process – comparative case study of the Cambridge cluster and an emerging Biomedico cluster in North Jutland

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Abstract

This paper discusses the role of the university in the emergence of local clusters by looking at technology transfer mechanisms and a direct role the university can play in this process. Analytical generalisation in the case study approach is applied: A historical study of the Cambridge Phenomenon leads to some general factors that are used to analysis of a case of an emerging Biomedico cluster in North Jutland based mainly on the interviews with university researchers. The analysis identifies the existence of some technology transfer processes at the region's university (Aalborg University) such as cooperation with industry, industry financing, university spin-offs, and etc. but a localised element of the university research is missing. It is suggested that analysis of the region's industry/companies is needed to better understand the cluster's emergence and its possible links to the university. The paper concludes with policy implications for the Biomedico cluster.

Introduction

In the last decades cluster initiatives and cluster policy have become a central feature of policy promoting growth on regional, national, and European level. The attempts to support cluster emergence rely on regional assets: Regional universities with strong competencies in one or more technical areas are often starting points for such cluster initiatives. Unfortunately, little is understood about how universities influence the development of regional industry clusters (Paytas et al. 2004). The main impact of universities on the industry is through technology transfer that is commercialisation of technology developed by university researchers, in other words basic and applied research become product or process innovations that are traded on the market. But there is also another possibility that the university tries to take a lead in regional economic development as it is illustrated by the case of Cambridge (UK) and the case of the Biomedico cluster initiative in North Jutland, Denmark. The main question to be answered in this paper is: "What is the university role in cluster emergence?" A case study approach is used comparing the Cambridge cluster with the emerging Biomedico cluster.

This paper tries to investigate the following problems: "How the scientific competencies at universities may be transferred to the regional industry and as a result affect the emergence of a regional industry cluster", and "what are the transfer mechanisms, and what is the role of policy (with emphasis on regional policy) in this process" and finally, "can a university play a direct role in cluster emergence process?"
Research and technology policy is until now mostly decided on the national level and it is not necessarily the region where the university is located that should benefit from its knowledge. Therefore it is important to investigate, whether regional policy can have any effects on technology transfer and cluster emergence.

The theory does not give a clear answer on the localised effects of the university research. The belief that universities can stimulate regional economic development is based on the assumption that there is a geographic component to the spillover mechanism (Jaffe, et al. 1993). A classical reference is Jaffe's often cited finding that "there is only weak evidence that spillovers are facilitated by geographic coincidence of universities and research labs within the state" (Jaffe, 1989). However, there is some evidence that the geographic clustering of economic activity is stronger in research-intensive industries. Audretsch and Feldman (1996), and Jaffe et al. (1993) found that the "paper trail" of spillovers documented by patent citations is significantly localised (Agrawal and Cockburn, 2002). In general it may be stated that there is little literature on the issue how industry clusters can emerge from university research.

On the other hand, there are many examples of successful clusters that have emerged from university research, e.g. Silicon Valley/Stanford (USA), Route 128/MIT (USA), and, Cambridge (UK). These cases clearly show that universities can play a role in the cluster emergence process. Thus, a case study approach seems to be appropriate to deal with a question how universities impact cluster emergence. This paper presents two cases: the "Cambridge phenomenon" that has been extensively described in the literature and a case of an emerging cluster in North Jutland. The reason to choose the Cambridge cluster is that, compared with Silicon Valley and Route 128, the University in Cambridge has exercised the longest influence on the whole cluster and it is characterised by the largest number of direct university spinouts (Spilling and Steinsli, 2003). Looking at development of high-tech industry around the Cambridge University allows identifying cluster emergence mechanisms and the university's role in this process. Furthermore, policy lessons can be derived for the emerging biomedical technology cluster in the region of North Jutland. As far as this cluster is concerned, it is still debatable whether there is already a Biomedico cluster in the region, since the main strengths are localised at the university and there are very few biomedical companies (Stoerring and Christensen, 2004). The biggest challenge for this cluster initiative is how the university's technology competencies may be transferred to the local industry. Analysing a cluster in a very early stage of its emergence is interesting for several reasons concerning cluster dynamics and policy implications. The dynamics of the interactions between university and industry are easier to identify in an emerging cluster, where the processes are still ongoing. Moreover, such an analysis allows better understanding of specific regional circumstances of the emerging cluster. This makes it easier to compare it with other cases (like the Cambridge phenomenon) enabling for more appropriate regional policymaking.

Outline

This paper starts with the history of the Cambridge cluster focusing on how the university research has been transformed into the regional success, which dynamics have taken place, and what was the

role of regional policy. Cambridge has become established as one of the world's most important models of local economic development based on university research commercialisation in which small firms played a leading role (Keeble, et al. 1999). The paper looks upon this classical example that has been very extensively described in the literature (Segal Quince Wicksteed, 2000). On the basis of a variety of secondary data, analysis and reports the emergence of the Cambridge cluster is described including the main factors stimulating the Cambridge phenomenon such as: the positive attitude of Cambridge University towards industrial development; the University's liberal attitude towards staff members who develop new products and earn extra income from their scientific research; spinouts from the university; establishment of the university science park (Cambridge Science Park); regulations concerning Intellectual Property Rights; the University's scientific credibility, reputation and prestige anchoring the high-tech industries in Cambridge; etc. (Segal Quince Wicksteed, 1985; Smith, et al. 2001).

After the presentation of the Cambridge Phenomenon the case of the Biomedico cluster in North Jutland is analysed. The Biomedico case study is based upon interviews with university and regional representatives (university researchers, persons important for technology transfer in the region), as well as quantitative data (number of patents, publications, spinouts). Conducting interviews is the best method to analyse a cluster in an early development stage, when there are no data that could be used to a traditional input-output cluster analysis (Andersson, et al. 2004). Some of the indicators examined during the interviews are: financing of university research – sources and dynamics; university spinouts; entrepreneurial tradition among researchers and students; number of students; etc. The interviews should help: to identify dynamics of the relationships between the university and the industry; to find out which technology transfer processes are already present in the region; and to identify the stage of the Biomedico cluster evolution. These findings should facilitate comparison with the Cambridge case study and deriving policy implications in the last section of this paper.

The Cambridge Phenomenon

The history of the Cambridge cluster

The high-tech cluster in Cambridge has been intensively analysed in the economical literature over the last 20 years. The first detailed study has been conducted and published by Segal Quince Wicksteed in 1985, which has been repeated in 2000. There are many other researchers that have investigated the Cambridge phenomenon, many of them in comparative perspective. In this paper this perspective is also used, however, the focus is on the emergence of the Cambridge cluster. Hence, the first report by Segal Quince Wicksteed has served as the main source for the description of the Cambridge cluster's history.

The history of this cluster can be tracked back to the past centuries, when Cambridge University had been establishing its world-class reputation. To imagine the scientific strength of Cambridge University, it is enough to cite that the number of Nobel Prizes for science for the Fellows of Trinity College alone (one of most prestigious colleges) is higher than for countries such as France. The industrial development in the high-tech cluster has also its roots in the previous century with Cambridge Instruments established in 1881.

Cluster development started in the late 1960s. In 1960 the Cambridge region contained no more than 30 high-technology firms. From 1972 to 1984 the number of high-tech firms increased from around 100 to more than 300. In the period 1980-1985 company formation growth rates were at 30

new firms per year and even 50 in the next three years (Garnsey and Lawton-Smith, 1998). In the employment terms, the new high-tech companies generated 4,100 new jobs in the period 1979-84 (growth of 43%) and 2,000 in the next three years (Segal Quince Wicksteed, 1985/1990).

The development of the Cambridge Phenomenon was very often presented as a direct result of close functional links between the University of Cambridge and local high-technology firms (being in many cases direct spin-offs from the University's research and scientific activity). The finding from the first Cambridge Phenomenon report (SQW, 1985) that "slightly over half of all the firms contacted maintained, or had done so in the past, links with local research bodies", 90% of these being with University departments (mainly engineering, computer science, and physics). These links had mainly informal and spontaneous character and was not a result of a deliberate policy by University or local government authorities. It is easy to imagine that postgraduates and science graduates leaving their former departments to set up their own companies, or work for local companies, maintained relations with the university.

An important element for the history of the Cambridge phenomenon that is often named in the literature is conducting the strict planning policies by the local authorities in the 1960s that should limit industrial development in the area around the city. The most famous conflict that resulted from these policies was the refusal of IBM to establish its European research and development laboratories in Cambridge. However, other companies were established in the area in this period such as Cambridge Consultants (1960), several research institutes, and a new national CAD-centre (Computer Aided Design Centre). At the same time when the local authorities were afraid of the industrial growth in the university city, the university authorities realised that it might be beneficial to the university if the city became an important regional development centre. This was accompanied by the move in the national policy towards supporting industry-university relationships. In consequence, Cambridge University established The Mott[1] Committee in 1967. The Mott report has been completed and published in 1969. It criticised the planning restrictions as a source of problems for the university and the region's development. It called upon more interaction between university and industry: "In looking ahead the Mott report concluded that it would be strongly in the combined and separate interests of the county, city and University to encourage a limited growth of existing and new science-based industry and other applied research units in and near Cambridge" (SQW, 1985). One of the main recommendations of the committee was creation of a 'science park' in the Cambridge area. As the Mott report got a positive response from the local authorities, the local planning policies have been revised and emphasis has been put on the development of the science-based industry.
The Mott report was very exceptional in Britain for its time but also now because in this case the university had taken so clearly lead in the regional planning. As far as the authorities are concerned, the report had an impact on the reshuffling of the relations between the city and county councils and raised the awareness of the local policies' role for economic development.

Cambridge Science Park was established in 1975 by Trinity College, one of the most important and richest colleges. This was a direct entrepreneurial activity by the Cambridge University that became a symbol of the Phenomenon. No public funding was involved in the development of the park. The company that has been mentioned before – Cambridge Consultants – was one of the first that moved into the park (they are still located there). After a slow beginning, the Cambridge Science

[1] Sir Nevil Mott was heading the prestigious Cavendish Laboratory (physics department) at that time.

Park expanded rapidly in the 1980s, e.g. it was hosting 65 companies with total employment of 2170 in 1987 (Keeble, 1989).
Other actions that have contributed to the development of the area:

- St. Johns College's innovation centre established in 1987 – another example of a direct entrepreneurial activity by a Cambridge college.
- Barclays Bank's activities supporting number of high-tech ventures (e.g. Acorn Computers) focusing on the university spinouts. Their support involved providing loans, business advisory services, etc.
- Formation of a club for business managers, where business knowledge could be gathered for listening to the professionals, and networking activities among firms have been initiated such as a common purchase of expensive facilities (e.g. photocopiers that were very expensive in the 1970s).
- Media campaign started in the local press raising the awareness of the regional business development.

The high-tech community in Cambridgeshire region was mainly characterised by (it is valid for the period analysed in this paper – the end of the 1980s):

- Sectoral variation of Cambridge high-technology companies that was important for the further development of the cluster. Thanks to this the cluster was less vulnerable to sectoral crisis. It also suggests that the Cambridge University was leading in many technological areas and thus the regional environment was attractive to a wide range of research focused technological activities, not just to a few specific sectors (Insert the Table with sectoral specialisation).
- R&D orientation - high share of businesses within research and development. In the survey conducted in 1985, the highest number of companies (42%) indicated R&D activities as the company's main area of operation, with manufacturing the second (37%), and consultancy the third (17%: Keeble, 1986).
- Geographical concentration of high-tech businesses in two neighbouring districts – South Cambridgeshire (including Cambridge Science Park) and Cambridge City (75 per cent of total employment).
- High growth rates (as indicated before) and a large number of very small firms. 60 per cent of all firms employ less than ten people (41 per cent of the firms employ between 1 and 5 people, and 19 per cent between 6 and 10), only 2.5 per cent employ more than 200 people.

The entrepreneurs and the firms

Entrepreneurial activity has been one of the main forces of economic growth and dynamism in Cambridge (Segal Quince Wicksteed 2000). The cluster emerged in the process of creation and growth of new independent firms by individual entrepreneurs. The successful entrepreneurs encouraged others and affected the emergence of entrepreneurial culture in the region. Cambridge Phenomenon is characterised by the high rate of start-ups and spin-offs – 70 per cent of new firms are spin-offs from the companies, while 25 per cent of the chief founders were employed either by a university or a research institution prior to start-up (Keeble et al, 1999).
The small size of the city (approx. 200,000 inhabitants) was also encouraging for the development of collaboration culture – the links are closer, people know each other better than in large cities. Furthermore, exchange of entrepreneurial model is easier than in the bigger centres.

As it has been mentioned before, the region is characterised by a large number of small firms. Taking the long history of the cluster, one can ask, why so many companies did not manage to

grow. Some authors as an explanation give the fact that the majority of entrepreneurs were inexperienced and lacked managerial and business skills.
Several initiatives have been taken to support the entrepreneurial culture of the area, like the Cambridge Europe and Technology Club, Cambridge High-Tech Association (CHASE) and Cambridge Network.

The role of large firms and large R&D consultancies

According to Segal Quince Wicksteed (2000), large firms played an important role in the early stage of the Cambridge Phenomenon, e.g. companies such as Cambridge Instruments, the Pye Group gave the first seeds to high-tech development. When the cluster emergence process started in the 1960s, large R&D consultancies such as Cambridge Consultants, PA Technology, Scientific Generics and the Technology Partnership, played a very significant role as sources of founders for local research-intensive spin-offs.
Especially the large R&D consultancies were employing university graduates, thus, overtaking the value system and the traditions from the university. These values have been further transferred to the entrepreneurial spin-offs, enhancing a regional culture for trust and collaborative research.
The importance of Cambridge Consultants on the international market (on average, over 60 per cent of their revenue is generated outside the UK) has enhanced Cambridge's international visibility.
Large firms have been a source of not only the founders of the new enterprises but they also provided the cluster with the trained and qualified staff, such as technical support staff, administrators, consultants and researchers.

The University of Cambridge

In 1985 there were 12,000 students and 3,000 of a teaching, research, and technical staff employed at the Cambridge University (SQW 1985). Presently, there are two universities in the Cambridge area: the Cambridge University and the Anglia Polytechnic University (APU). APU was founded in 1992 as a merger of two major colleges: The Cambridge College of Arts and the Essex Institute of Higher Education. There are approximately 23,000 students at APU and 16,500 full-time students at Cambridge University. Cambridge University has a staff of around 7,000. This development shows a growing capacity of the Cambridge Region.
About 17 per cent of the students at Cambridge University are from overseas (success rate of admission – 30 per cent).
Very characteristic for Cambridge University is trying to keep the art/science ratio 50/50.
Another interesting thing is the organisational structure based on two levels: On one level the University is divided into 31 colleges[2] that consist of people from different disciplines. On the second level the University consists of 62 different faculties and departments (29 are science based and 33 are arts based). Thus, people from different departments are members of the same college that makes easier exchanging ideas, improves networking and enhances interdisciplinarity of the University. Many companies have been founded on the basis of this interdisciplinary communication.
Cambridge University through the decades has been characterised by an open and supportive (non-bureaucratic) approach to the exploitation of research. It supports and encourages collaborative research programmes with industry and enables easy access to its expertise for the companies. The

[2] The colleges are privately funded autonomous institutions , which provide accommodation and teaching to groups of about 300 students from all faculties.

regulations concerning collaborative research are transparent ensuring that every company has a fair access and rights to results from research they sponsor, proportionally to its financial contribution.
As it may be expected for the region with the best university in Britain, the Cambridge region has the highest rate of R&D spending in the UK. In 1999, with 0.56 per cent of the UK's population, the region had 5 per cent of the national industrial research budget (Garnsey and Cannon Brookes, 1993). This illustrates the strength and size of the university-industry relations. A significant share of the firms in area have undertaken some form of innovative activity over the last few years, and a significant share of firms have research links with Cambridge region universities and regional government research bodies (Keeble and Moore,1997).
As the entrepreneurial traditions among students are concerned, a study by Segal Quince Wicksteed (2000) showed that mostly the students from both Cambridge Universities perceived their chances of starting their own businesses directly after graduation as very law[3]. Besides, the APU's students were more entrepreneurial inclined than Cambridge University's students. It can be connected with the high percentage of the international students at the latter one that implies that the university's sample does not represent region's entrepreneurial spirit. Segal Quince Wicksteed (2000) argue that the large size of the Cambridge University makes it still an important engine of entrepreneurial spin-offs, even if this engine appears to be running at low intensity.

There are following organisations that should support the university-industry links:
- The University's Industrial Liaison and Technology Office (ILTO), which mission is to promote and strengthen links between the University and companies. The main tasks of ILTO are: receiving and answering external enquiries, providing advice on research contracts, consultancy agreements and other forms of collaborative activities; operating CUTS – the University's technology exploitation company.
- Cambridge Research and Innovation LTD and Quantum Fund with university's involvement – small local investment funds for university scientists willing to commercialise their research.
- The Cambridge Foundation established in 1989 with an aim of raising 250 million pounds over 10 years to research and development.

The Cambridge University's impact on the development of high-technology firms cluster in the region can be summed up as follows:
- The positive attitude of Cambridge University towards industrial development symbolised by the Mott report. Another examples of the University's direct involvement in the regional development is establishment of the Cambridge Science Park and the St. John's Innovation Park.
- As the SQP report (1985) emphasised, the University has deliberately encouraged high-technology spin-offs and links with local industry as a matter of a broad policy since 1969 (Keeble, 1989) – the activities of its Wolfson Cambridge Industrial Unit (presently Industrial Liaison and Technology Office (ILTO).
- According to the first report on the Cambridge Phenomenon (Segal Quince Wicksteed, 1985) "the University either directly or indirectly gave birth to nearly all the high-tech firms in the area at that time" in the form of the university spinouts or spin-offs from companies that were formerly University spin-offs.
- The reputation of the University and the world-class research.
- The high quality labour market – possibilities of the interaction with scientific staff (with a majority of informal links) and access to graduates from the University.

[3] The results are based on a survey among 168 Cambridge University students and 148 Anglia Polytechnic University students.

- The generally positive and liberal attitude of Cambridge University authorities, towards intellectual property rights and the commercial development by academics of their own innovative research.
- The literature specifies an additional factor connected with the university policy – the high average age of first appointment in permanent positions at Cambridge University. This could cause that University staff on temporary contracts was more motivated to look for extra possibilities and supported entrepreneurial spirit (Keeble, 1989).

Policy role

Public policy was not a major driving force in the development of high-technology cluster in Cambridge. However, many authors call policy an important "background factor", especially during particular stages of development (Spilling and Steinsli, 2003).

Financing of the University or rather problems with research financing is often named as the most important factor. During the 1980s and 1990s UK science and technology policies were weak, and government expenditure on R&D and on university research was significantly reduced (Keeble, 2001). This has forced universities to look for other sources of financing and to increase their links to industry. Thus, the Cambridge University was also very active in seeking research funding, providing consultancy and promoting university-owned technology spin-offs and science parks.

The only clearly positive impact of national policy which has been identified in the Cambridge case (Keeble, 1989) is the positive effect of establishing nationally funded research centres in Cambridge in order to be closer to the University. The main impact measured by the number of spin-off companies, had CAD centre. Another example is the Medical Research Council's Molecular Biology Research Centre that was a catalyst for the development of biotechnology companies.

Regional policy contribution to the Cambridge cluster development consists of restrictive planning policies that preserved the city's historic architecture that made Cambridge an attractive living and working place. The residential attractiveness of the City was often indicated in the surveys of firm founders in Cambridgeshire as a significant location factor, the next after the availability of high-skilled labour (CCC survey, 1986). On the other hand, extraordinary, historic urban environment, dominated by the University and colleges' buildings helped to attract highly educated people to move to the region.
Furthermore, Segal Quince Wicksteed (1985) emphasise the impact of the restrictive planning regime which has prevented any large-scale development that may have changed the area's labour market and industrial picture not leaving space for small firms (no possibilities to high-tech industries to grow if there were big industrial factories).

Another important factor that is named as decisive for the development of the Cambridge Phenomenon is the supportive influence of local institutions other then the University and colleges. These institutions emerged together with the cluster development. An important example of such an institution is Barclays Bank (provided early capital for high-tech firms), together with a growing number of business support services and some initiatives of local government. Surprisingly, Keeble (1989) claims that the advisory institutions run by the local and central government did not have much influence on the cluster development in the 1980s.

Presently, there are more supportive government policies towards university-business technology transfer and links than in the past, although these policy initiatives are too recent to assess their effectiveness (Keeble, 2001) or impact on development.

The Case of Biomedico in North Jutland

In this section the case of an emerging Biomedico cluster in the North Jutland region in Denmark will be presented.
One of the biggest problems of this cluster is whether one can say that there is already a medical technology cluster in the region. A closer analysis suggests it is rather a dynamic cluster initiative that has intensified during last two years. This initiative has a starting point at the university research in medical technology that can be described as at the high international level. Thus, the biggest challenge of this cluster is how to transfer technological and scientific competences that are present at the university to industry in the region.

As the main research question of this paper is what role the university can play in the process of cluster emergence, the empirical investigation has concentrated on the university. We start with a short introduction of cluster initiative including description of the structural setting (Aalborg University (AAU), Aalborg Hospital and Industry in the region), followed by a presentation of actual policies towards promoting of Biomedico cluster. Afterwards, an empirical study based on the interviews with university researchers is presented. Although, the university is the main focus of this paper, it is necessary to learn more about this initiative in order to understand the interview questions. Knowledge of actual policies makes it easier and more realistic to present policy recommendations for this cluster initiative in the next section.

Cluster competences

During the last three years some projects were initiated to promote regional development in biomedical technology in North Jutland. At the regional level, actors interested in local economic development are looking for new industry that can supplement the existing Mobile Telecommunications (Information and Communications Technology, or ICT) cluster.
The ICT cluster shows the presence of a local entrepreneurial spirit and social network traditions in the region that is very unusual for periphery regions. It can also be a source of competencies that may be applied within the Biomedical Technology area, for example telemedicine, biosensors and nanotechnology.
In fact, it has been explicitly expressed (for instance, during interviews with actors involved in the cluster initiative) that the ambition is to replicate the successful development of the ICT cluster. Policy had an important role in the development of that cluster and policy-makers in the region are aware that active policy may likewise be decisive for the Biomedico cluster.
The actors behind the cluster initiative have identified competencies in the region that can be decisive for the emergence of this cluster.

- Aalborg University (AAU)

In recent years, the AAU has established a substantial activity within Health Science and Technology, Medico-technology, Biotechnology and related areas overall termed Life Sciences[4]. Particularly research within the medico-technical area at the Centre for Sensory Motor Interaction (SMI) has developed new methods for stimulating and treating electrical signals from muscles. Furthermore, new advanced methods are being developed for measuring and activating the motor

4 www.biomedcom.dk

system and for locating pain. Moreover, the university has developed a centre for research into stem cell technology to determine how stem cells may be used to develop human 'spare parts'. Another potential research field at AAU is biotechnology, and the cluster initiative actors also show possibilities in nanotechnology.

- Aalborg Hospital, Århus University Hospital

Denmark has a public health system and hospitals are under county authorities (in this case North Jutland County jurisdiction). Aalborg Hospital obtained university hospital status in 2003 on the basis of its own research and its tradition of co-operation with Aalborg University and Århus University[5]. This co-operation is formalised in the HEALTHnTECH Research Centre, established in 2003 that should offer support and evaluation of product ideas and applications developed by the industry.

- Companies in the region/Industry

As already mentioned, the main high-tech companies in the region are found within electronics and telecommunications. This sector is represented by big international companies[6], but also many smaller companies that play even more important roles for ICT cluster. However, in the Biomedico technology the region is not characterised as competitive from the industrial point of view. The cluster initiative identified in *The Competences Catalogue* about 35 companies whose profiles can be described as biomedical technology to a certain degree (their profiles range from medical devices production companies to IT companies). These companies are mostly very small development companies employing one to two people. Some of them are spin-offs from university research and should therefore rather be called development projects. Among these firms there are only five companies that can be classified as biomedical production/manufacturing companies and that employ more than 10 people.
Within the biomedical area, the region is characterised by a lack of big companies and a very small number of small companies whose specialisation profile is much differentiated.

Cluster initiative – Actual policies in North Jutland towards promoting of Biomedico cluster

The initiative was started in 2000 by the Aalborg Commercial Council[7] together with the Industrial Liaisons Office at Aalborg University, after which other actors – policy-makers such as North Jutland County and Aalborg Community, and finally industry representatives – joined. This initiative was formalised in 2003 when BioMed Community: Science & Innovation for the Living, a co-operation with the objective to develop and promote North Denmark's cluster within Life Sciences, was established. The competence group represents the main actors in the region interested in this cluster initiative – Aalborg University, Aalborg Hospital, Biomedical companies, North Denmark County, Aalborg Commercial Council and the Region Aalborg Co-operation – and so involves agents from universities, government, industry and venture capital/supporting services.

Publishing promotional material, marketing, attracting new firms to the region and the promotion of new and established companies have been the main activities of BioMed Community during the first two years. However, the cluster initiative has taken a more dynamic path recently:

[5] The co-operation with hospital gave Aalborg University the access to perform clinical tests and provide documentation, thus it plays also a very important role for the university's research.
[6] International companies like Siemens, Motorola, L.M. Ericsson, Texas Instruments and Flextronics have their subsidiaries in North Jutland as a part of ICT cluster.
[7] Aalborg Commercial Council provides the service to the more than 5,000 companies, including counselling of business establishment, financing, export, import, staff and management development, marketing, subsidies, and so on (Competence Catalogue).

In February 2003, the so-called 'Firms club' was established for companies from the whole of North Denmark (so not limited to North Jutland County), whose co-operation should establish synergies between companies in the region, especially by learning of each other's existence, identifying and discussing common problems, and influencing their co-operation with the Liaisons Office and the Hospital, to be able to support innovative activities within the industry more efficiently.
Determined to develop industry in the cluster, the cluster initiative actors have mobilised considerable financial resources in an attempt to speed up the process of cluster formation.
The present nurse and radiography school is being transformed into the 'Research House', including laboratories, to localise 10 to 15 research groups from the Hospital. There will also be scope to establish a new company or a department that is closer to the hospital (for example, for clinical testing), as well as an area dedicated to group rooms for students. The idea is to gather the innovation environment in one place.
The BioMed Community also employed three new people to work with the initiative – a start-ups consultant, an ambassador and a communication consultant.
Transferring competencies from the University and Hospital to industry and reaching a critical mass of companies is the cluster's main challenge.

The empirical study

As it has been presented, this cluster initiative could be described as a policy-driven, one of many biotechnology cluster attempts we can observe in the last decades. However, what may distinguish Biomedico cluster initiative in North Jutland from many similar policy initiatives, are the competences at Aalborg University's Health Technology department. These competences have focused the attention of the business leaders on the medical technology area and inspired to start this cluster initiative. Because of the central role of the university in this cluster, the interviews with the persons representing the university seem to be a good starting point to analyse this cluster.
This part is based on the semi-structured interviews with university representatives. The questions were inspired by the theory and experiences from the Cambridge Phenomenon. This means that some theoretical assumptions concerning processes that can affect cluster emergence have been present. Another important fact for the interviews was that the author already had some knowledge of the cluster initiative, i.e. about the policies conducted by the clusterpreneurs.
The aims of the empirical study at the university:

- To identify dynamics of the relationships between university and the industry (questions concerning industrial cooperation, industrial financing, regional, national, and international cooperators, possibilities of production in the region);
- To find out which technology transfer processes are already present in the region (the spinouts, patents, what happens with the graduates, and again the cooperation with industrial partners);
- To identify the stage of the Biomedico cluster evolution in the conclusion;
- The findings should make it easier to compare this cluster initiative with the Cambridge Phenomenon;
- This should lead to policy implications.

One of the questions concerned entrepreneurial spirit among the students and researchers at the university. The presence of the entrepreneurial tradition among the researchers may be important for this cluster because there is no industry in the region, where these students can be employed after they graduate. Hence, starting an own company may be the only possibility to stay in the region.

The interviews have been limited to the Institute for Health Technology that includes the research centre with the longest history (SMI – Centre for Sensory-Motor Interaction). If one should expect localised effects of the university research, it would be most probable to observe from the institute with the longest presence and biggest traditions.
As the cluster initiative includes also Biotechnology, which is a relatively young and new research area at Aalborg University, similar interviews may be conducted at this department in the future. For the similar reasons, the interviews did not include Stem Cell Research Group that started only in September 2000 and is presently expanding its capacity (in 2004 they had one professor and one PhD, in the period 3-5 publications per year).

The persons interviewed were: three professors (a head of SMI that is one of the key persons in the cluster initiative, a research professor/medical doctor that works simultaneously at Aalborg Hospital, and a guest professor, retired medical doctor), one associate professor (with a foreign background), one assistant professor and a research assistant (a person applying for a PhD). They represented SMI, Medical Informatics and Computer Vision and Media Technology. This selection was partly intended, as some of these persons cannot be omitted because of their role in the cluster initiative. Some of the persons, however, have been chosen by chance or their availability. In the interviews emphasis has been put on the SMI research group, as the most prestigious and recognised in Denmark and internationally, from the institute.[8]
The interviews were structured after key-questions, however, during the conversation there were many additional things discussed, according to a person's profile and his role at the university.

In the next part, the main questions together with the main findings are presented.

1) History of the research at the group together with their biography.
Looking at the history of the research at the Institute of Health Technology, the main finding from the interviews is that everything started with one professor employed in 1988, who came with a well-known name and with contacts and the network. This professor was a supervisor to the present leaders of SMI and she attracted one of them with a university position to come back to Aalborg after doing PhD in Canada and USA. One of the motives to come back was that AAU was very dynamic.
Another of the key researchers – cardiologist joined the group through the previous acquaintance with the first researcher. The first doctor from Aalborg Hospital – neurologist – started cooperation with the group in 1991. The English researcher interviewed came to AAU for a postdoc position. It was already a famous group in the artificial intelligence community and he thought that Aalborg was a good place to continue his academic career (1997).
The Institute has been building his reputation since 1988, on the basis of the key researchers: approximately 4 persons. SMI started as the first group in its area in Denmark and in many European countries (from 8 people to around 70 at the moment). In 1997 the group started International Research School– education of international PhD students (45 PhDs).

2) The university financing, proportion of the external financing, including private financing, the dynamics in financing, future perspectives.
In general one can say that the university research is in a major part funded externally (up to 70%) in form of the projects financed from the Danish Research Councils, European Union's framework

[8] As it has been expressed by one of the interviewees: "Everybody in Denmark knows that research in health technology takes place at Aalborg University".

programmes, private funds, and finally, industry partners (for SMI yearly industrial contribution can be estimated at 1-2 mln Dkr, mainly for PhD scholarships).
In 1993 SMI was awarded yearly financing at 10 mln Dkr from the Danish Basic Research Fund that expires in 2006. This money is considered as a decisive factor for SMI, its development and getting other financing. The head of SMI says that this money was critical for their research; also in this sense that now it is easier to find another financing when they are an established centre and have a doctoral school.
The university financing has been mostly based on the big grants that are periodically limited, that makes it difficult to talk about some trends. However, looking at the number of industrial collaborations may be helpful to identify some tendency (here insert the Table on SMI financing).
The heads of the institute and SMI are already involved in securing financing in the period 2006-2010 after the Basic Research Fund expires. There may be a positive aspect of the fact that the Basis Research Fund is running out/expiring – SMI is more forced to commercialise its research (as it has been expressed by the Centre's leader talking about future plans – "they want more cooperation with health sector and with industry").
The interviews with the potential PhD student exposed especially the problem of employment of talented people/keeping them at the university (this was also expressed by the interview with the guest professor/retired doctor and a person from Computer Vision group). The process of finding financing for his PhD has taken one and a half year and he is close to giving up and moving to the industry. Getting a permanent position at the university is another problem faced by the researchers that can lead to missing some valuable people and the competences they have.

3) The university attitude towards health technology and towards commercialisation of research (whether it has been supportive).
According to the discussants the university has been very supportive towards their research, although telecommunication has been the key research area and one could discuss if the support may have been bigger.
The Aalborg University's tradition of project-based education has been a very important factor for the health technology research, as the researchers identify students' projects as important part of industrial collaborations. Many of the inventions, of which some have been patented, have a starting point in the students' projects (as a case of a potential PhD student interviewed).
The university's application to the Ministry to start the medical doctor studies at AAU proves that they want to build and have more basic competences in the medical area.
Another issue is the university's direct involvement in the commercialisation of the research results that has started with an introduction of the new university law in 1999. The university patent office should assist researchers in patenting process and in starting collaboration projects with industrial partners.
The persons that were assisted by the Patent Office have experienced their help as of the great value, as the university secures the financial part of the very costly patenting process. One cannot undermine the role of advisory support.
As far as the impact of the new university law concerning IPR on the number of new spin-offs is concerned, the interviews show the mixed feelings. Some of the companies that have been presented here have been established to patent their inventions.
The conclusion is that the university has a very open attitude to the external cooperation's and financing. One of the interviewees heard from the companies that it is easier to approach AAU than universities in Århus or even Copenhagen.

4) The university spin-offs – how many they know, whether they have been involved in them.
There has been one university spin-off (Judex) started 20 years ago by one of the leading researchers and then the next spin-off from the university research related to health technology was in the mid-1990s.
Following spin-offs from SMI have been identified (the interviewees are one of the owners): Neurodan, Neurocon (bought by Neurodan), and Neurotrain (until today has profits from a license sold to a German company), JNI Biomedical, Index. Neurodan is the most described and according to some of the interviewees the most successful of this cluster's start-ups.
The persons interviewed were also involved in following spin-offs: Cardiotech, OBI, and AALQTEC (these small start-ups hold rights to their patents – the reason to be established). Start-ups from other research groups at the university: Alpha, Anybody.
Most of these start-ups stem from SMI. The SMI director expressed his doubts whether the potential of one research centre may be finished/expired for now, taken relatively high number of spin-offs.
In the discussion with people involved in some of the start-ups, the business experience has been pointed as very important for a successful entrepreneurship.

5) Cooperation partners (other universities, private companies, hospitals – public sector; what kind of cooperation: joint projects, joint articles).
The research groups at health technology have many different kinds of cooperation types ranging from academic cooperation with other research institutions (universities involved in the European projects), more clinical contacts with institutions in the public sector (hospitals), and industry collaborations. This includes both national and international partners, the latter enhancing international visibility and prestige of their research. As for the industry partners there are names of the world's most important industry players: Siemens/Maquet, GE Healthcare, Novo Nordisk, Radiometer, etc. as well as few small local companies: Judex, RTX Healthcare, Neurodan.
The interviews show that the cooperation is very often based on individual researchers' contacts to the companies, other universities, hospitals, etc., thus it suggests that informal contacts play very important role for cooperation patterns at the university.
For the SMI industrial cooperation it is not easy to find Danish collaboration partners that are interested in their technology, as it is a relatively new area. Hence, they have some international collaborators that are not involved in financing. The Danish companies they work with are mostly small companies that finance PhDs in spite of the problems with financial commitments for 3 years. Another types of cooperation are lending instruments/facilities and finally, consulting activities of individual researchers.
An interesting thing is that increasing number of Danish companies expresses their interest for the SMI research that may be a sign that these companies are looking for new markets. This also concerns the telecommunication companies in North Jutland.
The interviews did not find any examples of writing publications together with people from companies apart from people from the university spin-offs (Neurodan example).

6) Patents, possible products from their research, production possibilities in North Jutland (their interest in commercialisation of research).
Common impression is that patenting is a normal activity/practice among the researchers. Some of them are very interested in commercialisation of their results, and some think more in terms of basic research. They also think in terms of the products as results of their research.
The interviews found two examples of contacting a big international company GE Healthcare to sell them a patent owned by AAU. Both patents were the results of students' projects. The first projects

resulted in a company (Alcotech) and negotiations with Americans have turned out successful, so far. The other attempt finished with fiasco and at the moment the university tries to establish a joint venture company with NOVI that should enable financing PhD for a student that invented the patent (the research assistant who has been interviewed). The both cases illustrate a long process of commercialising university results and how many risks are involved.
An important factor for a long-term development of the innovative part of their research, thus commercialisation, is a clinical support in form of a closer cooperation with hospitals and doctors. According to the university professor they need clinical people that are more enthusiastic about technological possibilities. The interviews reveal that a medical personnel at Aalborg Hospital is not so much interested in research and cooperation with the university. However, it may be caused by the time restraints and it can change with more financial resources devoted to research. Most of the interviewed people (in line with the university's authorities) believe that this situation could change with establishment of medical studies at AAU.
The interviewees agree on the very small number of health technology companies in the region. However, it does not exclude the possibility that the products – possible results of their research – may be produced in the cluster using local suppliers.

7) Human capital: students/graduates and PhD students (number of students/graduates, employment possibilities in North Jutland).
The education of the engineers in health technology (as the separate education) started in 2000 – the first graduates will graduate in the summer 2005. Before there were old specialisations at the engineering educations – engineer/civil engineer/medical engineering, biomedical informatics, specialisations in electrical engineering with 20-25, sometimes under 10 graduates. In last two years they had 40-50 students that started a 5-year education in Medical Technology.
The majority part of PhDs comes from the International Research School at SMI that also implies their foreign origin. On the question about the job perspectives for the graduates the head of SMI answered that the engineers can be easily absorbed by the health sector in Denmark. It is more difficult with PhDs as employment of academic types is still very limited. However, some of their PhD graduates got employed in the industry abroad (Germany, Norway). They are not able to keep all the graduates, so they very often move to other research institutions (in the case of the foreigners – the institutions they were coming from).
Another important aspect of the supply of human capital from health technology that has been discussed during the interviews is the possibility of finding a job in the region of North Jutland. The picture is quite clear that it is almost impossible to find employment in medical industry in the region, as there are very few and very small companies. Most of the colleagues of the interviewed student moved to other regions in Denmark (Århus, Copenhagen). The persons who stayed in North Jutland were employed in the telecommunication companies.

8) Entrepreneurial culture/spirit among researchers and students.
There is an entrepreneurial spirit among researchers as the examples of persons interviewed show (they are altogether behind approximately 8 start-ups). Similarly, the potential PhD student interviewed agreed that he could imagine starting a company himself but he would need more business support. He did not know any graduate who was involved in a start-up.
Asked about the entrepreneurial spirit among the students, the professors are truly convinced that the students (especially the youngest generation) are very much interested in technology applications. A semester spent at the hospital which is the obligatory part of the new education in medical technology has already resulted in many exciting projects. The students are closer to the

patients and the problems at the hospital, thus it is easier to think about technology solutions and this can lead to start-ups.
The professor said that entrepreneurial spirit is present at the students' group, in spite that the students are not educated in entrepreneurship.

9) Their knowledge and interest of the Biomedico cluster initiative.
The answer to this question was very much connected to the person's involvement in the cluster initiative (two of them may be treated as initiators of Biomedico). The rest of people (they were also asked about the other researchers' attitude) heard about the initiative from media and have a rather neutral attitude to the cluster (some admit to have an 'observer' status, some have very limited knowledge of it).

10) The role of the cluster initiative/policy measures for their research and technology transfer processes.
The persons could not explicitly say whether the cluster initiative may have played any role for their research. A closer analysis of the interviews shows two possible impacts of the policy measures:
- Involvement in university research (still very limited): BioMedCom is taking part in financing of SMI research in the period 2006-2010; The student won the BioMedCom's competition for the best project (20,000 Dkr).
- The student's decision to choose health technology specialisation was affected by the publicity around the Biomedico cluster (expecting better job possibilities).

11) Public knowledge of their research and public attitude to the cluster initiative.
They experienced a growing attention of the media (especially the local newspapers) on health technology research at AAU.[9]
They feel that average people support the initiative hoping for the positive impact of the new cluster on the regional developemnt. This can be the best seen in the public support to the initiative of starting medical studies at AAU.

12) Cooperation with Aalborg Hospital
An important characteristic of this cooperation is that Aalborg University together with some individuals has been a driving force of this cooperation. The opinion that the cooperation would not exist without university's initiative has been expressed during an interview.
All the researchers interviewed highlighted the role of the hospital cooperation for their research: they need clinical experiments (patients' recruitment); students are partly educated in the hospital; they use facilities at the hospital. Their PhD students work together with some doctors and finally, some people from the hospital are employed at the university.
However, the cooperation with Aalborg hospital is shadowed by the problem of lacking research culture at Aalborg hospital (discussed earlier in question 6). The interviewees believe that the research tradition can be built gradually.

13) Possibilities of attracting a bigger industrial player to the region.
A general impression is that people are very sceptical about the possibility of attracting a big health technology company to the region. The persons more attached to the cluster initiative are more positive about catching the attention of the R&D part of the big industry (however, in a long-term perspective) but they also exclude the possibility of moving production facilities to the region. The

[9] A closer analysis of the local newspapers shows that this part of university research was maybe not so often but on the regular basis presented there starting in 1997.

persons impartial to the cluster initiative were very negative about any possibility of repeating the ICT cluster story.

14) The initiative of establishing the Research House (whether it can be perceived as a science park).
The answer given to the question about establishing a Research House next to the Aalborg Hospital suggest that (with the exception of one person) the university is not involved in this initiative (people interviewed had no or very limited knowledge of it). The clinic/doctor who is partly employed as professor at SMI was the author of this project and according to him it should be a place where education, research and innovation can meet. It looks that the County and possibly the hospital is responsible for this project.

Discussion of both cases and conclusion

The main research question of this paper was: what is the university role in the cluster emergence process. As the literature does not give a clear answer how universities influence the development of regional industrial clusters, case analysis has been applied looking at the well-described Cambridge Phenomenon.
In this section findings from the Cambridge case study are used to generalise a kind of theory (that may also be supported by the literature on the different aspects) on the process of cluster emerging from the university research. From the methodological point of view, it is *analytical generalization*, where the investigator is striving to generalize a particular set of results to some broader theory (Yin, 2003).
On the basis of the analysis of the Cambridge Phenomenon we distinguish two types of the processes when university can influence cluster emergence in the region.
The first set concerns technology transfer that is considered as the main way of transferring the university competences to a regional cluster. The second set is related to a more direct and active role that university can play in the cluster emergence. As one can observe in the Cambridge cluster some of the processes are interconnected – technology transfer mechanisms can result from the university's direct role.
The both types are presented in the following.

THE CAMBRIDGE CASE

Technology transfer processes

1. The scientific position of the university research, i.e. how strong technologically the university is.

This feature was especially apparent in the case of the Cambridge university with a centuries long traditions and a series of prominent researchers. In this respect, the Cambridge case can be extreme but we still argue that university's research competences are crucial for cluster development.

2. Research cooperation that has two aspects:

- Informal cooperation that is said to be a dominant type in Cambridge;
- Formal cooperation that was not much spread in Cambridge during the period considered in this paper. On the other hand, the case analysis emphasised the role of transparent regulations and non-bureaucratic procedures for a good collaboration with industry that involves also the regulations concerning Intellectual Property Rights (IPR).

3. Research spin-offs.

The Cambridge case shows entrepreneurial spin-offs from the university research as a crucial mechanism for a cluster emergence.
Another interesting feature concerning university spin-offs that can be observed from this case is a very dynamic process in which the number of direct spin-offs is changing with the0 cluster development. This means that at the beginning the university is a main source of spin-offs in the region but in time it is more the second-generation spin-offs (spin-offs from existing companies) that shape local companies development.

4. Entrepreneurial culture.
Most of the literature on the Cambridge Phenomenon emphasise that the Cambridge cluster development was based on entrepreneurial activity by individual entrepreneurs originating from the entrepreneurial culture at the university.

5. University graduates.
- The access to highly qualified graduates from the Cambridge University was given as one of the most decisive localisation factors by the companies that migrated to the region.
- The university graduates can also establish new companies, although the Cambridge history does not show many examples of the entrepreneurial activity by the students.
- There is also a third aspect of the processes connected to the university graduates – the presence of industry in the region where the graduates can be employed. In the Cambridge early history the old companies such as Cambridge Instruments, the Pye Group played the role of the first employers for many future founders of high-tech companies.

6. Financing of research.
The Cambridge case shows a twofold meaning of the processes connected to the university financing. On the one hand, continuous accessibility to research financing secures high-quality research. But on the other hand – that is clearly illustrated by the Cambridge case – problems with public financing can enhance the interaction with industry. This happens when researchers are forced to look for other sources of financing (assuming that the university is ambitious enough to expand its research capabilities).

7. Science parks.
The university-based science parks strengthen the interaction between university and industry. In the Cambridge case they were an important element of the cluster growth (the Cambridge Science Park became a kind of a symbol of this cluster).

University's direct role

1. University directly involved in the cluster development.
The Cambridge case shows that the university can play an important role in the local economic/industrial development by interacting with local authorities (e.g. Mott's report impact on regional policies).

2. The university promoting technology transfer.
Patent offices and university industrial liaison offices are means of direct promoting and strengthening links between the University and companies.

3. University's entrepreneurial activities.

The university can be directly involved in commercial actions, e.g. science parks, university companies, but as the Cambridge example shows it can also support development of entrepreneurial culture to the region.

4. Special features of university.
In the case of the Cambridge Phenomenon there were some specific characteristics of the Cambridge University that are recognised as important to the development of this cluster:
- The most important is the University's open and supportive approach to the commercial exploitation of research by the university staff.
- Another feature of the Cambridge University is a relatively high share of the staff on the temporary contracts.
- The next one is the Cambridge University's organisational structure that supported informal contacts and interdiciplinarity, which further resulted in the spin-offs.

In the next part, on the basis of the empirical investigation from the section before, technology transfer processes and the direct university role in the Biomedico cluster are discussed according to the previous schema.

THE BIOMEDICO CASE

Technology transfer processes

1. The scientific position of the university research.
There are strong technology competences at the Institute for Health Technology with internationally recognised research.

2. Research cooperation.
Informal individual cooperation has played an important role for competence building at the university but is also very important for industry contacts.
Formal contacts are mostly within specific projects (e.g. EU projects, sponsoring of the PhDs).
AAU is possibly easier to approach for the companies than other Danish universities.
There are some problems with cooperation with regional hospital in spite of the researchers' belief in the importance of these contacts.
There are not many regional industrial collaborators because of a very small number of the medical industry in the region.

3. Research spin-offs.
There are several examples of the university spin-offs. However, it is difficult to assess, whether they have had any influence on the region's industry, as they are very young and small. Only one spin-off can be described as an established company in the region.

4. Entrepreneurial culture.
The university spin-offs confirm the existence of the entrepreneurial culture among researchers that has roots in their interest for commercialisation of the results.

5. University graduates.
Until now there was a limited number of graduates from the Institute but the situation will improve with the graduates from the new education coming out next summer.

Because of the lack of the medical technology companies in the region, there has been a 'brain drain' of the graduates (including PhDs) to the other regions in Denmark and Europe. This is also a concern for the coming generation.
Very few examples of graduates' entrepreneurial activities have been found. There might be potential spin-offs from the future graduates.

6. Financing of research.
The secure financing was decisive for competence building. There is a high degree of external financing but industry financing takes a small part of it.
However, there is a trend of increasing cooperation with industry partners and appearing problems with financing can strengthen this tendency.
On the other hand, there is as danger of decreasing competences.

7. Science parks.
There is a university based science park – NOVI (mostly concentrated on the ICT sector) that already hosts one spin-off company and was involved in other start-ups.
The Research House that is an initiative of the cluster's organisation seems to have a very loose connection to the university.

University's direct role

1. University directly involved in the cluster development.
Aalborg University was one of the initiators behind the Biomedico cluster initiative seeing potential for the region's development (especially, some individuals are involved). However, the university's priority area is telecommunication sector.

2. The university promoting technology transfer.
The university has a Patent Office and the Industrial Liaison's Office that should promote technology transfer. The Patent Office was involved in selling patents to some industrial players.
The Industrial Liaison's Office represents the university in the cluster initiative forum.
It is difficult to evaluate their role, as they have existed not so long (5 years).

3. University's entrepreneurial activities.
The revealed university's entrepreneurial activities involve the above examples of selling patents to the big industrial players.

4. Special features of university.
Aalborg University has one feature that makes it attractive and important to the industrial players – project-based education system. Thanks to this system the university is problem-oriented and has a long tradition of cooperation with the regional industrial partners.

The above analysis shows that there are already some technology transfer processes at Aalborg University such as cooperation with the industry, industry financing, entrepreneurial activities among researchers, supply of graduates but a localised element of this transformation process is still missing and it is difficult to measure without investigating the local industry. Furthermore, the university's policy towards research commercialisation can also be described as supportive.
We have already described this cluster initiative as policy-driven. Therefore it is important to present some policy implications/considerations.

Policy implications

The first lesson that comes from the history of the Cambridge Phenomenon is that cluster emergence from the university competences is a very long process. This has a very important policy implication:
"(…) any regionally specific policy of promoting technology-transfer from universities and of supporting new high-technology firms, must be viewed as a long-term initiative which is unlikely to bear fruit for at least a decade, and probably as much as two or three decades" (Keeble, 1989, p. 170).
During the interviews this long commercialisation process of the university research has also been exposed. As the Biomedico in North Jutland is a cluster initiative started by the policymakers, it is important that the political support stays stable.

The Cambridge case shows the important role of the local institutions – business support services such as banks, consultancies, and venture capital funds – for the business development. If the region is not characterised by a well-developed private business support sector, there may be a potential area for regional policy. For the North Jutland region particularly the venture capital ability is very limited. The latest initiative of the central government – Entrepreneurial Fund – may possibly improve a situation of potential entrepreneurs. But more focus on the support to people interested in starting their own company is still needed, as the spin-offs seem to be the most probable way for this cluster's development. The problem of more support to the entrepreneurial culture also concerns the university education. Offering more courses in entrepreneurship may stimulate the students' interest for starting their own company.

Looking at the actual policies towards the Biomedico cluster promotion, one can observe some similarities with the Cambridge history, e.g. establishing firms' club, cooperation with the hospital and the Research House. However, the interviews revealed serious problems in some of these initiatives that give a place for the improvements from the policy side. The main deficiency of these cluster activities is a weak formal cooperation between the university and the hospital. As far as a strategy of attracting an external company to the region is concerned, the interviews show a rather sceptical attitude towards the possibility that a big industrial player in medical technology could move to the region because of the university competences (at least not in the nearest future). The Cambridge case demonstrates that the promotion of university-based science parks can play an important part in local high-technology growth but the science parks can also attract external companies. The Research House that has a potential to become a regional science park seems to be limited to the hospital. The local policymakers should try to improve the links between the university and the hospital.

The Cambridge case shows the importance of regional policies to enhance residential environments and quality of life. Such a policy in north Jutland could convince young people to stay in the region or attract the others to move here.

The Cambridge Phenomenon is known as the development with a limited policy support in the early stages. However, the latest decade was characterised by many policy actions that have not been discussed in this paper. This can be an area for further investigation and a good source of policy lessons to the Biomedico clusters.

Limitations and further research

A common complaint about case studies is that it is difficult to generalize from one case to another. This can be also a main criticism for this paper – how one can compare the world's biggest university with a small university in the periphery region that has only 30 years of history. Thus, this case study did not attempt to compare directly these two cases but only to identify the possible role of the university in the cluster emergence process from the Cambridge Phenomenon and then try to establish, whether an emerging Biomedico cluster in North Jutland may already be characterised by some technology transfer mechanisms.
In the Cambridge the environmental requirements related to the city's attraction were of the important factors. The environmental uniqueness of the Cambridge area limits the possibilities any direct comparisons and policy implications from the Cambridge experience. However, it depends on how much impact these environmental issues had on the Cambridge development and this impact is very difficult to measure.
Another problem with the comparative case study in this paper is the choice of the considered period for the Cambridge cluster. In this paper we have analysed the period until the end of the 1980s. There is possibility to look at the newer Cambridge history with the focus on biotechnology sector or what some call – biotechnology cluster in the region. It may be possible to find some parallels with the role of the broad high-tech cluster in Cambridge for the emergence of the biotechnology cluster and the role of the existing ICT cluster in North Jutland for the Biomedico cluster[10]. This can be a potential area for further research.

One of the aims of the empirical investigation at the university was to establish at which stage of the cluster emergence this cluster is presently. It is difficult to answer this question without closer analysis of the region's potential, the companies, and which dynamics are present in the region. As it has been stated in the report "Universities and the Development of Industry Clusters" (Paytas et al. 2004): "The university can produce the seeds of new firms and industries, but the region must offer a fertile climate for them to flourish". The analysis of the Biomedico cluster in this paper shows that the university has strong competencies in research, and that there are already some technology transfer processes but it is difficult to say, how much localised they are. Thus, it is necessary to look at the existing industry in the region, whether there is the potential for further emergence of a biomedical technology cluster.

This paper considers mainly the university factors. Future research will investigate industry factors that are vital to successful university-industry cluster development. Thus, the next step is conducting a survey among the companies, followed by detailed interviews in the selected firms.

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[10] Especially that it has been stated that the local ICT companies are interested in the medical technology area.

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