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Competitive paper

Commercialization of Medical Technology

How medtech start-up companies build up collaborative network relationships

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Abstract

This paper deals with new medtech companies commercializing research-based inventions. It focuses on how such firms, in the early phase of their life, build up collaborative relationships with users/customers, suppliers, academic researchers, and various types of innovation support organizations. Four in-depth case studies of Swedish medtech start-ups have been carried out. They confirm the importance of the early relationship-building activities.

In particular, the results show that it is essential for medtech start-ups to establish collaborative relationships with potential users/customers for carrying out clinical research. This requires strong efforts, for example, in order to find suitable partners and manage collaborations. Also at an early stage, in order to start up production there may be a need to establish technological collaboration with suppliers. A problem is that for a small start-up – with scarce resources, no track record, and an uncertain future – it can be difficult to make potential partners interested in collaboration. If the start-up company is a university spin-off, the relationship with the inventing research group is very important at the beginning. However, the importance of this relationship tends to diminish over time. Especially for new university spin-offs building relationships with public support organizations can be helpful in order to gain access to valuable resources, directly or indirectly.

The implications and lessons for management tend to be context-specific and difficult to generalize. As to public policy, it must be concluded that its role in this context is relatively limited. The effects of bridging organizations on relationship-building are mainly indirect.

Keywords: Relationship-building, Innovation, Commercialization, Growth, Medtech start-ups

INTRODUCTION

This paper is based on a study carried out for the EU project AEGIS on knowledge-intensive entrepreneurship.[1] It deals with the development and growth of new medical technology ("medtech") companies in Sweden and focuses primarily on the networking of these firms during the early phase of their life (i.e. the first 5-10 years). It is assumed, as will be explained below, that the outcome of such networking activities is an important success factor for such firms.[2]

Background

The idea behind this study came up as a result of a previous study carried out on behalf of Vinnova (the Swedish governmental agency for innovation systems). In that study (Laage-Hellman et al, 2009) the long-term effects of public investments in life science research were investigated. Medical technology was one of two sub-sectors chosen for the effect analysis, which focused on two areas: industry and academia respectively.[3] One conclusion was that the formation of new companies is a key mechanism for commercializing results from academic research. Although many established firms benefited from collaborating with medtech research environments, for example in terms of competence development and technology scanning, it was relatively rare that such firms picked up and commercialized specific research-based inventions. This despite the fact that much of the medtech research carried out at universities is application-oriented and aims at developing new methods or devices for medical diagnosis or treatment. Even if there is a potential need in the market, it is in many cases difficult for the academic researchers to make the established firms interested in taking over the responsibility for commercialization. Common reasons are that the idea does not fit in well with the company's current strategy or that the technology is perceived to be too unproven and too far from the market. Although there are exceptions, the large medtech companies tend to be niche-oriented and, given the fierce competition in the market, be focused on relatively short-term goals. Therefore, in many cases in order to have a certain research-based invention commercialized the only way is to start up a new company.

In Sweden, like in many other countries, academic entrepreneurship has during the last two decades become a popular phenomenon and it is actively supported in different ways by governments and public bodies.[4] This has enabled a large number of medtech university spin-off companies to be formed. In the cited Vinnova study we identified some 50 medtech companies spun off from fifteen key research environments over a 20-year period. A

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[1] AEGIS stands for Advancing Knowledge-based Entrepreneurship & Innovation for Economic Growth and Social Well-being in Europe and is a EU-funded project within the 7th Framework Program.

[2] The author is grateful to all persons and organizations which have contributed to this study. It includes interviewed company managers and researchers as well as the AEGIS project, Chalmers University of Technology, University of Gothenburg and the Institute for Management of Innovation and Technology (IMIT). The present study is one of several studies carried out by a Swedish-Danish team under AEGIS project contract No. 225134. The research has been managed and coordinated by the Institute of Innovation and Entrepreneurship at the University of Gothenburg's School of Business, Economics and Law. IMIT administered the contract for the team in order to promote collaboration across universities and to promote diffusion of activities to firms and public policy-makers.

[3] *Medical technology* can be broadly defined as "Products/solutions/systems used in hospitals, other care centers or for out patient/home care" (ActionMedtech, 2007, p. 65). This includes high-technology devices (equipment and supplies) as well as "lower"-technology products used to assist healthcare professionals in their care of patients. *Medical devices* and *biomedical engineering* are two other terms commonly used as synonymous with medical technology.

[4] The general importance of university spin-off companies as a mechanism for commercializing academic research is discussed, for example, by Shane (2004).

rudimentary analysis of these companies' performance showed that very few of them had achieved a significant growth. The majority had remained small and others had disappeared due to, for example, bankruptcy or acquisition. This picture confirmed what we know from other studies, namely that building up new and growing research-based firms from scratch, in this industry, is a difficult and challenging task. But at the same time we also know that long-term growth in this industry to a large extent comes from new innovation-based firms (ibid.).

The creation of new venture companies in the medtech business is thus an important phenomenon, especially if it is believed like in Sweden that the medical technology industry offers promising opportunities both for economic growth and for addressing healthcare needs.[5] The above mentioned Vinnova study dealt only with companies spun off from medtech research environments. However, we know that medtech companies may have other origins. First, other types of university spin-off (USO) are coming from clinical research (typically university hospitals) or from basic/pre-clinical medical research. Second, other companies are corporate spin-offs (CSOs) or are founded by what we may call "independent entrepreneurs" (i.e. persons who do not come directly from academic research or are involved in corporate spin-off activities). Even if they have not spun off from universities such companies may be rather R&D-intensive and dependent on science.

These types of firm are often called "start-ups". In line with this popular terminology the term medtech start-up company will be used in this paper. It should be admitted, however, that this is an ambiguous term. It is not clear when a company stops to be a start-up and becomes "a normal firm". However, in this study we are dealing with the early development of medtech companies, which makes it appropriate to use this term.

Purpose

The underlying question raised in the cited Vinnova study is why and how medtech start-up companies succeed to innovate and grow. There are of course many factors, internal as well as external, contributing to explain why firms succeed. All of them are not covered in this study. As already mentioned, it focuses on the companies' networking activities in the early phase of their development. In other words, the main purpose is to investigate how medtech start-ups build up collaborative network relationships with various types of counterparts.

There are good reasons why this would be an important topic worthwhile to focus on. There are previous studies, including some work carried out by the present author[6], that have shown that building up collaborative relationships with external actors is a key success factor for research-based medtech companies. We will come back to this in the following section which presents the theoretical framework.

THEORETICAL FRAMEWORK

A network approach

As will be described in more detail below, this study builds on the assumption that medtech companies, like firms in many other businesses, operate in networks where they have important exchange relationships with different counterparts in the environment. A start-up company may have some relationships when it is founded (e.g. through its founders), but to a large extent the network relationships needed for accomplishing a successful development and

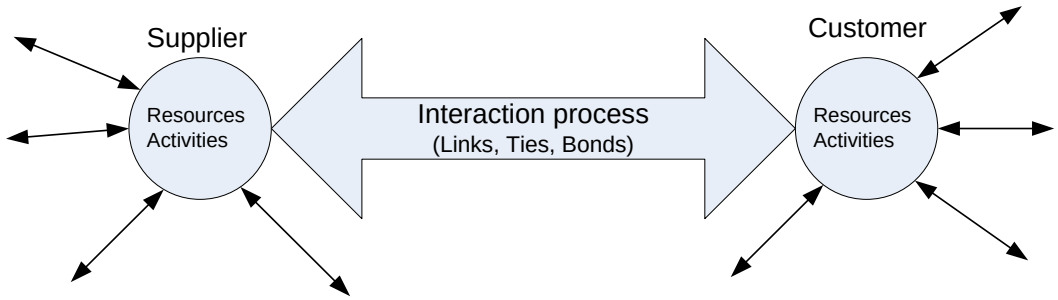
[5] See, e.g., Focus Medtech Agenda (2005), ActionMedtech (2007) and Arvidsson et al (2007).
[6] See, e.g., Shaw (1991), Biemans (1992), Laage-Hellman (1993 and 1998) and Laage-Hellman et al (2009).

to grow are missing. Therefore, an important part of the business development process is to establish relationships with external actors and build positions in relevant networks. So, which are the counterparts with which medtech start-up companies need to build relationships? In this section, the most important types of potential counterparts will be identified and commented.

Let us start with the *business partner*s. In business-to-business markets (in contrast to consumer markets) the selling and buying of products tends to take place through business relationships, rather than through single transactions on an atomistic and faceless market as assumed in neoclassical economics. Moreover, these relationships tend to be connected to each other, that is, what happens in one relationship may affect or be affected by interactions taking place in other relationships. That is why, according to the so-called Industrial Network Approach (INA), business-to-business markets can be described and analyzed in terms of industrial networks. There is a vast amount of literature based upon this theoretical approach.[7] While the bulk of the work is concerned with marketing and purchasing issues there are also a fairly large number of studies focusing more specifically on technological innovation.[8] These studies have shown, *inter alia*, that business relationships are not only important from a commercial point of view but may also have an essential role to play in the development of new products or production processes.

The business relationship is thus a core concept in INA. The interaction process that takes place between the selling firm and the buying firm/organization (Figure 1) can be described and analyzed in several dimensions such as duration and time perspective, volume, contact interface, degree of formalization and degree of relationship-specific adaptation. The latter can, for example, take the form of technical adaptations of products or production processes. More extensive adaptations may require R&D collaboration and result in innovations, which can be incremental or of a more radical nature. Over time the interaction may result in a strengthening of the relationship in the form of activity links, resource ties and actor bonds. As indicated in the figure each firm is at the same time engaged in relationships with other actors and these may affect or be affected by the focal relationship. That is why it is relevant to analyze business relationships from a network perspective.

Figure 1. Business relationship



[7] Some key references are Håkansson (1982), Håkansson and Snehota (1995), and Håkansson et al (2009), and Ford et al (2011).

[8] See, e.g., Håkansson (1987 and 1989),), Laage-Hellman (1989 and 1997), Håkansson & Waluszewski (2007) and Ford et al (2011, Ch. 7).

Usually, new companies do not have any customers or suppliers when they are founded. Building up business relationships with *customers* and *suppliers* therefore becomes a natural and important part of the company's development process. More or less close relationships are often needed for the purpose of "ordinary" selling and buying. In addition to that, as hinted above, collaborative relationships with business partners may be needed in order to carry out technological development activities. Research-based start-up companies, for example in the medtech field, are usually founded for the purpose of commercializing a new product idea or an invention (rather than a "me-too product"). Turnomg this idea into an innovation, that is a product that can be sold in the marketplace, normally requires extensive investments in R&D (for development of products, applications and manufacturing processes). In line with results from INA-based research, collaboration with potential suppliers and customers is often an important element in the industrial innovation process. It is often argued that early involvement of such business partners is a success factor in technological development. Unlike established firms, new companies do not normally have existing business relationships that can be used for technological collaboration. Therefore, it can be assumed that finding suitable partners and establishing collaborative relationships with them is an important and challenging task for start-up companies.

As also shown by research on industrial networks collaboration with the company's direct customers and suppliers may not be enough. For example, in order to gain access to the right resources and influence key actors in the network it may be necessary to involve the *customers' customers* or the *suppliers' suppliers*. The former may be the end-users and those who are most profoundly affected by the features of the new product.

Furthermore, on the marketing side *distributors* is a type of external actor that firms may need to develop relationships with. They are not "real customers" but trading companies which are performing an intermediary role between the innovating firm and the final customers. Distributors are first of all important resources for marketing and sales, but they may also play a role in product development (since they may have good knowledge about their own customers' needs and wishes).

The importance of involving users in the product development has been stressed also by scholars representing other research traditions. In particular, Eric von Hippel has over many years made pioneering contributions in this field (von Hippel, 1988). He is for example the creator of the lead user concept, which has gained widespread popularity.

In addition to vertical collaboration along the supply chain, backward and forward, companies may need or wish to establish technological collaboration also with *other companies in the industrial network* that it is part of (or aim to become part of, in the case of new entrants). It may be firms producing complementary products, that is, products which are bought by the same customers and which in some way are used together with the focal company's own product.[9] Here, successful innovation may require coordination of R&D activities in order to make a fit between the different products.

Firms may also be interested in establishing collaboration with *competitors* or more generally firms which belong to the same industry.[10] It is not uncommon, for example, that competing firms join forces in pre-competitive research or in standardization work.

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[9] Håkansson (1987, Ch. 3) gives a typical example from the "wood saw network" where saw blade manufacturers and sawing machine manufacturers are supplying complementary products to the saw mills. Other examples are computers and software, packaging machinery and paper, and engines and fuel.

[10] Companies making similar products may target different market segments, application fields or geographical markets. Although they belong to the same industry they may not perceive each other as competitors.

Universities and other types of research organizations constitute another type of R&D partner that companies may establish collaborative relationships with. For obvious reasons, the purpose is different from the industrial collaboration (unless the researchers are customers). Typical benefits sought by the companies are access to research-based knowledge and competencies that can be used in the own R&D process. [11]

The importance of university collaboration varies among industries (Mansfield, 1998). It goes without saying that universities play a particularly important role in so-called science-based industries. Here we find, for example, the life science industry which medtech is part of. Medtech products tend to be knowledge-intensive and it is quite common that new products incorporate new knowledge emanating from academic research. [12]

In the case of academic spin-offs, the company already at its birth has one or several relationships with academic research institutions. This relationship to "the parent organization" (e.g. a research group) may need to be further developed in the course of the company's own development, for example, in order to effectively transfer knowledge to the firm or enable the firm to take advantage of future research results. In addition to that, the company may need to establish collaboration with other research environments, for example, in order to access complementary technologies, test prototypes or promote the own concept within the academic community.

In addition to those categories mentioned above, there are a range of other actors in the environment that companies may need to interact with during the innovation process. Here we find, for example, various types of *bridging organizations* which have the task to support commercialization of new technology. They are of particular relevance to science-based start-ups since their main focus is often on commercialization of academic research. Thus, they tend to play an intermediary role between universities and industry. Typical examples of bridging organizations that start-ups interact with are the universities' own technology transfer offices ("TTOs"), incubators and science parks. These organizations may provide seed funding of innovation projects as well as other types of support (advice, coaching, project management, contacts, etc.). Bridging organizations are usually public bodies.

Government agencies are a type of actor that some companies may need to interact with. They may provide funding or be important interaction partners if they have a regulatory function.

Building relationships with *venture capital (VC) firms*, or other types of investors, may also be helpful. Like bridging organizations, VC firms may not only provide money but also support the companies in other ways (e.g., by recruiting skilled managers and board members, providing advisory services and arranging contacts with other firms).

Figure 2 summarizes the above discussion by illustrating the most important actors that a start-up company may consider to build relationships with during the innovation process. Which relationship-building activities a certain company chooses to engage in are of course dependent on the company's needs (e.g. for complementary resources) and the related collaboration strategy – which may be more or less introvert or extrovert. We can therefore expect that networking patterns will vary among firms.

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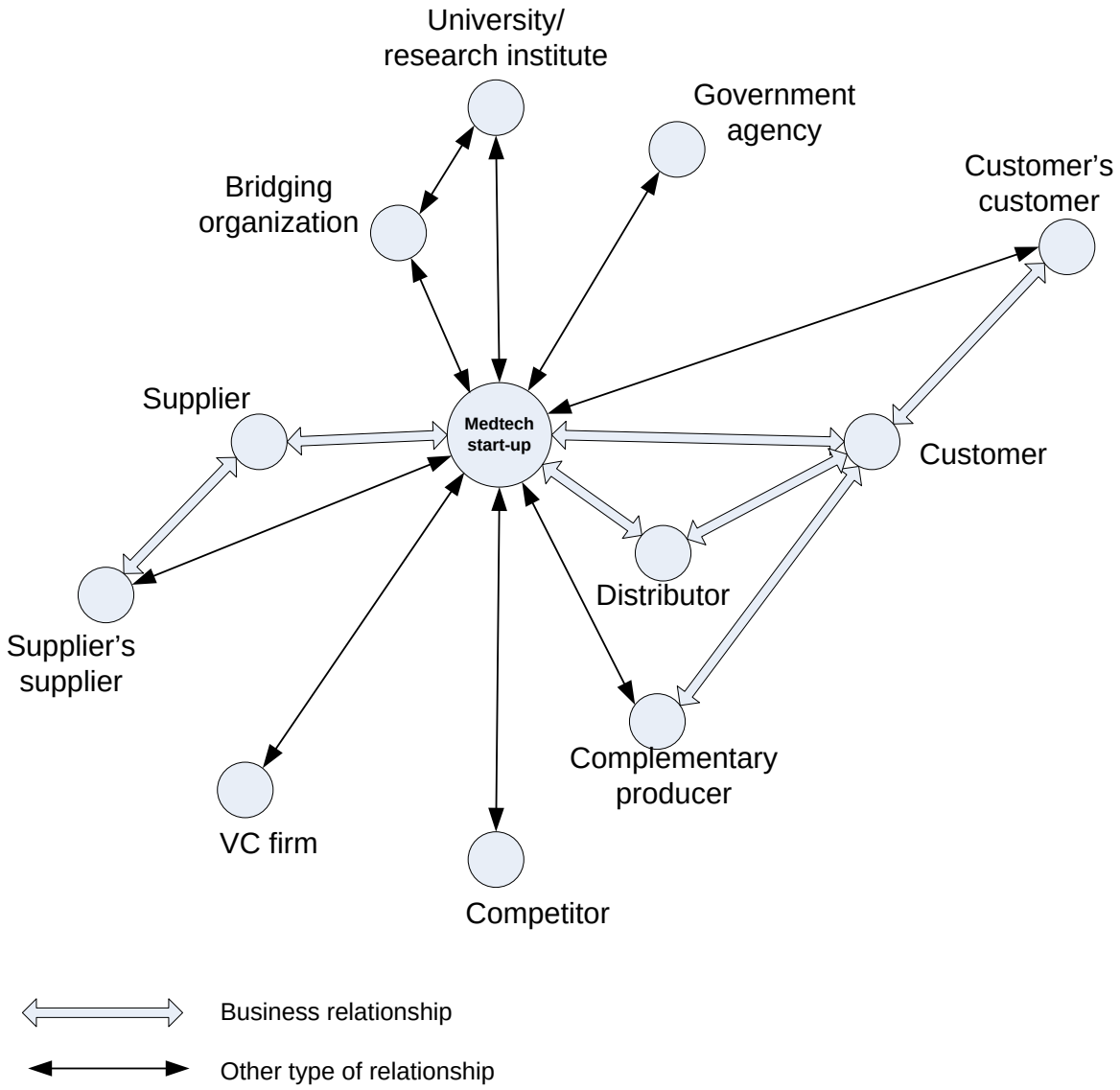
[11] In their frequently cited overview article Salter and Martin (2001) identify six major mechanisms for diffusion of university research to industry: Increasing the stock of useful knowledge; Educating skilled graduates; Developing new scientific instrumentation/methodologies; Shaping networks and stimulating social interaction; Enhancing the capacity for scientific and technological problem-solving; and Creating new firms.

[12] Laursen and Salter (2004) conclude that the work of universities rarely translates directly into new products and services for industry. One exception, however, is biotechnology.

Figure 2. Types of counterparts involved in the innovation process



Let us comment Figure 2 from a medtech perspective. We can first conclude that most medtech firms can be said to operate in industrial/business-to-business markets. With some exceptions the products are bought and used by organizations such as hospitals or other types of healthcare (HC) providers. Usually, these customers are also to be considered as end-users. Healthcare customers cam be public or private.

The medtech company's relationships with customers may be rather complex involving different types of actors within the healthcare system. The purchases are often handled by people belonging to the administrative function of the hospital. But the actual use of the product takes place in the clinics, care centers or other operative units. Therefore, physicians, nurses and other healthcare personnel may be important interaction counterparts – not least when it comes to development and introduction of new products.

Some medtech companies may not sell directly to the healthcare sector, but act as sub-suppliers to other (usually large) medtech companies which take the role of system integrator.

Such firms may, for example, supply special components, modules or software products. For them, the healthcare providers are the customer's customers. Even though they do not sell directly to healthcare providers interacting with them may be a necessary element in the product development (e.g. for testing or getting feedback on design solutions and performance).

On the supply side, typical input goods used by medtech companies include mechanical and electronic components as well as various types of advanced materials. Due to the increasing computerization of medical equipment software has in many cases become an important part of the product. Medtech companies also buy various types of services in areas like design, engineering, testing and contract manufacturing. Regarding supplier's supplier, a possible case is direct collaboration with up-stream manufacturers of key components or materials.

Medtech companies may draw on research results coming form different types of research environments. Thus, it is not only technical research focusing specifically on healthcare applications (often called "biomedical engineering") that is of relevance. First, companies may need to acquire new technologies of a more generic character (e.g. new signal processing methods or new types of materials). Second, clinical research is very important to the development of medtech products. Such research is carried out mainly at university hospitals, but may occur also at other types of healthcare institutions. These clinical environments are also potential customers. Thus, here we have partly an overlap between the customer side and academic research, and this is a rather unique feature of the life science sector.

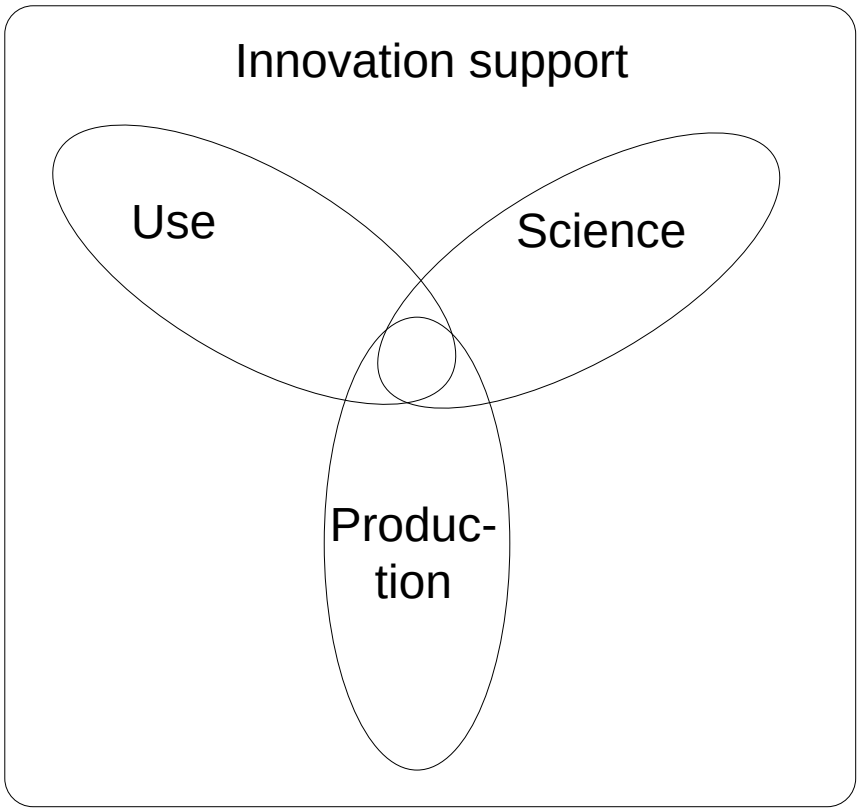
Since many medtech start-ups are university spin-offs they often choose to use the services offered by bridging organizations. There are, for example, certain incubators or science parks which are dedicated to life science.

Authorities and government agencies play a particularly important role in the healthcare sector due to the many regulations that govern the development and use of medical products. During the past decades safety regulations on medtech products have gradually become stricter (i.e., more similar to pharmaceuticals), and this has affected how firms carry out their R&D and commercialization activities. Contacts with regulatory authorities may therefore be a necessary element in product development. For the purpose of carrying out clinical trials the companies may also need to interact with local/regional authorities.

Four contexts of innovation

It is clear that innovation is an interactive process where companies link up with various types of counterparts. In the above discussion we have identified a range of external actors which are important to medtech start-ups. They bring different types of resources and play different roles in the innovation process. As seen from the perspective of the medtech firm they represent four different empirical contexts, or settings: science, use, production, and innovation support (see Figure 3).

Figure 3. Four contexts of innovation



This division of the environment in different contexts has been inspired by Håkansson and Waluszewski (2007) and Ingemansson (2010). They argue that in order to understand innovation it must be appreciated how the new solution has "survived" in three different but inter-related empirical settings: use, production and development. These settings have different economic logics which the innovating firm needs to consider and cope with.

According to the logic of *use* the innovation is not only about novelty but, even more importantly, about compatibility. Hence, in order to become economically useful an invention must be made to fit in with established resources and practices in the specific environment where it is going to be used. In regard to *production*, given contemporary organization of industrial activities firms tend to be strongly dependent on external suppliers, and these often have to be engaged in joint development processes. Thus, in order to be economically produced the new product needs to be made compatible with existing investments in the production setting. It means that this setting must be subject to the same type of profitability assessment as the use setting. The *development* of the new solution requires that the original idea is turned into something more concrete. This is a process often characterized by trial-and-error. It is very much an open process of trying new directions and combinations. However, for the use and production settings to be able to economically benefit from the invention the latter cannot remain an open solution. In other words, there is a strong need to relate the development of the new product to the use and production settings.

The present study deals with products that have their origin in science or require a scientific input in order to be developed. Thus, the development to a large extent takes place in a scientific context, represented by the company's own research activities as well as those activities carried out by external partners, e.g. at universities. That is why the term scientific context, rather than development context, is used in this paper.

In the context of use, if we link back to Figure 2, the firm interacts primarily with customers and other types of users. But relationships to certain other actors such as distributors, suppliers of complementary products and competitors also belong to this context.

Suppliers obviously constitute the main interaction counterparts in the context of production.

In our model (Figure 3), innovation support context has been added as a separate context where start-ups may want to develop relationships to bridging organizations. However, this context does not have its own economic logic related to the invented product. Instead, it has a supportive function. Thus, young start-ups may use these relationships to gain access to resources needed for successful action in the other three contexts.

To summarize, in order to turn the invention into an innovation and achieve commercial success the medtech start-up usually needs to interact with actors from all four contexts. The importance of the respective context in the individual case may of course vary depending on the characteristics of the product and the market as well as on the innovating firm's situation. Furthermore, the importance of different contexts may vary over time. There is also, as shown in Figure 3, an overlap between contexts. This means that certain activities and actors may belong to several contexts (e.g. the aim of an academic research project may be to develop a new production method).

Research questions

As point of departure for the present study, and being in line with the preceding discussion, it is assumed that the medtech start-up company's ability to establish fruitful collaborative relationships within the four empirical contexts identified above is of crucial importance to their innovative and growth performance. To a large extent we already know, through previous research, what types of external actors that medtech companies need to establish relationships with and the role and contributions of these interaction processes. What we need to know more about is rather *how* companies go about building up relationships and utilizing them for making innovations and creating growth. Thus, the main research questions addressed in this study are:

1. How do medtech start-up companies find and initiate relationships with different types of counterparts within the four contexts? For example, to what extent can companies draw on contacts or relationships existing already when the company is founded?
2. To what extent are the interaction processes in the different contexts overlapping or related?
3. What are the problems and opportunities associated with the companies' relationship- and network-building activities? For example, what difficulties and challenges do companies encounter and how are these problems solved? What opportunities do the collaborative relationships offer?
4. What kind of lessons can be drawn based on the companies' experiences? For example, can certain generally applicable success factors be identified?

METHOD

Case studies have been chosen as the main methodological approach. It is assumed that in-depth case studies offer an opportunity to learn more about how the networking activities are carried out and what problems, challenges and opportunities that are associated with these activities.

Four case studies have been carried out. Table 1 gives some basic data for the companies. The choice of cases was governed by different considerations. One conscious selection variable is the type of origin. Three of the companies are university spin-offs (USOs), but they come from different types of research environments. More precisely, one comes from clinical research, one from more basic or pre-clinical medical research and one from technical research. It is assumed that what type of environment the company comes from will affect networking prerequisites. The fourth case is a corporate spin-off (CSO).

Table 1. Case companies

Name of the company	Origin	Year of founda-tion	Product	Number of employees (2010)	Turnover (MSEK, 2010)
Micropos Medical	USO (clinical research)	2003	Positioning system for radiotherapy	5	0
Aerocrine	USO (basic research)	1997	Asthma diagnostics	58	85
Promimic	USO (techn. research)	2004	Surface coating	7	0.3
Entific Medical Systems	CSO	1999	Bone-anchored hearing aids	200	437

USO = University Spin Off; CSO = Corporate Spin Off

The intention was to focus on companies that already had proven commercial success and shown significant growth. In other words, it should be possible to describe them as “success stories”, as we see these companies today. It means that they have completed the early-development phase, during which the focal network-building activities are assumed to take place. Only two of the four companies fulfill this criterion, namely Aerocrine and Entific. Despite not having made commercial success so far, Micropos was chosen at an early stage of the research process as a test case. The reason for choosing this firm was that the author had pre-existing knowledge indicating that Micropos had been involved in several different networking activities and was a potentially interesting study object. Promimic is in a similar situation, that is, it is still in the process of entering the market. This company was chosen, as the last case, because it seemed to offer, besides being a spin-off from technical research, some complementary knowledge relative to the other cases (in terms of type of partner and associated network-building challenges).

It must be admitted that the choice of case companies is at least partly convenience-based. However, it can now be concluded that all four cases are relevant, given the purpose and research questions at hand, and contribute valuable data.

Regarding the varying origin of companies it can be argued that one type of medtech start-up is missing. This is a company founded by one or several “independent entrepreneurs”. Compared to the spin-offs, this type of company can be expected to face different types of problems as well as opportunities in their networking. Therefore, this category should be included in future studies of medtech start-ups.

The data has been collected mainly through semi-structured personal interviews with key individuals who were involved in developing the company's network relationships during the early years. As usual, basic information about case companies have been gathered through homepages, annual reports and similar sources. Occasionally, publications have been used.

The cases have been documented in the form of traditional case stories, that is, they are based on a fairly rich account of information introduced more or less in a chronological order. The complete case descriptions, each one followed by a comment highlighting some key observations, are included in the final report delivered to the AEGIS project (Laage-Hellman, 2012).

This paper presents some key results from the case analysis relating to the four contexts of innovation. The Appendix provides a summary of the most important collaborative relationships identified for each case and for each context. It is clear that many of these relationships have played a crucial role for the companies' development. Some of them have been relatively easy to establish and manage. Others have been associated with larger difficulties and can sometimes be described as problematic.

THE CONTEXT OF USE

All four cases clearly show that building up collaborative relationships with users/customers is of crucial importance to medtech start-ups. Needless to say, as in all business-to-business markets customer relationships are needed in order for the company to sell its products. But before coming to that stage, collaboration with potential customers is an indispensable element of the product development process. Here we can distinguish two types of customers: healthcare providers and industrial firms.

Clinical collaboration

Medtech products are used in healthcare and in order for the company to come up with a product that effectively meets the needs of the healthcare providers and can be integrated with other existing products, systems and work practices, clinical users need to be involved. And this requires establishment of collaborative relationships with at least some partners within the healthcare system. Such collaborations offer opportunities to get user opinions on how the product (including hard as well as soft elements) should be designed and to test the product in a clinical (real world) setting.

Not least, there is a great need for clinical research, that is, studies on humans. Normally, such studies cannot be made without involving the healthcare system, which has access to patients. There can be several reasons for carrying out clinical studies. First, these can be useful when developing the product itself. New research-based inventions commercialized by start-up companies often consist of an entirely new method for diagnosis or therapy. This means, *inter alia*, that besides the new hardware there is also essential application knowledge that must be developed. And this kind of knowledge can be difficult to gain without making tests under real life conditions in a clinical setting. Second, clinical trials are often necessary in order to get the new product/method approved for sale and included in national clinical guidelines and reimbursement systems. The latter is a common prerequisite for large-scale use in the healthcare system and consequently also for the company's commercial success.

To initiate and carry out clinical research of high quality companies usually have to take action and support the clinics involved. New start-ups may of course have had some contacts with clinicians, but most of them, unless they are clinical spin-offs, lack collaborative relationships on the clinical side when founded. Thus, it is extremely important for such firms

to find suitable partners and initiate clinical studies. And this should be done at an early stage, since the results will affect the product itself as well as the possibilities to have it approved and accepted on the market.

The cases give several illustrations of how this relationship-building can take place. For example, close contact with one clinician with high credibility (e.g. a key opinion leader) can be used to reach other potential partners and get them interested in participation. It is about taking advantage of existing partners' own networks. A dilemma for start-ups is that they often lack the necessary resources – in terms of money, staff and organization – to finance and work with clinical research. This tends to delay the development and commercialization process, and this obviously has negative effects on time-to-market and growth rate (e.g. compared to the situation where the commercialization takes place in an established firm which already from the beginning has these resources in place). To avoid too much delay the company first of all needs to have managers and board members who fully understand the need to work with clinical research. It also needs to have owners willing to allocate resources to this kind of activity. This may include early establishment of a medical affairs function.

Micropos Medical is a spin-off from *clinical* research. This means that it already from the beginning, through its four founding inventors, had indirect links to several clinics which constituted potential test sites. This was an advantage. However, somewhat surprisingly the case shows that starting up clinical collaboration with a clinic where one of the inventors/founders is located is not always unproblematic. The inventor's close tie to the company can give rise to adverse reactions from colleagues, who may for example question the objectivity of the inventor. The lesson learned by Micropos is that it should strive to build up its own relationship with the clinic without relying too much on the inventor. This means, perhaps, that the competence of the inventor is not fully exploited in the clinical research. Maybe one should not draw too far-reaching conclusions from this example, but companies are advised to be aware of this potential problem.

Entific is a corporate spin-off and had from the start existing clinical collaborations that could be further developed by the new company. This is probably a general advantage of CSOs. It means that compared to other medtech start-ups they can more quickly gain access to research results that can be used in marketing-oriented activities (e.g., for getting the product approved for sale and qualified for reimbursement). In the case of Entific, a high growth rate could be realized already during the first three years after foundation. A substantial share of this growth came from a new indication (single-sided deafness) which was developed in collaboration with a group of key clinical partners.

If we go back to the origin of the invention commercialized by Entific, it has its roots in both clinical and technical research at universities. However, we cannot see that the company (Nobelpharma in those days) had any problem with the clinical collaboration caused by the clinical inventor's presence at the clinic. But there is one major difference compared to the Micropos case, namely, that this person was not directly involved (had no ownership) in the commercializing company. Hence, there was a different, more arm's length relationship between the company and the inventor. This reduces the risk of making others suspicious about the latter's objectivity as a scientist.

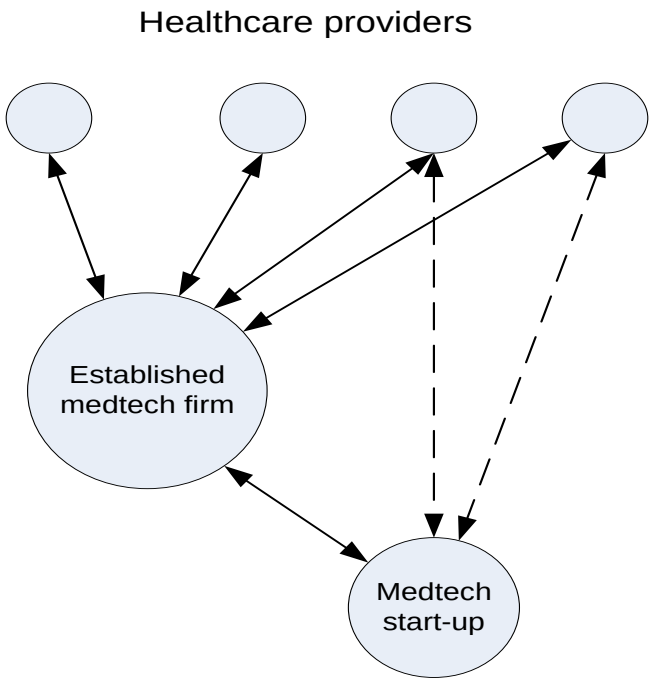
In two of the cases, the companies had from the beginning close contacts with clinicians, which were co-inventors. These clinicians had their own national and international contact networks within the clinical community. Both companies have in a fruitful way been able to use these (indirect) networks in order to establish clinical collaboration with new partners around the world. In other words, these key partners (irrespective if they are founders or not) have served as effective door-openers. The possibility to use inventors in this way is an

obvious advantage for clinical spin-offs compared to medtech start-ups with a different origin. Other companies must find other ways to link up with the clinical community, and this may require long-term and dedicated efforts.

Industrial collaboration

From a marketing point of view Promimic is in a different situation compared to the other companies. Its product – a method for surface-coating of implants – is not going to be sold directly to healthcare customers. Instead, Promimic is a sub-contractor to implant manufacturers which will use the coating technology when producing their own products. This situation, illustrated in Figure 4, is not unusual for medtech start-ups. The invention they commercialize often constitutes a component in a system, typically supplied by a large medtech company. In Promimic's case there is no option to sell directly to the healthcare providers. In other cases, it may be possible to sell the product both directly and indirectly. One example is Micropos' positioning system RayPilot. While the current main approach is to sell RayPilot to radiotherapy clinics Micropos also considers to use the big system suppliers as a complementary marketing channel. Medtech start-ups focusing on software development often become sub-contractors to system suppliers.

Figure 4. Medtech start-up as sub-contractor to large firms



Also for companies with this type of market situation, collaboration with potential customers – i.e. large medtech companies – is an important part of the innovation process. Again, customer collaboration is needed both for developing the company's own product offer and for obtaining evidence that the product works and brings valuable benefits to customers and end-users. The Promimic case illustrates that for a small start-up establishing relationships and carrying out collaborative projects with large medtech companies is not always easy. First, there is the challenge to make a first contact and to start up a dialogue. The potential partners have large organizations often spread out globally. For a small start-up which is not known in the industry it might be difficult to attract attention and find the right entry point.

Promimic, now focusing primarily on the orthopedic segment, is working hard to establish relationships with potential partners and future customers. It has found out that participation in trade fairs is an effective first step to create visibility and make contacts. In the next phase intensive interacting with individual companies is needed before real collaboration can take place. This is a kind of relationship-building interaction that requires careful preparation and knowledge gathering in order to be successful. All this is time-consuming and a costly activity for a small start-up. There is great need for perseverance, financially as well as mentally. The owners need to understand that these are processes that take time and that desirable collaborations in the market place cannot always be rapidly established.

Promimic's experiences from its early collaboration with Nobel Biocare, a leading manufacturer of dental implants, show that the execution of joint projects with large customers is not always easy. The start-up may not be seen as, or treated as, an equal partner to the large company. This may, for example, affect the former's possibility to get information from the partner, which reduces the learning effects. But it may also decrease its ability to contribute its own competence. The case also provides a nice illustration of the start-up's single-sided dependency on its partner. It exemplifies how a collaborative project may be abruptly terminated due to strategic changes in the partner firm triggered by external events or circumstances. While the large company may be only marginally affected by the changed relationship the start-up is much more vulnerable and may end up in a difficult situation (like Promimic for which the joint project with Nobel Biocare was the main track toward commercialization). This unbalanced dependency is probably a fact of life that start-ups have to learn to live with.

THE CONTEXT OF PRODUCTION

The inventions commercialized by Aerocrine, Entific and Micropos consist of apparatuses produced by assembling different kinds of components and sub-systems. For all of these firms it has been necessary to involve suppliers in the product development. As is common in the medtech industry they have chosen to outsource much of the production. While the final assembly and quality control is done by the firm itself components and sub-systems are purchased from external suppliers. Standardized components can be bought off the shelf and do not require close interaction with the supplier. But since these firms commercialize inventions of a more or less radical nature the product normally incorporates unique parts that are not available in a standardized version on the open market. Therefore, in order to have these parts effectively designed and manufactured it is necessary to have the suppliers involved. This collaboration should preferably take place at an early stage since input from the supplier may have an impact on the product design.

The cases illustrate that it is not always easy for a small start-up to find suitable and willing suppliers and develop fruitful collaborative relationships with them. Sometimes a lengthy search process is needed just in order to find "the right partner". Moreover, it can be difficult for the start-up to make a potential supplier interested in collaboration and making the necessary investments in customization of product and production process. The reason is that the start-up is at least initially a very small customer which in addition has limited resources, lacks track record and has an uncertain future. The supplier may have other options to use its own resources and these may appear to be more promising. For the start-up an intensive interaction may therefore be needed in order to convince the supplier to invest resources in the relationship. Another problem is that the start-up itself may lack competence regarding how to formulate specifications and, more generally, how to work with suppliers. It is advantageous for the start-up, if it can afford it, to recruit managers who have previous experiences from the

medtech industry. Such individuals may have existing contacts, skills and credibility that facilitate the establishment of collaborative relationships with potential partners.

Overlap with other contexts

This work on finding a functioning solution for the production of the new product usually takes place in parallel to the company's networking with users/customers. There is not necessarily a direct coupling between these two types of activities, but they are of course mutually dependent on each other. As pointed out, the economic logics are different. Thus, the solution worked out in one context must not be in conflict with requirements from the other. This necessitates some coordination of the activities. It is also obvious that without successful development of network relationships in both of these contexts there will be no innovation, and no growth.

There may be some overlap with the context of science, for example, if the component is further developed by introducing new technologies coming from research. One example is Entific's vibrating transducer which is a key component of the hearing device and a core invention. Over a long period of time the responsibility both for development and production was outsourced to the inventors at Chalmers, through their own company. This solution secured a close coordination between science and production and this seems to have had positive effects on the development of this component. However, when the management of Entific prepared the company for sale this strong dependency on the inventors was perceived to be too risky and undesirable in the long run. After long and tough negotiations Entific took over the full responsibility for the vibrator. It turned out, however, that the transfer of production to another supplier did not work, due to quality problems, and Entific finally chose to insource the production. Now production is once again well integrated with the product development, this time within the company. However, there is no longer any overlap with science since the company does not have any collaboration with the researchers.

This example shows that for very unique components invented and developed by the start-up a satisfactory external production solution may not exist. This depends of course very much on the availability of capable suppliers. Furthermore, for such components the establishment of a close collaborative relationship between the customer and the supplier (manufacturer) may be necessary in order to solve various technical problems and secure an effective linkage between production and product development. Therefore it is beneficial, especially for small firms, to have the supplier located close by. This points to the advantage of belonging to a cluster, where a young, innovating firm can gain access to specialized suppliers, which have emerged as a result of previous networking among other regional firms (see further comments below).

Strategic alliances

The preceding discussion in this section concerns more normal collaborative relationships with suppliers. The Aerocrine case illustrates how the production solution can take the shape of a strategic alliance with a large, multinational medtech corporation. Here the Japanese partner takes the main responsibility both for designing the next product generation (based on the start-up's functional specifications) and for manufacturing it. This seems to be a relatively unique solution for a small medtech company. The more common pattern is that large companies acquire start-ups and integrate them in their own organization.[13]

[13] There are many Swedish medtech start-ups which have been bought by foreign companies. In some cases, all or most of the activities have been moved abroad. In other cases the buying firm has continued to invest in the

In Aerocrine's case it can be noted that the alliance was made at a relatively mature stage. The company was already well established in the market and it is now developing the third generation of its product. This explains why it was possible for Aerocrine to make a large firm interested in such an alliance, where the start-up retains the marketing rights.

It is hard to see that establishing strategic alliances of this kind can be used by smaller and younger start-ups as a feasible solution for production. The alternative to organic growth is rather to sell the company or its business to an established player in the industry. This usually means that the company disappears, at least as an independent business entity.

THE CONTEXT OF SCIENCE

Here we need to distinguish two types of relationships to research environments. First, for companies founded by academics (USOs) there is always some kind of relationship between the start-up and the research group or department from which the company was spun off. Second, the start-up may establish collaboration with other research units.

Relationships to inventing research environments

When a company is created for the purpose of commercializing results from academic research there is always from the beginning a relationship between the company and the inventing research unit (group, department, center or institute) – or units. Ii is not unusual, in fact, that there are founders coming from several different units. In the Micropos case, for example, the company was formed by four clinicians working at different hospitals. Aerocrine was founded by two research groups at the same university. Promimic by contrast has founders coming from the same research group.

It is obvious that the relationship to the inventing research unit(s) is crucial to the firm at the time of foundation. First of all, the invention to be commercialized – in the form of knowledge, technical solutions and intellectual property (IP) rights – has to be transferred to the company. It seems that this is normally not so difficult. Thanks to the so-called teacher's exemption, which gives Swedish university researchers ownership of their inventions, patents can easily be transferred to the firm. In Sweden, unlike in most other countries, there is usually no need to negotiate with the university. The knowledge needed to exploit the patents are usually transferred by the inventors themselves. In Sweden it is common that the inventors stay at the university even if they become actively involved in the company in the form of owners. They may, for example, contribute to the technology transfer by working part-time for the company, by acting as consultants or collaboration partners, and by being board members. But it also happens that inventors/founders take the full step from academia to business and become full-time employees. This can take place when the company is started or at some point later on.

Furthermore, the contacts with the inventing research unit can be used to recruit skilled personnel – either more senior researchers or younger individuals (e.g., PhD or master graduates) who have received training at the unit. Another way to make use of the unit's competence is to engage students to carry out their master's thesis on behalf of the company. For example, much of the early development work at Micropos was done by such students. Some of them were afterwards employed by the company.

Swedish subsidiary and the business has continued to grow. One example of this is Cochlear's acquisition of Entific.

We can thus conclude that this type of relationship, almost by definition, is crucial for the company's early development. However, as well illustrated by our cases, there is a tendency for this relationship to diminish in importance over time. This is a typical pattern that has been observed also in previous studies (see, e.g., Laage-Hellman, 1993). This finding is rather logic. When the technology to be commercialized has been transferred and the company has taken over the responsibility for further development of the invention it is natural that the company becomes less dependent on input from the research unit. At the same time, there are other types of relationships that become more important. In other words, the company has good reasons to prioritize the building of relationships with users/customers and suppliers. If the company is going to effectively adapt the product according to the logics of use and production it is not possible to let the design process be too much influenced by new ideas from science.

An exception from this pattern of decreasing importance for inventing research units is of course the clinical spin-off. Here, the inventing unit is also a potential customer and the relationship can be used to develop clinical collaboration.

Another possible reason why the importance of this relationship to the inventing unit is decreasing over time is that the unit's research focus may change after the spin off. Thus, the research carried out by the inventing unit may not be of such a great interest to the company, which has to focus on its own product.

If the inventing unit by contrast continues to do research in the field the company has good reasons to at least monitor the development and keep in touch with the key scientists. In the short term, the new knowledge that comes out of this research may not be applicable to the company's ongoing product development. But when the company sooner or later needs to develop a new product generation with enhanced features it is possible that new technologies developed by the academic researchers might be useful. If the company keeps in contact with the unit – and for example shares its own problems, ideas and plans with the researchers – it may have an opportunity to influence the research activities in a direction that is favorable to the company. There are several ways in which the relationship can be kept alive. It is obvious that having one or several of the inventors staying at the unit constitutes an efficient channel of ncommunication. The interaction can also take the form of joint research projects, industry PhD students, adjunct professorships and scientific advisory boards. Keeping in contact with the research unit also provides valuable opportunities to recruit skilled personnel with suitable competence.

Relationships to other research environments

To judge from our cases, finding other academic research units to work with is not so important to the medtech start-ups, at least not in the early phase (with the exception of clinical partners, of course). Instead, if there is need for complementary technologies not coming from the inventors these are in the first place sourced from industrial suppliers.

However, a need to establish collaborative relationships with academic research units other than the inventing ones may arise at a somewhat later stage, that is, when developing the next product generation. Especially if the company is aiming for new, advanced technologies in the scientific forefront, universities may have a role to play. For some medtech firms, for example, the currently rapid development of nanotechnology offers interesting opportunities to miniaturize products and achieve a leap-wise improvement in performance. This is a young technological field where the knowledge development is still to a large extent driven by academic research. Thus, collaboration with universities, or research institutes, can be an effective means to gain access to such technology. For example, Aerocrine started a joint

project with a research group at KTH in Stockholm. This project is linked to the strategic alliance with the Japanese partner. The two relationships are of different kinds but are connected. This exemplifies the overlap between the two contexts of production and science.

THE CONTEXT OF INNOVATION SUPPORT

The relationship-building activities that take place within the three preceding contexts are directly related to the company's business. Hence, the counterparts with which the company establishes collaborative relationships contribute in different ways to the start-up company's product development and market introduction. In the context of innovation support we find actors that contribute to the firm's development in a more indirect way. There are a range of so-called bridging organizations, usually publicly funded, which have a role to support the commercialization of science. They can be seen as intermediaries between universities on the one hand and established industry and markets on the other. For many of these organizations a main task is to support formation and growth of start-up companies, in particular those spinning out from universities. Therefore, it is relevant in this study to consider how medtech start-ups make use of and interact with bridging organizations. Needless to say, the relationships established with bridging organizations are of a different kind compared to those dealt with in the other contexts.

Generally, bridging organizations play a role in the very early phase, in many cases even before the company has been founded. The services offered can include such things as low-cost premises, seed funding, coaching and help with network-building.

Two of the university spin-offs, Micropos and Promimic, have made extensive use of the public innovation support system, especially the regional one. Both of them have chosen to locate in an incubator. To be accepted by an incubator the project has to go through a selection process. An advantage with this is that the project owners (usually the inventors) are forced to develop their business idea so that it can be successfully evaluated by the incubator. This increases the probability for future success. Once accepted the firm gains access to the incubator's service offer. Representatives of both these firms testify that belonging to an incubator has had major positive effects on the company's development.

Thus, the two cases illustrate how an incubator can help the company to get a good start. The funding is important since at this initial stage it is usually very difficult for a start-up (at least in Sweden) to get VC-funding. In other words, there are few other alternatives. The coaching is also very important since new start-ups are often managed initially by people with limited business experience (e.g., the academic inventors themselves). The coach can contribute in many different ways, such as developing business plans, strategies and organization. In line with our reasoning in preceding sections an important task of the coach is to help the company to start up the relationship-building activities in the three other contexts. The coach may even have own contacts with potential partners that can be used.

Aerocrine chose to not take advantage of the services offered by the innovation support system of Karolinska Institutet. The founders did not believe that going into an incubator would contribute much to the company's development. This may of course have been a false conclusion. However, it should be borne in mind that Aerocrine was founded in 1997, that is, 6-7 years before the other two USOs. In those days, the innovation support systems associated with universities were generally not as well developed as they are today. Over the past 10-15 years the quality of bridging organizations has increased tremendously, for example, in terms of competence and experience. This enables them to give incubator companies much better support than they used to in the 1990s.

One reason why Aerocrine may not have benefited so much by belonging to an incubator is that it managed to recruit, for being a start-up, unusually competent managers. Thus, there was no need to bring in an external business coach. Initial funding was also arranged through other contacts.

Entific is a corporate spin-off and like Aerocrine it has done well without seeking help from bridging organizations. However, one should not draw the general conclusion that a CSOs would never be able to benefit from the support system. It depends on how mature the project is. In Entific's case there was within Nobel Biocare an established business to build upon. The sales volume was still relatively low but many things were in place such as organization, production structure and customer relationships. Once a dedicated firm was created and led by professional managers the company could start to grow rapidly – effectively exploiting these existing assets.

There may be other CSOs where the project to be spun off is less mature. If it is a research project that has not yet resulted in a commercial product the start-up is in a situation that is more similar to that of an USO. In such a case, it may be advantageous for the new company to locate in an incubator and seek complementary funding and support from other bridging organizations.

Venture capital funding

The VC firms are usually private companies but in a broad sense they can be seen as members of the innovation support system. Many medtech start-ups, like other R&D-based companies, are dependent on VC funding. Under current market conditions it is difficult to get VC funding for starting a new company. But at a somewhat later stage, for example when the introduction of a product can be envisaged, VC firms often come in and take over as main financiers.

All of the four case companies have used VC-funding. One can often hear complaints that VC firms lack knowledge of the medtech industry and in reality only provide money even if they promise other value-adding services. However, our case companies seem to be quite satisfied with their owners. Interviewees give examples of how, for example board members from VC firms have contributed valuable knowledge and helped the company with contacts. The VC firms have also in several cases proved to be patient owners and continued to support the company despite long lead-times and backlashes. Note that both Micropos and Promimic have existed for almost ten years and have not yet started to sell their main product.

In other words, the cases illustrate how the companies have managed to build fruitful relationships with VC firms (and also with some other owners). But this does not happen automatically. To benefit from the owners, especially the CEO has to spend a great deal of time interacting with them. This is needed, *inter alia*, in order to inform them about the company's development, situation and plans. This is undoubtedly a resource-demanding task for a small start-up, where the managers also have many other things to do. However, this is at the same time a necessary activity in order to secure support from the owners and enable the company's long-term development and growth.

THE IMPORTANCE OF CLUSTERS

Both Entific and Promimic belong to a biomaterial cluster in Western Sweden.[14] The cases illustrate how the development of start-ups can benefit from this. More precisely, thanks to

[14] See Laage-Hellman et al (2011) for a description of this cluster.

the cluster there are potential collaboration partners available in the region where the company is located. This includes users and suppliers as well as academic researchers. There may also be bridging organizations with specific competencies in the field.

This availability of local partners is of particular value to start-ups, since they are small and usually have scarce resources. It makes it more difficult for them, compared to large firms, to find and work with partners in other parts of the world, within the country or abroad. Geographical proximity both reduces the costs for interaction and facilitates frequent face-to-face meetings. The latter is especially important in the early phase when the product is still under development. For example, the specifications remain to be finalized and how to manufacture the product is still an open question.

Entific is in itself a product of the cluster. Its bone-anchored hearing aid is historically a spin-off from Nobelpharma/Nobel Biocare's dental implant business. The company had important regional relationships from the beginning – for example, with Nobel Biocare, Sahlgrenska University Hospital and Chalmers. Later on two other biomaterial companies from the region became suppliers: Elos Medtech and Astra Tech. If these companies had not been present, Entific would certainly have found other solutions outside the region. But it is obvious that the opportunity to work with local partners was greatly appreciated by the company.

Today, after Cochlear's acquisition of Entific, the company is no longer to be considered as a start-up and it is less integrated in the region/cluster than before. It still uses the same suppliers, but the regional research collaborations, both in the technical and medical fields, are limited. This is partly due to the fact that the company now belongs to an international group, which has its own R&D facilities and research collaborations in other countries. Nonetheless, Cochlear so far finds it advantageous to stay in the region, not least for the opportunity to recruit competent personnel.

Unlike Entific, Promimic did not come from the cluster. But already from the very beginning it has taken advantage of the opportunity to interact with various cluster actors. For example, the coach at Chalmers Innovation, who later on became CEO, had knowledge of biomaterials and helped the company to direct its development efforts toward medical implants. At a very early stage contacts were established with the two dental implant manufacturers in Gothenburg and this resulted in a collaborative project with one of them. It is true that these relationships did not lead to any business for Promimic (besides R&D grants). But it seems that they were important from a knowledge development point of view. This is something that Promimic can draw on when it is now building collaborative relationships in the orthopedic market. There are no major manufacturers of orthopedic implants in Sweden, so Promimic has to go abroad in order to find suitable partners and future customers. Promimic has also established contacts with some other cluster members, but it is too early to see what that will lead to.

Most Swedish medtech start-ups are located in university cities where there are many other medtech firms and extensive life science research. Although they can benefit in different ways from these environments few of these start-ups belong to a specific cluster in the more narrow sense exemplified above. Thus, the existence of a surrounding cluster is not a necessary condition for a medtech start-up to flourish. Companies can always go outside their local environment to find partners – and they also do that to a large extent. Having said this, it must be concluded though that belonging to a cluster definitively offers advantages in the form of local interaction opportunities. And this means more for small companies, such as medtech start-ups, than for the big firms which have larger resources and more easily can work with distant partners.

CONCLUDING REMARKS

The present study consists of four in-depth case studies of medtech start-ups. The cases, reported in Laage-Hellman (2012), give context-specific descriptions of how these companies have built up collaborative relationships with various actors in the surrounding network. It is believed that by reading these cases and subsequent comments and analysis people involved in such firms – e.g. as inventors, managers, owners and advisors – can gain valuable insights about networking in young medtech start-ups. Due to space limitation the present paper does not include the cases. But it presents in the preceding sections some general findings related to the four contexts of use, production, science, and innovation support. The cases confirm, first of all, that the relationship-building activities, especially in the contexts of use and production, are crucial for achieving commercial (and economic) success. But they also show that doing this is often associated with various difficulties and challenges. There are issues related to, for example, the identification and choice of potential partners, the establishment of a relationship and the management of collaborative activities.[15]

In the context of use new start-ups have to make big efforts, more or less from scratch, to establish collaborative relationships with potential customers in different countries. To succeed it is advantageous, *inter alia*, to acquire internal competence in clinical research ("medical affairs") and to use indirect relationships through close clinical partners (e.g. inventors/founders). Scarcity of resources, a typical feature of young start-ups, is a reality to many firms and a common barrier to effective networking with users/customers. This holds true also for relationship-building in the production context. As we have seen it can be a big challenge for a small start-up to find and establish effective collaboration with suppliers of key components. By contrast, the relationships to academic partners are usually easier to handle, and besides in the initial phase they tend to be less critical to the commercial success.

Many of the implications and lessons are context-specific and difficult to generalize. It is clear, however, that due to the unique characteristics of the market for medical devices (e.g. in terms of regulations and payments) medtech firms need managers and advisors/coaches who have a thorough understanding of the medtech innovation process. This type of competence and experience is necessary in order for the start-up to build up the required collaborative relationships.

Another general conclusion is that with regard to networking the role of public policy seems to be limited and mainly indirect – e.g. through advice and support provided by bridging organizations. Furthermore, in order to help start-ups to develop and introduce new medtech products it is important that the healthcare providers are open to collaboration, for example, by practicing public innovation procurement. A prerequisite for the new products to reach the market, and contribute to improve healthcare, is that the companies gain access to clinical environments where the design and application of proposed solutions can be tested and fine tuned.

The present study has taken a broad view of the start-ups' early networking trying to capture all types of relationship-building activities. The main focus has been on how this is done in the medtech industry. For future research on this topic it is suggested that the relationship-building process is studied more narrowly, for example, by focusing on particular types of partners and on individual relationships. That would give an opportunity to gain deeper knowledge about the difficulties, challenges and their handling. It would also be interesting to see similar studies carried out in other industries.

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[15] It may be worth noting that the findings coming out of this study are to a large extent supported by insights that the author has gained from several other studies of the same industry.

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Appendix: Some key information about the four cases

Micropos Medical

Year of foundation: 2003
Type of start-up: university spin-off from clinical research
Founders: Four clinical researchers (inventors), the CEO and Chalmers Innovation (incubator)
Product: Electromagnetic positioning system for radiotherapy (RT) consisting of an implantable transmitter, a receiving system and computer software
Number of employees 2010: 5
Turnover 2010: 0
Ownership: public company (listed on Aktietorget)

Key relationships:

	Relationships existing at the time of foundation	**Relationships established after foundation**
Context of use	RT clinics in Gothenburg, Stockholm, Bergen and Borås	- Other RT clinics in Europe - Large manufacturers of RT equipment (Elekta, Varian, Siemens) - Manufacturers of add-on products - Distributors
Context of production	Some other medtech companies	Raumedic, transmitter
Context of science (non-clinical research)		Chalmers University of Technology (two departments)
Context of innovation support	Chalmers Innovation	Innovationsbron Väst, Nutek, Region Västra Götaland, Vinnova
Others		Patient organizations

Aerocrine

Year of foundation: 1997
Type of start-up: university spin-off from basic research
Founders: Two research groups at Karolinska Institutet (KI)
Product: Method for diagnostics of asthma
Number of employees 2010: 58
Turnover 2010: MSEK 85
Ownership: public company (listed on NASDAQ OMX Stockholm)

Key relationships:

	Relationships existing at the time of foundation	**Relationships established after foundation**
Context of use		Clinical research groups at several university hospitals in Europe and the USA Distributors
Context of production		1:st generation: Monitor Labs, Amersham Biosciences, Swedish technical consultancy 2:nd generation: IT Dr Gambert, Sanmina SCI 3:rd generation: Panasonic Shikoku Electronics
Context of science (non-clinical research)	Two research groups at KI (inventors)	Royal Institute of Technology (KTH)
Context of innovation support	Karolinska Innovation	
Others	Corporate finance firm Stock brokerage firm	Patient organizations

Promimic

Year of foundation: 2004
Type of start-up: university spin-off from technical research
Founders: Two researchers at Chalmers University of Technology
Product: Surface coating method for medical implants
Number of employees 2010: 7
Turnover 2010: SEK 300 000
Ownership: mainly VC firms

Key relationships:

	Relationships existing at the time of foundation	**Relationships established after foundation**
Context of use		Nobel Biocare and Astra Tech (dental implants) Four orthopedic implant manufacturers (USA and France) One dental implant manufacturer (Japan) Invibio (materials manufacturer in the UK) Q-Sense (surface analysis sensor) Arcam and Elos Medtech (biomaterial firms)
Context of production		
Context of science (non-clinical research)	Research group at Chalmers Research group at Sahlgrenska Academy (Odontology)	Research group at Malmö University Other research groups at Sahlgrenska Academy
Context of innovation support	Chalmers Innovation	Almi, Innovationsbron Väst, Region Västra Götaland, Sahlgrenska Science Park, Vinnova
Others		

Entific Medical Systems (today: Cochlear Bone Anchored Solutions)

Year of foundation: 1999
Type of start-up: corporate spin-off from Nobel Biocare
Founders: Nobel Biocare and two VC firms
Product: Bone-anchored hearing aids
Number of employees 2010: 200
Turnover 2010: MSEK 437
Ownership: Cochlear Ltd (after acquisition in 2005)

Key relationships:

	Relationships existing at the time of foundation	**Relationships established after foundation**
Context of use	ENT clinic at Sahlgrenska University Hospital Other university clinics	Other university clinics (for new indications)
Context of production	Nobel Biocare (implant) External suppliers (device)	Elos Medtech (implant) Astra Tech (surface treatment of implant)
Context of science (non-clinical research)	Inventing research group at Chalmers	Researchers at Sahlgrenska Academy Institute for Biomaterials and Cell Therapy
Context of innovation support		
Others		