Biomedical Firms in Western Sweden

A study of a regional innovation system from a Biomedical firm's perspective

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December, 2007

www.chalmers.se/tme/EN/centers/ride

RIDE/IMIT Working Paper No. 84426-024

IMIT – Institute for Management of Innovation and Technology
RIDE – R&D and Innovation' and 'Dynamics of Economies

VINNOVA

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Executive summary

This report presents a study of biomedical firms operating in Western Sweden, which we have defined as comprising the Västra Götaland Region and the County of Halland. The study has been carried out on behalf of the Vinnväxt Initiative Biomedical Development in Western Sweden: a New Innovation System ("BMV"). BMV is a ten-year regional development programme, or rather "process", financed by VINNOVA along with a number of public and private actors in the region. The overall aim of the programme is "to create a solid base for long-term growth in the biomedicine field within Göteborg region, by cultivating academic research and commercial innovations and adaptations within the health care system". It is envisaged that by 2015 Western Sweden will have established itself as one of Europe's leading biomedical regions. Publicly, BMV is also known under the name GöteborgBIO, which is the communication platform of the programme.

The authors have been engaged by BMV and given the role of conducting research on the development of the programme and the innovation system; their main purpose is to provide support for all learning that can be garnered from the BMV process for the benefit of the process management and other actors involved, as well as for VINNOVA and any other interested parties. The present study is one of several activities being carried out in this context. Its purpose is to map regional biomedical firms' activities, especially those related to technological innovation, and their views on the region.

The study takes its theoretical starting point from an innovation system approach, where the term innovation system is used in accordance with VINNOVA's definition. Correspondingly, this means that innovation system consists of and comprises all actors within the research, industrial and political/public sector who, in collaboration, generate, exchange and use new technology and new knowledge in order to create sustainable growth; whether by means of new products, services or processes. In this case the innovation system is delineated by a specific region and a specific sector. Networks and interaction processes linking the actors within the region – as well as other actors outside the region, in an international context – are vital features of any innovation system. Therefore, in order to understand more profoundly in what directions and by what mechanisms the biomedical innovation system in Western Sweden needs to be developed, the present study focuses on the role of regional biomedical firms in the creation, diffusion and use of knowledge. More specifically, a central theme of the study is the interactive learning processes and the flow of knowledge amongst different actors.

In the region of Western Sweden, there are more than 200 firms that satisfy our broad definition and can be classified as "biomedical". This incorporates firms that develop, manufacture and/or market the following types of product or service: pharmaceuticals, diagnostics, medical devices (including aids for disabled persons), biotechnology tools for research and production, and contract or clinical research. Using a web-based survey tool, a questionnaire was sent to all these firms. Out of the 222 firms that received the questionnaire 78 have completed it, which gave us a 35 percent response rate. The response rate was higher (46%) for firms that perform research and development (R&D) than for those that didn't (21%). As a complement to the survey, personal interviews were carried out with thirteen of the companies regarding their external R&D collaborations.

Analysis of the industry structure showed that from an economic or employment point of view a small number of large firms dominate the market. These firms are AstraZeneca R&D Mölndal, Astra Tech, Getinge, Nobel Biocare, Mölnlycke Health Care and SCA Incontinence Care. While AstraZeneca R&D Mölndal works in the pharmaceutical field, the other five firms are all medical technology ("medtech") companies. This observation exemplifies and illustrates a more general pattern. In the pharmaceutical sector, the region's biomedical industry is completely dominated by AstraZeneca. There are very few small drug development firms. By contrast, in the medical technology sector there exists, in addition to the large firms mentioned above, a significant number of small and medium-sized companies. In the field of biomaterials, one can identify a cluster of

companies that perform complementary or competing activities. In the third major sub-sector, that is biotech supply, there are no big companies but rather a growing number of small R&D-based firms. Some of them belong to an emerging cluster doing work with stem cells.

In addition to companies, the biomedical innovation system comprises other important participants, such as universities, research institutes, health care providers, and various other support and policy-making organisations. The following actors belong to some of the more significant ones: Sahlgrenska Academy at the University of Gothenburg, Chalmers University of Technology, Sahlgrenska University Hospital, Region Västra Götaland, Business Region Göteborg, *Innovationsbron Väst*, and Sahlgrenska Science Park.

There are a number of findings from the study that should be emphasised. Biomedicine, or more broadly biosciences, is characterised by highly dynamic and intense competition centred upon knowledge development and technological innovation. In such a field as this, the *formation of new firms* is a key element in the renewal process by which new science-based knowledge is brought into practical use –in conjunction with industrial and economic development. A majority of respondents perceived it to be relatively easy to start new companies in the region. However, one general obstacle is seen to be the lack of regionally based seed-financing. Here, there is obviously room for an active concerted policy.

Moreover, the results show that the two universities in Göteborg mentioned above (Sahlgrenska Academy at the University of Gothenburg and Chalmers University of Technology) have played a decisive role in the establishment of firms in the region; for example, almost half of the firms that perform R&D characterise themselves as university spin-outs. Several conclusions from this can be drawn. First, that the existence of strong academic research in the region constitutes a precondition for the spin-off process. Second, that another of the region's critical strengths is the existence of what appears to be well-functioning incubators, particularly the one that is dedicated to biomedicine (at Sahlgrenska Science Park). Third, that these incubators are components of a publicly-funded regional support system that is directed at academic entrepreneurship; though there are complaints that this support system is too fragmented and difficult to understand. This has led us to conclude that there is a need to simplify the system and provide more transparency. Fourth, that in order to successfully start up new companies that are founded on academic research, there is a need for capable managers who have a thorough understanding of the biomedical innovation process. Given the short supply of such proficiency in the region, it is of great value that the BMV programme has established a school of entrepreneurship that focuses on biomedicine.

One-fifth of the responding companies characterised themselves as corporate spin-outs. While there is no general rule, based on this current stock of biomedical companies, that demarcates what is considered a positively sufficient contribution to entrepreneurship, it is quite possible that the spinning-off of more companies from the established firms represents an opportunity to develop the region's biomedical industry that is not being fully exploited. The region's large biomedical firms are of particular interest, as they may have R&D projects or businesses that do not fit their future strategies. Companies like AstraZeneca do, periodically, reconsider their project and business portfolios and may decide to cease certain activities, or to temporarily place some activities outside their firm's parameters. With suitable support from regional policy-making organisations, initiatives may be taken to ensure that such activities remain in the region where they may be further developed even if in a new setting. A good example would be a project being transferred to another firm or organisation, or taken as leaping-off point for the establishment of a new company.

In order for the industry and the innovation system to prosper, it is simply not enough to create new firms; it is needless to say that to achieve the desired results these firms have to grow. And *growth* does not follow automatically upon the formation of a firm. As a point of fact, the bioscience industry is generally characterised by the relative absence of growing firms. There are quite obviously many difficulties and inherent problems that biomedical and biotech firms have to overcome in order for them to grow and become prosperous. The responses indicated that many of the aspects

related to firm growth do seem to work well in the region; for example, many firms described themselves as having strong technologies, a strong market position, high R&D intensity, many projects in the pipeline, and plans to enter new markets and introduce new products. Furthermore, the firms seem to have good relationships with both competent customers and knowledgeable financiers. There are, however, also some worrying signs. For instance, despite expansion plans many of the companies did not foresee the recruitment of new personnel to any major extent. The responses also indicate some of the weaknesses of the region that may affect future growth. In particular, the absence of a critical-mass of firms is seen as a major drawback. Additionally, respondents point to the lack of regionally-based venture capital and the dearth of dedicated lobbyists.

The respondents do not see their location in the region of Western Sweden as a major competitive advantage *per se*. This does not mean, however, that the regional characteristics are unimportant it may merely mean that the companies do not emphasize them. In actuality, the firms collaborate with many regional partners and greatly access knowledge from the region. Consequently, by providing firms with a supportive environment that encourages and enables them to gain access to valuable resources, the regional innovation system can prove a significant factor in these firms' success. Subsequently, the BMV programme's function, as a tool to unite and mobilise key regional actors, has a central role to play. Not only by stimulating the formation of firms, but also by helping existing firms to grow.

In spite of the fact that the majority of activities related to innovation are carried out internally, external collaboration is of crucial importance to the companies. Customers and suppliers constitute their most important category of partnership. Hence, business relationships are used not only for purely commercial purposes, but also as a vital resource for the development of technology. Usually this type of partner is located outside the region, quite understandably given the small size of the region and the companies' need to establish strategic partnerships in different geographical markets. Universities also critically act as key partners, and collaborating universities are often located in Western Sweden. This means that regional universities not only play a key role as breeding grounds for new firms, but equally, they provide established firms with vitally important opportunities for co-operation. Research – in contrast to later-stage product development – usually involves a higher amount of tacit (not codified) knowledge; this most likely explains why geographical proximity and face-to-face interaction are relatively more imperative when it comes to academic collaboration (in contrast to customer-supplier collaboration).

Looking to the future, there are a number of opportunities and recommendations for developing the innovation system that can be identified. It is quite apparent that the firms in the region, both those existing as well as new ones, have an important role to play – if the ambitious goals of the BMV programme are to be realised. Let us start with the issue of *firm formation*. First, it should be possible to exploit the existing entrepreneurial role of the universities. It is true that both the Sahlgrenska Academy and Chalmers have embarked on promising initiatives to help researchers start new companies; yet there is room to further improve incentives and support systems. Second, the opportunities for spinning off new firms from established companies should be more thoroughly explored. Third, enriching the innovation system by attracting Swedish or foreign firms to establish their activities in the region should be more actively pursued. In particular, the strength of the biomaterials cluster (including firms as well as research units) should be utilised as a valuable asset in this context. In the field of drug discovery and development, the likelihood of cluster building hinges upon the active participation of AstraZeneca. Fourth, so far there seems to be a wealth of largely untapped ideas and inventions originating in practical health care operations that could serve as a valuable source of new firms (as well as innovations in established firms).

As previously mentioned, the specific prerequisites for the firms' continued *growth* seem to be favourable; however, the current lack of a critical mass of biomedical firms in the region is seen by many respondents as an inhibitor. To increase the number of firms and enable their growth the availability of venture capital in the region needs to be improved. Measures to increase the mobility

of employees, both within the industry and between the industry and academia, as well as assisting small firms to internationalise can also be expected to pay positive dividends. Once again, how AstraZeneca chooses to act is crucial in its effect on the pharmaceutical field. Ongoing attempts to extend the participation of academic researchers in the company's drug development process could, hopefully, reap benefits in growth potential for both AstraZeneca and possible partner companies in the region.

To conclude, the following conceivable threats or risks that could jeopardise the positive development of the innovation system should be mentioned. First, given the industry's dependence on the regional universities, a weakening of the universities' research base would undoubtedly lead to negative consequences, especially in the long term. Second, several of the region's key companies are, to some extent, owned by foreign investors or belonging to foreign groups. There is a risk that foreign ownership may decide, for a variety of reasons, to move certain activities out of the region. A third possible threat concerns the actions, or inactions, of the managements of the universities and the university hospital; should they take measures or send signals that reduce researchers' willingness or opportunity to engage in commercial isation, this effect on the innovation system would be to slow down the formation of firms and make it more difficult to establish fruitful university-industry interaction. Experience indicates that there is a need to improve the coordination and co-operation between the different units that are engaged supporting innovation. Failure to do so, resulting in too many parallel and competing support activities, could lead to inefficient and redundant performance.

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1 Introduction to a survey of biomedical firms

1.1 Biomedical Development in Western Sweden – The BMV programme

There are a number of well-known and successful biomedical companies located in Göteborg and the surrounding vicinity, among them are AstraZeneca's R&D unit in Mölndal, Nobel Biocare, Astra Tech, Mölnlycke Health Care and SCA's incontinence care business.[1] Over the years, all of these companies have developed and brought to market a range of innovative products; some of which were developed primarily in-house, and others whose development was based on collaborative research with local academic scientists and health care institutes. In addition to these large firms, there are a growing number of smaller biomedical firms that in numerous cases have been founded for the purpose of commercialising research results and product ideas that originated within the region's universities and hospitals. Some of these technology-based firms develop different types of medical devices – often related to the use of new biomaterials – while others focus on pharmaceuticals, diagnostics, or other biotechnology-based products or services.

In line with this positive historical account, there is an increasing consensus among actors in the industry and in the public sector (including local policy-makers) that there is an even greater potential – so far largely untapped – to further develop this type of industry. In fact, the life science sector, broadly defined, is growing rapidly worldwide, and there is potential for the region to be a key player in that development. In order to realise these growth opportunities, it is perceived that regional as well as national policy measures are needed to support the development of the biomedical industry and to strengthen its international competitiveness.

One of several such initiatives taken in recent years is a long-term, regional development programme, named "Biomedical Development in Western Sweden: A New Innovation System" (hereinafter to be called *the BMV programme*).[2] It started in 2005 as a public-private partnership financed jointly by Vinnova (through its *Vinnväxt* programme),[3] and a number of regionally-based actors in the public and private sectors.[4] The aim of this programme is "to create a solid base for long-term growth in the biomedicine field within the Göteborg region, by cultivating academic research and commercial innovations and adaptations within the health care system".[5] Externally, BMV is better known as GöteborgBIO, which is the programme's "communication platform" (i.e., one of its five sub-processes).[6]

Expressed in the terms used by Vinnova, the BMV programme aims at developing "the biomedical innovation system" in the Göteborg region. According to Vinnova's definition, an innovation system consists of "actors within the research, industrial and political/public sector who through collaboration generate, exchange, and use new technology and new knowledge in order to create

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[1] We use the term biomedical companies in a broad sense, incorporating firms that develop, produce and/or market pharmaceuticals, diagnostics, medical devices, biotech supply products (i.e., tools for biotechnology R&D and production), and contract/clinical research services.

[2] In Swedish it is called *Biomedicinsk utveckling i Västsverige: ett nytt innovationssystem*, or *BMV*.

[3] Vinnväxt is an industrial political initiative of Vinnova, the Swedish Agency for Innovation Systems, to promote strong research and innovation environments. It was launched in 2001 and set up as a competition between different proposals for regional development programmes. The winners received a ten-year grant from Vinnova on the condition that regional actors from the public and private sectors would allocate matching funds.

[4] The principal players in the BMV programme are: Business Region Göteborg, Region Västra Götaland, The University of Gothenburg, Chalmers University of Technology, *Innovationsbron Väst*, AstraZeneca, Mölnlycke Healthcare, Nobel Biocare, and Doxa.

[5] This aim is stated on GöteborgBIO's homepage (www.goteborgbio.se). GöteborgBIO is also used as a brand name for the region's biomedical innovation system. See also Laage-Hellman and Rickne (2007) for a description of how the BMV programme emerged as a result of a regional interaction and legitimisation process.

[6] The other sub-processes are: Incubator, Göteborg International Bioscience Business School (GIBBS), Focus area Biomaterials and Cell Therapy, and Focus area Cardiovascular and Metabolic Diseases.

sustainable growth by means of new products, services and processes".[7] An innovation system can be deliniated to a nation, a region, a sector, or a combination thereof. In this case, the focal innovation system is obviously delineated by regional and sector. In fact, the networks and interaction processes linking the actors within the region – and to other actors both outside the region and in an international context – are vital features of any innovation system. Consistent with this assumption, the BMV programme sees the strengthening of collaboration and the flow of knowledge between various types of biomedical actors, such as firms, academic institutes, and health care organisations, as important means by which it may achieve its long-term goals. Moreover, it is thought that more effective interaction among actors within the region and connections to knowledge hubs globally, will benefit the commercialisation of scientific knowledge and other valuable resources residing within the universities, and lead to more rapid growth.[8]

In order to understand more profoundly *in what direction* and *by what mechanisms* the regional biomedical innovation system needs to be developed, this report presents the activities and views of biomedical companies.[9] It should be noted that in this study the concept of Western Sweden has been enlarged to encompass the whole of the *Västra Götaland* Region as well as the County of *Halland*.[10]

In particular, there is a major focus on the companies' learning processes and their flow of knowledge, so as to better grasp the needs of the firms and the functioning of the regional innovation system. For the interested reader, prior to presenting the findings this report starts off by giving a brief commentary on the theoretical approach used and the methodological issues that were raised. The report then continues with an overview of the biomedical actors operating in Western Sweden (section 2). Section 3 begins by illustrating the characteristics of new firm establishment; it then takes it a step further. In order to understand the needs and competencies of the biomedical sector the activities of the responding companies, in terms of R&D efforts, innovation, their role in the value chain, and expansion plans, are all analysed. Section 4, brings us to a discussion of knowledge necessities, knowledge sources, and the collaborative patterns of the companies in the region. Section 5 discusses the role of the region. Finally, the concluding section summarises the main findings and identifies several of the key opportunities available for the further development of the biomedical innovation system.

The analysis presented in this report is in essence based on a comprehensive questionnaire distributed to all biomedical firms in Western Sweden – including those active in pharmaceuticals, diagnostics, medical technology and "biotech supply" (i.e., firms developing, manufacturing or marketing biotechnology-based tools for research or production).[11] [12] In addition, complementary

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[7] Translated from Swedish. See http://www.vinnova.se/Om-VINNOVA/Nyckelbegrepp/.

[8] The BMV programme has ambitious goals including doubling the number of employees in the sector in ten years and establishing Göteborg as one of Europe's leading biomedical regions.

[9] As part of this regional programme, Laage-Hellman and Rickne carry out a research project with the purpose of tracing the developments and analysing mechanisms of industrial renewal. The research is carried out in collaboration with RIDE at Chalmers University of Technology and CIRCLE at Lund University (both RIDE and CIRCLE are Vinnova-sponsored centres of excellence specialising in innovation research). We gratefully acknowledge financing from the BMV programme, and administrative assistance from the Institute for Management of Innovation and Technology (IMIT).

[10] Although the name of the programme contains Western Sweden it is clear from the proposal submitted to Vinnova that BMV is mainly concerned with the Göteborg region.

[11] This is one of several research activities carried out within this project. For example, a similar survey has been carried out aimed at biomedical researchers at academic institutes in the region. Our greatest appreciation is directed towards the companies that have answered the survey, and also to GöteborgBIO for their help in identifying the firms.

[12] The survey was carried out during the second half of 2006, whereby an on-line, web-based survey tool was used. Out of 222 questionnaires distributed, 78 had been completed when the data collection was finished at the end of December. After having eliminated questionnaire-receiving firms that turned out not to be relevant to the study, the response rate amounts to 35 percent. For more details regarding the methodology, see Appendix 1. See Appendix 2 for a list of the companies included in the study (i.e., receivers of the questionnaire).

data of a more qualitative nature has been collected through the use of interviews conducted with thirteen selected companies that represented different sub-sectors.[13]

1.2 The innovation system approach

An innovation system is an analytical concept widely used by academic researchers studying technological innovation, industrial development and economic growth. In recent years this concept has also become increasingly prevelant among policy-makers in many countries around the globe. This includes policy-makers working at the national and regional levels, as well as in international organisations such as the OECD, UNIDO and the European Commission. With this dissemination of the concept, it is today used by all types of actors, including firms, universities, financiers, etc. It should, however, be noted that while the use of the term "innovation system" as defined above is well established in academia and in the policy-making world, many practitioners often use it differently. When talking about the innovation system, what they frequently refer to is the *support system*, that is, the various support or bridging organisations that are set up for the purpose of stimulating innovation (e.g., science parks, incubators, technology transfer offices, financing organisations etc.). In contrast, the term innovation system as used by analysts and policy-makers in general, and by this report in particular, does not only include the aforementioned support system, but also encompasses *all the actors* that in various ways contribute to the generation, use and diffusion of new knowledge and innovations. The innovation system also includes the *knowledge and the artefacts* related to the specific innovation processes (in this case biomedicine), the *networks* between actors, and the *institutions* guiding any actions.

In fact, innovation systems customarily are described and analysed in terms of precisely these *structural components*, that is, artefacts, actors, networks and institutions.[14] First, *knowledge and artefacts* may also include technology, intellectual property, as well as products. Second, the *actors* includes firms along the entire value chain (including those both up- and downstream), universities and research institutes, public organisations and authorities, and private organisations (e.g, trade associations and venture capitalists). In the field of biomedicine, the public sector is represented both by health care providers (e.g. hospitals) and other public organisations involved in regional or national policy-making or support activities (such as science parks, incubators and seed financiers).

The third component, *networks*, consists of different types of relationships that in various ways link the actors to one another and to other actors outside the borders of the specific region or sector. These relationships can be both formal and informal. Of great importance are, for example, the business relationships between buyers and sellers, or the collaborative relationships between firms and universities or other research-performing organisations (in the case of biomedicine, important research activities, for example, are often carried out at hospitals). Firms may also be involved in other types of relationships or networking activities, with different types of bridging organisations, financiers, non-governmental organisations (NGOs) and consumer interest groups.

The fourth component, *institutions*, represents "the rules of the game", this includes laws and regulations as well as softer aspects such as norms, routines, habits and cultures. The biomedical field is, for obvious reasons, heavily regulated and thus governed by a broad range of laws, rules and guidelines that have a crucial impact on the actors and in turn how the innovation system develops. There are also many other institutionalised practices that the actors have to take into consideration when, for example, developing and commercialising new products.

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[13] This interview study focusing on collaborative patterns is separately reported in Andersson et al (2007). In selecting the firms to be interviewed, we chose to focus on mid-sized, R&D-intensive firms in three "sub-sectors"; those being, pharmaceuticals/diagnostics, medical devices, and "others" (mainly developers of biotechnology R&D tools), as well as a few small start-ups. In analysing and interpreting the survey data we made use of complementary knowledge and insights.

[14] See e.g. Carlsson and Stankiewicz (1991).

Another way to describe and analyse an innovation system, and to perhaps better capture its dynamic aspects, is to not only study it in terms of its *structural components* but also in terms of the system's *functional patterns* and *functionality*.[15] This implies a focus on what we call the *key processes*, or *functions*, around which the system is built. These key processes include: the creation, diffusion and utilisation of knowledge; how actors and technologies are given legitimacy; the process by which markets are formed; entrepreneurial experimentation; how and to what extent appropriate resources are mobilised; the processes influencing actors to seek out and exploit specific knowledge or opportunities; and the process by which 'free utilities' such as a pooled labour market are created.

In this report, we analyse a regional innovation system for biomedicine from the perspective of the associated biomedical firms. This means that first we map-out who these firms are, what they do in terms of R&D and product development, and what their market focus is. Our concentration is therefore on understanding how these firms experience the key processes mentioned above, with particular emphasis on the creation, diffusion, and use of knowledge. We analyse this by ascertaining the details of the firms' innovation processes, what types of knowledge input they require, and how this knowledge can be acquired through their collaboration with other actors – regionally, nationally or internationally. In addition, we asked the firms about their own views concerning the regional innovation system, and in what dimensions they felt the region and its resources are satisfactory and where improvement was needed.

Accordingly, in relation to the regional innovation system as such, we determined the need to analyse some of its structural components. The report's focus is on one type of *actor*, the biomedical firm, whereas other actors are only mentioned in as far as they are partnering with biomedical firms.[16] The *networks* we aim to capture are the firm-specific networks, that is, the web of relations surrounding each company, connecting it both to other actors within the region and outside of it.[17] In terms of *key processes* (or *functions*), the report reviews how *knowledge* is created, disseminated, and used by the biomedical companies (see, in particular, section 4). We also touch upon some of the other key processes: to what extent technologies and products are given legitimacy, the firms' view on entrepreneurial experimentation, to what extent the firm can mobilise the appropriate resources, and whether a pooled labour market exists.

2 Biomedical actors in Western Sweden: an overview

This section familiarises the reader with the biomedical innovation system by giving an overview of the structure of the actors involved, with emphasis on the companies. We will thus start by identifying which firms belong to the innovation system, giving some basic data about the larger firms, and proceed from there to identifying and commenting on the other important actors that also belong to the innovation system. The section finishes by matching up our research to a cluster study that was carried out by Vinnova a couple of years ago; and finally by characterising the sample that was obtained.

2.1 Biomedical companies

In the focal region there are more than 200 firms that can be termed "biomedical", in keeping with our broad definition. However, from an economic perspective the industry is dominated by a relatively limited number of large firms. As summarised in Table 1, there are six companies that carry out major industrial activities and have a comparatively large number of employees in the region:

[15] This is argued by e.g. Bergek et al (2006).

[16] The *artefacts* of the system – e.g. specific technologies, intellectual property, products, etc. – are not analysed in detail, although knowledge – as an artefact – is at the core of the mapping of collaborative patterns.

[17] Institutions are not at the centre of this analysis, but they make their way into the report through their being mentioned by the respondents as explicitly influential.

AstraZeneca R&D Mölndal, Astra Tech, Getinge, Nobel Biocare, Mölnlycke Health Care, and SCA's product segment for incontinence care.

Table 1. The largest biomedical firms in Western Sweden[18]

Name of Company	Types of products	Turnover (BSEK)	Total number of employees	Total Number of employees in the region	Form of Ownership
AstraZeneca R&D Mölndal	Pharmaceuticals	n.a.	2,700	2,700	AstraZeneca (public company)
Astra Tech	Medical devices	2.7	1,900	880	AstraZeneca (public company)
Getinge	Medical devices	13.0	7,500[19]	530[20]	Public company
Nobel Biocare	Medical devices	5.4	2,000	250[21]	Public company
Mölnlycke Health Care	Medical devices	4.1	5,500	300	Private company[22]
SCA Incontinence Care	Medical devices	11.7	n.a.	300	SCA (public company)

AstraZeneca is the only large pharmaceutical firm in the region that has a major R&D unit; however, several other "big pharma" firms have sales offices located in Göteborg. In addition to their sales and marketing activities, some of these offices are also involved in running the clinical trials that these firms carry out in Sweden (e.g., GlaxoSmithKline and Bayer).

AstraZeneca's R&D unit in Mölndal is one of the company's eight complete and multi-skilled R&D centres that are carrying out both drug discovery and drug development. Within AstraZenca's global therapy area-led R&D organisation, since the time of the company's formation through a merger between Astra and Zeneca in 1999, the Mölndal facility has had the responsibility for both cardiovascular medicines and gastrointestinal medicines. In both of these therapy areas the R&D unit in Mölndal has historically been very successful in developing new blockbuster products (including the ulcer medicine Losec and its follow-up Nexium). Since the merger, the Mölndal unit has expanded by investing in new facilities and through the recruitment of new people. It now has approximately 2,700 employees, mainly R&D personnel, but also some hundred people who are involved in the global marketing of products that are developed in Mölndal.[23] It is not expected that the staff will increase in the near future; more likely it is the other way around. In the first half of 2007, AstraZeneca announced its plans to reduce the total number of employees in the group. Though, it is not yet known how large these reductions will be and where they will take place.[24] [25]

[18] The data presented in this table has been sourced from the companies' homepages, annual reports for 2006, the *Affärsdata* database, or in some cases through direct contact with company representatives.

[19] In August 2007, after having acquired Huntleigh Healthcare in the UK, Getinge had 10,500 employees worldwide.

[20] About 495 in Getinge (20 at the head office and 475 working for the business area Infection Control) and 35 in Skärhamn.

[21] At the end of 2006, Nobel Biocare had 460 employees in Sweden (Göteborg, Karlskoga and Stockholm).

[22] Current owners are Investor, Morgan Stanley Principal Investments, and the Management group.

[23] AstraZeneca R&D employs around 12,000 people who are working at facilities in seven countries. Close to 5,000 are working in Sweden (Mölndal, Södertälje and Lund).

[24] As a result of a strategic review of its R&D focus, AstraZeneca has decided to withdraw from certain disease target areas. This includes the development of drugs for hypertension and certain gastrointestinal disorders for which the Mölndal unit is now responsible. It is not known the effect this will have on projects that are already in progress, and the related personnel resources.

[25] It should be noted that this unit is an R&D facility. This means that the production and sales of new products coming out of this unit will take place elsewhere, that is, outside of the region of Western Sweden. This also means that the effects of producing the new products, in terms of increased sales and employment, will not be visible in the statistics

Unlike AstraZeneca, all of the other large firms operating in the region are manufacturers of medtech products. Two of them, Nobel Biocare and Astra Tech, belong to the world leaders in the field of dental implants. Nobel Biocare is a pioneer in the field and currently the world's largest supplier of titanium-based dental implants. The company was established by Bofors (later Nobel Industries) in 1981 with the purpose of commercialising Professor Per-Ingvar Brånemark's pioneering research on osseointegration, i.e. bone-anchoring of prostheses. Although not being a typical academic spin-off, Nobel Biocare's business, now covering the whole area of restorative aesthetic dentistry, has its origin in research that was carried out at the University of Gothenburg. Today, Nobel Biocare is a global company with a legal residence in Switzerland, and headquarters in both Zürich and Göteborg. Of its 2,000 employees worldwide, 460 are based in Sweden 250 of whom are in Göteborg.

Astra Tech, a subsidiary of AstraZeneca, located in Mölndal close to the pharmaceutical R&D unit, is one of Nobel Biocare's major competitors in the world market for dental implants. While the latter is totally focused on dentistry, Astra Tech also manufactures other types of medical devices, primarily single-use products for the therapeutic areas of urology, surgery and radiology. Sales of these products account for half of the firms' annual turnover.

Mölnlycke Health Care (MHC) was formed in 1997 as a spin-off from SCA and Tamro in Finland. MHC is now a private company, since early 2007 it has been owned by Investor and Morgan Stanley Principal Investments, with minority interests held by the Management. MHC is a truly global company with its headquarters in Göteborg. Its business is divided into two divisions, Surgical and Wound Care, both of which are world-leading suppliers of single-use products. Manufacturing takes place in nine factories, though none them is located in Sweden. However, the R&D activities of both divisions are located at facilities in Göteborg.

Since it spun off its clinical division to form Mölnlycke Health Care, SCA's medtech activities have been entirely focused on incontinence care, where it has built up a world-leading position with its strong global brands. Incontinence Care is one of three product segments within SCA's Personal Care business area which is headquartered in Munich (Germany). However, the key strategic functions for international marketing and R&D are located at SCA's office in Mölndal. In 2006 the turnover for the Incontinence Care segment amounted to BSEK 11.7, which corresponds to 55 percent of the Personal Care business area's total sales. The production of these products takes place in more than ten plants around the world. A small quantity is manufactured at SCA's plant in Falkenberg. More importanty, from a regional point of view, is that close to 300 people are working for the segment in Mölndal, the majority of them with R&D.[26] Given the overall size of the business SCA's presence in the region, in terms of employment, might not seem so impressive. Nonetheless, given the strategic importance of the activities carried out in the region, SCA must be considered as an essential medtech player that has the potential of making important contributions to the development of the region's biomedical industry and the innovation system as a whole.

Getinge is a highly internationalised medtech company with headquarters in Western Sweden, more precisely in Getinge in southern Halland. The company has expanded rapidly in recent years, predominantly through the acquisitions of Swedish as well as foreign firms. In addition to the group headquarters, one of Getinge's three business areas, Infection Control, is operating in the region (in 2006 it had a turnover of BSEK 4.3 and 2,800 employees worldwide). In the Infection Control business area the company produces disinfectors, sterilisers and other products used to prevent the onset and spread of infection. This production is conducted in twelve plants around the world, two of which are located in Western Sweden (Getinge and Skärhamn) where they are producing sterili-

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for the region. The result of this is that in order to correctly measure the economic effects of the research carried out in Mölndal one has to take into account activities that are carried out in other parts of the AstraZeneca Group.

[26] Almost all R&D activities related to the incontinence care products are carried out in Mölndal. This also means that many of the most important collaboration partners for these products are located in the region or in other parts of Sweden. Chalmers, for example, is the most important partner on the academic side.

sation equipment. Getinge has two other business areas, Medical Systems and Extended Care, but they are not carrying out any activities in the region.

Of the firms just presented above, AstraZeneca's R&D Unit in Mölndal, Nobel Biocare and Mölnlycke Health Care are all actively involved in the BMV programme, as principals, and additionally as participants in specific projects.[27] The remainder of the above mentioned firms are currently not involved, even though they are undoubtedly central actors in the innovation system and may, through their own actions, affect how the system develops. Needless to say, there is the possibility that at a later stage they will also become more directly involved in the programme itself.

As well as these large firms, a large number of other biomedical firms call the Western Sweden region home. Of particular interest for the present study are, quite evidently, those that are carrying out R&D activities, be they related to the research or development of products (goods), services or processes. There are also many biomedical firms that are not performing any technological R&D whatsoever, or only to a limited extent; for example, many of the firms are sales companies that simply distribute and market products that are most often imported from abroad. Furthermore, there is a range of more service-oriented companies that do not have any R&D function either.

Many of the R&D-performing companies are small and/or young. But as shown in Table 2, there are a considerable number of firms that are quite active in pursuing R&D in the three sub-sectors of pharmaceuticals, medical technology, and biotech supply, in this context they can be characterised as mid-sized.[28] They have established products on the market, and have to varying degrees started to grow.

As the data in Table 2 suggests, with the exception of AstraZeneca the pharmaceutical sub-sector is quite weak in this region. Currently, there are only two mid-sized drug companies with substantial operations in the region, namely Abigo Medical and NeuroSearch. The former manufactures and markets licensed products, as well as products developed in-house, such as wound healing or other product areas of a medium or low research intensity. NeuroSearch – previously known as Carlsson Research – is originally a spin-off from the University of Gothenburg that was based on Nobel Laureate Arvid Carlsson's pioneering research on diseases of the central nervous system. In 2006, the Danish firm NeuroSearch A/S bought the company and renamed it. Arexis, another company that moved to Göteborg a few years ago and began to expand, in 2006 it was acquired by the Stockholm-based Biovitrum (Sweden's largest drug discovery company). Since then, most of Arexis' research has been moved to Stockholm, and as of today it is still unclear what level of research activity, if any at all, will remain in Göteborg. While there are several other university spin-offs in the field of pharmaceuticals, such as Pharmasurgics, Duocort, and Vivolux, these firms are still very small and in an early stage of development.

We can conclude that in the pharmaceutical sector, there is no real company cluster in the region. AstraZeneca, through its large R&D facility in Mölndal, can be characterised as a "monolith" which utterly dominates the industry. It accounts for more than 70 percent of all the employees in the pharmaceutical industry.[29] AstraZeneca has no main linkages to other drug companies in the region; Arexis (now Biovitrum), for example, was rather seen as a potential competitor.[30]

[27] This means, e.g., that these firms make economic contributions to the programme and are represented on the Board and in other management groups at lower levels.
[28] Note that the table includes Biovitrum/Arexis, which is now moving out of the region.
[29] In 2004, the whole pharmaceutical sector employed 3,760 people across 57 companies (Vinnova, 2005).
[30] AstraZeneca has collaborations with biotech supply companies in the region, e.g., regarding specific research tools.

Table 2. Mid-sized biomedical R&D-performing firms in Western Sweden

Name of Company	Types of product	Year of foundation	Total Turnover MSEK*	Number of employees*	Form of Ownership
Abigo Medical	Pharmaceuticals	1989	39	23	Private company
Biovitrum (previously Arexis)	Pharmaceuticals	1999	n.a.[31]	n.a.	Biovitrum (public company)
NeuroSearch AB (previously Carlsson Research)	Pharmaceuticals	1998	n.a.	n.a.[32]	NeuroSearch A/S (public company)
Artimplant	Medical devices	1991	5.5	30	Public company
Breas Medical	Medical devices	1991	175	61	Vital Signs Inc. (public company)
Carmel Pharma	Medical devices	1996	146	46	Private company
Cochlear Bone Anchored Solutions (previously Entific Medical Systems)	Medical devices	1998	286	74	Cohlear Ltd (public company)
Elos Medical**	Medical devices	n.a.	85	94	Private company
Fujirebio Diagnostics (previously CanAg Diagnostics)	Medical devices	1983	73	35	Fujirebio Inc. (public company)
Neoventa Medical	Medical devices	1987	25	19	Private company
RTI Electronics	Medical devices	1981	24	23	Private company
Surgical Science	Medical devices	1997	11	7	Private company
Qualisys	Medical devices	1989	28	14	Private company
Cellartis**	Biotech tools	2001	8	24	Private company
Cellectricon**	Biotech tools	2000	58	21	Private company
Millipore/NovAseptic**	Biotech tools	1993	218[33]	59	Millipore Corp (public company)
Q-sense**	Biotech tools	1996	16	11	Private company
Spotfire**	Biotech tools	1996	(125)	(66)	Private company
Vitrolife	Biotech tools	1989	131	71	Public company
Arcam	Manuf. equipm.	1997	(47)	(21)	Private company
Pharmadule Emtunga**	Manuf. equipm.	n.a.	(1,400)	(515)	Private company

* These numbers are drawn from the *Affärsdata* database, unless otherwise stated, and refer to 2006, if not otherwise stated.

** For these companies, turnover and employment numbers are from 2005.

In the medical technology sector, by contrast, the region is the home of several successful companies (see Tables 1 and 2). Thus, this sub-sector is not as concentrated as is the pharmaceutical. All the same, it can be estimated that the five largest companies account for approximately 75 percent of the sector's total employment in the region.[34] The sector is strong, especially in biomaterials-related businesses. As well as the large companies (Astra Tech, Nobel Biocare, and Mölnlycke Health Care) there are several others working in the field including Artimplant and Cochlear (see Table 2); in addition to these there are also several smaller ones, such as Brånemark Integration, Integrum, Integration Diagnostics, Promimic, Tendera, and Biopolymer Products. In conjuntion with regional academic institutes that are active in the area these firms form an internationally strong cluster.

There are also successful companies in the region that range across other areas of the broad field of medtech; we have already mentioned Astra Tech, Mölnlycke Health Care, Getinge and SCA Incon-

[31] In 2005, before Biovitrum's acquisition, Arexis had 28 employees and a turnover amounting to MSEK 5.
[32] Before NeuroSearch's acquisition in 2006, Carlsson Research had 33 employees (*Ny Teknik*, 2006).
[33] April 2004 – May 2005; according to company press release (15 June 2005).
[34] In 2004, the whole medtechmedtech sector employed 3,000 people across 97 companies (Vinnova, 2005)

tinence Care. All of them have successfully developed and put on the market different types of products, sold both in Sweden as well as abroad; now several others are following suit. Breas Medical (home care ventilation and sleep therapy products) and Carmel Pharma (system for handling of toxic drugs) are two companies that have grown relatively quickly in the past ten years, and reached significant sales totals. Finally, there are several other companies which have developed and launched unique R&D-based niche products, but as is common in this type of business they are still experiencing a slow penetration of the market; examples of these are Neoventa Medical (perinatal medicine), Surgical Science (computer-based tools for training of medical professionals), and Qualisys (systems for optical motion capture).

The medtech companies mentioned above can be characterised as "research-based" and many of them commercialise products based on technologies that originated in academia. The region also has other more traditional medtech companies that manufacture various types of devices. The largest firm in this category, and included in Table 2, is Elos Medical, which is an export-oriented manufacturer of surgical and orthopaedic implants and instruments. It acts as a sub-contractor for a range of medtech companies in Europe and North America.

There are other, more recently founded companies that are engaged in the development of new medical devices, most of which have not yet reached the market. Some illustrations of companies that seem to have promising products in their pipelines are Aidera (transmission of information from glucose meter and insulin pump), BioPix (imaging software for quantification of cellular objects), Micropos Medical (system for 4D radiotherapy), and Velsosense Biodiagnostics (point-of-care diagnostics).

Reminiscent of the medical technology sector, the biotech supply sub-sector is characterised by diversity in the types of product the companies work with. But unlike the medical technology subdivision there are no big companies operating in the region. We can, however, see in Table 2 that there are a number of fairly successful R&D-based companies. Both Vitrolife and Cellartis belong to a small cluster that is dealing with stem cells that not only includes internationally-leading academic research groups, but also includes a small start-up company called Cell Matrix. Vitrolife, with its origin emanating from the University of Gothenburg's pioneering research on in-vitro fertilization (IVF), is now active in three product areas – Fertility, Transplantation, and Stem cell cultivation – producing a variety of types of solutions, media, and instruments.[35] Cellartis is a world leader in stem cell technology serving as a significant source of human embryonic stem cell lines. The company's current focus is on stem cells acting as tools to be used in drug discovery and toxicity testing.

The other firms in the biotech supply category work in very disparate product and application areas. Spotfire – originally based on bioinformatics-related research that was carried out at the University of Maryland in the US and at Chalmers University of Technology – is a very successful software company with some of its most important customers coming from the global pharmaceutical industry (which uses Spotfire's products for data-mining in its search for potential drug candidates). The headquarters of the company, which since its inception has expanded its business to other application fields (e.g. business intelligence), moved from Göteborg to Boston a few years ago, but much of the development work is still carried out in Sweden. In May 2007, the California-based TIPCO Software Inc. announced its plan to buy Spotfire for a price of BSEK 1.3.

Both Cellectricon and Q-Sense are spin outs from Chalmers and commercialise advanced analysis tools. The former, active in the fast-growing nanotechnology field, develops miniaturized cell-based screening devices for applications in biotechnology. Their products are used by large pharmaceutical companies in their drug discovery research. AstraZeneca is one of the top-reference customers

[35] We have chosen to classify Vitrolife as a biotech supply firm. But through its IVF products Vitrolife is also active in the medtechmedtech field.

that Cellectricon collaborates with.[36] Q-Sense is developing an instrument for studying molecule-binding on various surfaces, with potential applications in nanotechnology, biomaterials, drug discovery and biosensor development.

Unlike the previous two firms, Millipore/NovAseptic supplies products for production rather than research. More precisely, this company, which since 2005 is owned by American Millipore, is a rapidly growing manufacturer of process components for sterile and aseptic applications in the pharmaceutical and biotech industry.

In addition to the above mentioned biotech supply firms, there is a range of other, smaller, and younger ones who are working on exciting new technologies. The following firms are typical examples of this: Appeartex, Cell Matrix, CIVO Bioscreening, Denator, Layerlab, Midorion, Nanoxis, and Tataa Biocenter.

In Table 2 we have included two other companies that should not be forgotten. Arcam and Pharmadule Emtunga are not usually described as biomedical firms, but they are essential suppliers of production equipment to the biomedical industry and should therefore be included in the innovation system. The former is an interesting high-tech company for which biomedicine – more precisely the manufacture of medical implants – is one of several important application fields. Arcam provides medtech companies with uniquely designed equipment for the free-form fabrication of complex parts from metal powder. In 2006, it had 21 employees and reached MSEK 47 in sales (however, it is not known what share of the medical implants market this accounts for). Pharmadule Emtunga is a world-leading supplier of advanced modular production facilities. One of the two divisions, located in Göteborg, produces facilities for the pharmaceutical and biotech industry and has several large pharmaceutical firms as customers (in 2005 the company had, in total, 515 employees located predominantly in Western Sweden, and a turnover of BSEK 1.4; however, just as in Arcam's case, no information on what share of the biomedical market this accounts for).

As for the biomedical sales companies operating in the region, some of them are subsidiaries of foreign manufacturers (usually large firms) while others are Swedish firms representing several foreign manufacturers. On the pharmaceutical side there are some twenty companies, including the two national drug distributors – Tamro and Kronans Droghandel – both of whom have major warehouses in the region supplying pharmacies all over the country.[37] Among the foreign pharmaceutical firms we find Bayer, Organon, GlaxoSmithKline and Fujisawa. On the medtech side (including aids for disabled persons and dental products), there are more than fifty sales companied located in the region. Most of them are relatively small (less than fifty employees) and specialised, dealing with very specific types of devices or application fields. There are also 10 -15 companies that specialise in selling biotech supply products.

These sales companies are, with a few exceptions, not carrying out any R&D activities, but thanks to their role as intermediaries between manufacturers and buyers in the health care sector they can be seen as integral parts of the innovation system. They may, for example, play a central role in the introduction of new innovative products into the market and/or the giving of feedback concerning user information to the product developers.

In the biomedical field there are other companies that cannot naturally be categorised as belonging to the main sub-sectors of pharma, medtech or biotech supply. Here we find, for example, Contract (or Clinical) Research Organisations ("CRO-firms"). The largest one based in our region is A^+ Science (previously Scandinavian CRI). There is also the company NMCT, although it is not a real CRO but rather supports clinical trials by assisting pharmaceutical firms to recruit research subjects. In the region, there are additionally a range of other firms selling various types of consultancy services to biomedical firms, or to the health care providers (e.g., Imego, Nordic Medical Advisor,

[36] See Company Brochure available at the company's homepage: www.cellectricon.com.
[37] In 2006,Tamro and Kronans Droghandel had, respectively, 240 and 220 employees in the region.

Medical Radar and Prevas). Moreover, there are companies engaged in such fields as medical analysis/diagnostic services, rehabilitation and implants, and dental services.

2.2 Other actors

Among other actors in the innovation system, the following main categories can be distinguished: universities and other institutes of higher education, research institutes, health care providers and various types of support and policy-making organisations. These actors are of interest to identify as they may be collaboration partners with the region's biomedical firms or in other ways affect the development of these firms.

The University of Gothenburg and Chalmers University of Technology are the largest academic institutes in Western Sweden, and also the most important ones in the biomedical field. There is, since 2001, one faculty inclusive of all health sciences at the University of Gothenburg, this being the Sahlgrenska Academy (SA).[38] The size of the staff is approximately 1,500 people, 850 of whom are researchers or teachers. SA is organised into six institutes: Biomedicine, Clinical Sciences, Health and Care Sciences, Medicine, Neuroscience and Physiology, and Odontology. SA is conducting a broad range of research activities – from basic pre-clinical research, right through experimental and more applied studies of disease mechanisms, to studies on public health care and epidemiology. The pharmaceutical research undertaken is of a distinctly clinical nature and is carried out in close collaboration with the Sahlgrenska University Hospital, where SA's clinical departments and research groups are located. According to SA's own homepage, examples of strong research fields are obesity with cardiovascular research and diabetes, biomaterials, pharmacology, neuroscience, paediatrics, epidemiology, rheumatology and microbiology. Furthermore, their odontological research is said to be at the cutting edge internationally, in fields such as dental biomaterials, implantology, and hard tissue biology.

The University of Gothenburg also has a Faculty of Sciences where there are departments and research groups that carry out research of relevance to the biomedical field. This holds particularly true for the Department of Cell- and Molecular Biology located at the Lundberg Laboratory, and with research focused on genetics, interface biophysics, microbiology, and molecular biology.

At Chalmers University of Technology, technically-oriented research of relevance to biomedicine and health care is performed in different parts of the organisation. In 2005, Chalmers Biocenter was established with a responsibility for coordinating all broadly defined bioengineering activities. Their aim being to strengthen research related to biology, biotechnology and medicine. Currently, major efforts are being made to build up a strong research environment in the field of quantitative systems biology. SP Technical Research Institute, SIK (the Swedish Institute for Food and Biotechnology) and IMEGO are three publicly-owned research institutes that carry out R&D activities in the field of, or of relevance to, the biomedical industry.

In the health care sector, the region is home to the Sahlgrenska University Hospital, which is one of Northern Europe's largest hospitals; additionally, there are a few other relatively large hospitals (e.g. in Skövde and Halmstad). As well as those units providing health care services, Region Västra Götaland, which is responsible for financing and managing public health care in the region, is of course a key actor in the innovation system.

In the region there is also a range of support, bridging, or policy-making organisations that are involved in biomedicine, for example, Sahlgrenska Science Park, Chalmers Innovation, and Business Region Göteborg. Among important regional financiers of biomedical R&D or other innovation activities, one finds the state-owned Innovationsbron Väst, Chalmers Invest, and the private venture capital firm InnovationsKapital. Industrifonden, a state-owned venture capital firm, established a local office in Göteborg a couple of years ago.

[38] For more detailed information, see www.sahlgrenska.gu.se.

2.3 A comment on Vinnova's regional cluster study

In 2004, Vinnova carried out a mapping of the biomedical company cluster in Western Sweden.[39] Focusing on the number of employees in the region, and relating these numbers to key activities, the report describes "cluster profiles" for different subject areas (drug development, diagnostics, medical technology, biotech tools, etc). The study identified 170 biomedical companies which together had 7,800 employees in 2004. This list constituted one main source of information for our work in defining the population for our survey. As mentioned, the questionnaire was sent to 222 firms. Since our survey was carried out only two years after Vinnova's cluster study, there are no dramatic changes with regard to the company structure. However, among Vinnova's 170 firms forty of them were not included in our survey (26 in medtech, 6 in pharma, and 8 others). There are several reasons for that. In some cases, companies have moved out of the region (e.g. Biovator), been acquired by or merged with other regional firms (e.g. Swedmed), or gone into bankruptcy. As well, several of the firms were demmed by us to be classified as health care providers and therefore not regarded relevant for our study. The majority of these forty firms, most of whom are small (with 1-10 employees) and working with sales and marketing, seem to have just "disappeared" (they may have discontinued their activities in the region for one reason of another).

Our survey study clearly includes some ninety firms not covered by Vinnova's cluster study. In some cases, companies have been founded during the last two years. However, the foremost explanation is that BRG's list of firms that we used as our starting point (see the methodology in Appendix 1) was more extensive than Vinnova's list; though it should be noted that most of the added firms seem to be relatively small. Furthermore, in our work we have identified some R&D-based firms that do not appear on any of these lists.

Despite the abovementioned changes during the two last years, it is our opinion that Vinnova's cluster study still provides a fairly accurate picture of the company structure in the region. Thus, on the aggregate level, there are no large changes with regard to the number of employees or what type of activities they are involved in; although individual companies, of course, may have gone through major changes. It is, however, quite normal during a two-year period for any industry to have some companies disappear or downsize, while still others are founded or achieve substantial growth.[40]

2.4 Characterising the sample

The comprehensive questionnaire was distributed to all of the above described biomedical firms in Western Sweden, therefore inclusive of all the firms in pharmaceuticals, medical technology and "biotech supply". Out of these, 35 percent of the firms in the region chose to answer the survey (see Figure 1).[41] [42]

Out of the 222 companies in the study, 123 firms (55%) carry out R&D activities in the region (see Figure 1).[43] As described above, many of the others are service-oriented firms or sales companies that are marketing biomedical products in the Swedish or regional market. These firms have been included in the study for two reasons. First, despite not carrying out their own R&D activities they

[39] Vinnova (2005).

[40] It should be noted that Vinnova's study, like our text in this section, "only" describes and analyses the companies' activities. An important structural aspect of clusters, like innovation systems, is the relationships and networks that bind the companies and other actors – and create important prerequisites for the industry's future development. This type of information is still to a large extent lacking regarding the biomedical industry in Western Sweden. Hopefully, the present study will help shed more light on this. A main focus of our survey data is on the flow of knowledge and R&D collaboration. Institutions are also important for industrial development, however the institutional factors are not a main focus of the present study.

[41] This may be considered a relatively high response rate in an international comparison.

[42] The report also leans on qualitative data, collected through interviews with thirteen selected companies, representing different sub-sectors.

[43] We classified the firms as performing R&D based on the report by Vinnova (2005) as well as company information, such as their web-pages.

may play a role in the transfer or use of new R&D-based knowledge. Second, representatives of these firms may have relevant opinions on, and knowledge about, how the innovation system is functioning. Our response rate is higher for the R&D-performing firms (46%) than for those that are not doing any R&D (21%). This is partly explained by the fact that we have given priority to R&D performing firms in our attempts to increase the response rate.[44]

Figure 1. Response rate and age of the responding companies

The firms

	Number	Response rate
Total sample	222	35% (78 firms)
Firms with R&D	123	46% (57 firms)
Firms without R&D	99	21% (21 firms)

Year of establishment (N= 222, n=78)

2000-2006	19%
1996-1999	22%
1990-1995	13%
1986-1989	17%
1980-1985	10%
1970-1979	4%
before 1970	15%

This sample is relatively balanced in regards of the firms' distribution across different sub-sectors. To put it another way, the response rates reflect the profile of the region's biomedical industry, that being a predominance of medical technology firms in comparison to pharmaceutical and biotech supply firms. In fact, based on the firms' self-descriptions, less than one fifth (17%) of the responding companies are involved in pharmaceuticals, while the same number of firms (13 firms) have diagnostics marked as their main product area. Medical technology, including biomaterials, is the dominant product area (59% of the firms), while biotech supply accounts for only one tenth of the responding firms.

As shown in Figure 1, the age of the companies that have answered our questionnaire varies greatly, with more than half of the respondents established after 1990. Thus, there is a relatively even distribution of age for the responding firms.

3 Firm formation and activities

In order to understand how the regional innovation system can best support the firms in their innovation processes, this section presents facts about firm formation in the region and then analyses the activities the companies are engaged in. In our analysis of R&D activities and innovation output we limit our analysis to those 57 firms that we have classified as R&D-performing (i.e., excluding sales companies), while in the subsequent discussion of the companies' value chain activities and expansion plans, data from both these 57 firms as well as the responding 21 non-R&D performing firms is used.

3.1 New firm formation in the region

The creation of new firms is a vital and central mechanism for the development of innovation systems; accordingly, the stimulation of firm formation is one of the goals pursued by the BMV programme. This section therefore poses the question of how firm formation comes about in the region, and how this process can be further stimulated and encouraged.

As an initial note, we would draw attention to the fact that Western Sweden is a region in which more than half of the R&D-active firms felt that it is *reasonably easy*, or even *easy*, to establish a company. This indicates that there are no major institutional or resource-related blocking mechanisms to the formation of firms in the region. In looking at the responding firms, we found three main categories of the processes by which a firm is formed. First, a company can be founded by one

[44] See Appendix 1 for further details concerning the methodology.

or several independent individuals, who have a business idea. Second, the new firm can be the outcome of a process where it is somehow spun off from an existing organisation. Here, we can distinguish two variants. If the firm is based on scientific knowledge or specific research results residing within a university, it can be called a university spin-out (USO), or spin-off.[45] While, thirdly, if the firm is instead established by an existing company, we call it a corporate spin-out (CSO).[46]

It is clear that the university spin-out is a dominant form of biomedicine-related firm formation in this region. One interesting observation is the significant role played by academic research which has been historically strong in the region. As much as 43 percent of the R&D-performing respondents view themselves as university spin-outs (a third of all responding firms), almost all of these founding researchers were working at *regional* universities at the time of their firm's formation.[47] Today, most of the firms still have founders as co-owners, but whereas around a fifth of the firms are owned by the founder *alone;* the vast majority have a mixed ownership profile that includes several stakeholders.

The corporate spin-outs make up one fifth of the responding firms. If we take our responses to be a representative sample, it could perhaps be seen as somewhat surprising that in a region with such a large number of biomedical companies the CSO phenomenon is not more pronounced. However, this does correspond well with the general observation that roughly three out of four of all respondents state that there is a lacking critical mass of biomedical firms in the region.

Interestingly, venture capitalists were engaged in the formation of approximately one tenth of all respon-ding firms, these being all established during the first half of the 1990s and subsequently thereon. While this may not be a fully representative figure,[48] it is interesting to note that the VC engagement appeared in the 1990s and yet seems not to have been a dominant factor in the firm formation process.[49] Today, VC companies figure as co-owner for almost a third of the responding companies. In general, while the majority of companies do not think it is easy to secure seed or venture financing, it is definitely easier to find financiers in Sweden or in the region than abroad (see Figure 2).

We can conclude that the spin-out of companies from universities is a vital driver behind the innovation system's development and growth; when it comes to the field of biomedicine, this is of course not a phenomenon unique to this region, but a general pattern that is observed in many countries and regions. This indicates that it is of utmost importance not only to secure a continued supply of innovative aca-demic researchers, but also to ensure that the incentive system and other structures at the universities are such that the formation of firms is made possible and perhaps even encouraged. Furthermore, there are some indications that the phenomenon of the CSO has played an important, but so far relatively limited, role for the innovation system. This observation may be linked to the lack of a critical mass of firms that was emphasised by many of the respondents. Thus, efforts to support the growth of existing firms and the establishment of foreign companies in the region will also improve the prerequisites of the CSO process. Nonetheless, to further spur the

[45] These two terms are used interchangeably. According to Shane's (2004) definition, a USO is "a new company founded to exploit a piece of intellectual property created in an academic institution." (p. 4). Given the Swedish teacher's exception, academic start-up companies are usually founded by individual scientists, rather than by the university as an organisation. Thus, USOs denote both firms established by a university *per se*, and those started by an individual researcher or research group employed by or strongly related to the university. Thus, the USO classification is based on the respondents' own view.

[46] A corporate spinout can be defined as a new and independent firm created from resources that previously were part of an established firm. See Wallin (2007, p. 20-25) for a further discussion of the definition and the CSO phenomenon more generally.

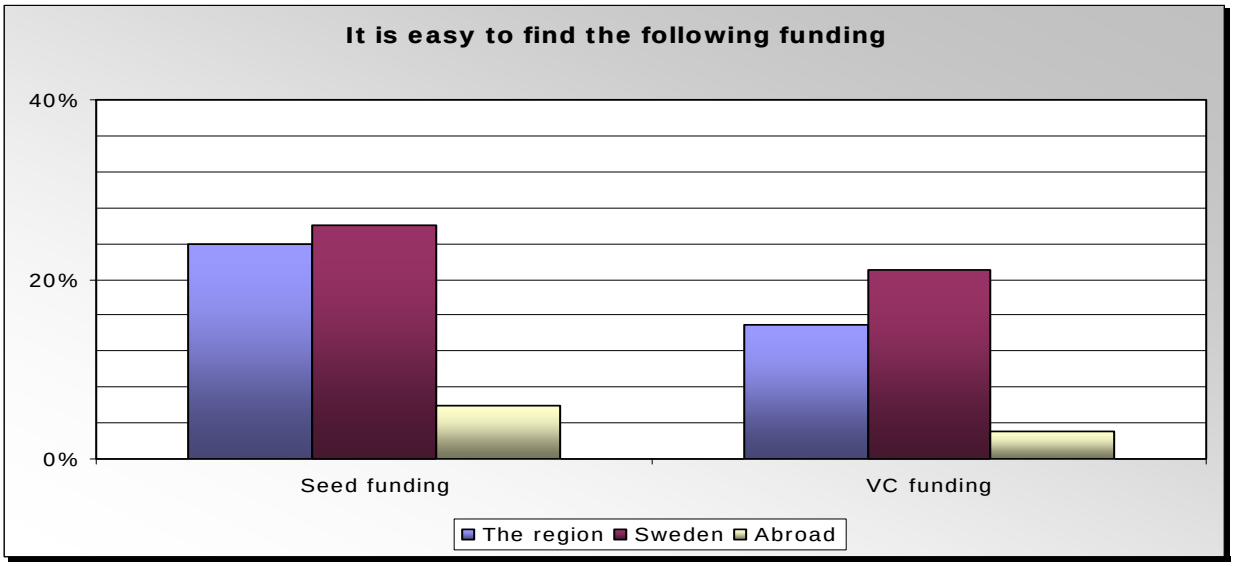
[47] Out of the firms that were founded by a university researcher eight were co-founded with a private individual, two were co-founded with a private individual and a venture capitalist, and one was founded with the help of a venture capitalist. Hence, 14 of them were actually founded by a university researcher alone.

[48] The figure is not statistically significant due to the small number of observations.

[49] This could possibly be further analysed in additional studies.

formation of CSOs, as a means of exploiting existing technologies for the benefit of the innovation system, certain directed policy-measures might be warranted.

Figure 2. The firms' view on the ease of securing Seed vs. VC funding



3.2 R&D activities

The biomedical firms that responded to our survey are engaged in R&D activities that aim at various forms of innovative output, where some develop only products/goods and others develop new processes and services as well.[50] In fact, a large majority firms that perform R&D carry out development activities with a focus on *products*, while four out of ten state that they are involved in *process* development, and one third claim that they develop *services* (see Figure 3).

Figure 3. R&D activities

R&D activity	
The firms that perform R&D (N=123 firms)	
• Develop products	95% (n=56)
• Develop processes	41% (n=49)
• Develop services	33% (n=48)
• Spend more than 10% of total costs on R&D	60% (n=55)
• Spend more than 20% of total costs on R&D	38% (n=55)

Interestingly, these firms tend to spend a comparatively large amount of their resources on R&D, when measured as a percentage of their total costs. Indeed, in 2005 about 60 percent of the firms spent more than 10 percent of their total costs, and more than one third spent over 20 percent. These numbers are high in comparison with industrial firms in general. This meshes well as many firms in the biomedical field are science-based, and there is a need to invest in science and technology in order to develop products for the market. In fact, in our sample as many as six out of ten of the

[50] The data reported in this section is based on those firms in our sample that we have classified as performing R&D (57 firms out of the 123 in the sample).

R&D-firms carry out scientific work or develop basic technologies.[51] Despite the observed high intensity focus on R&D, the R&D expenditures in terms of absolute numbers are in many cases less impressive. Indeed, three quarters of the firms spent less than ten man-years on R&D in 2005, and only four firms invested more than 20 man-years. This is, above all, a reflection of the fact that most biomedical firms in the region are relatively small (see, e.g., the structural description in section 2).

Also quite notably, an analysis of our data shows that the R&D-intensity varies with different types of firms, with university spin-outs (USO) spending relatively more on R&D than corporate spin-outs (CSO) do. However, this observation seems to be logically based for two reasons. First, because it is reasonable to assume that activities spun off from existing firms tend to be more mature than start-up activities that are based on academic research results; the USOs thereby needing more R&D input. Second, it may simply be that USOs are relatively more focused on research intensive products and processes than are CSOs.

Comparing the R&D-intensity for pharmaceutical, medtech, and other firms, there are no significant differences in our data. The general pattern, according to the information that we received, is that the R&D intensity is substantially greater for the development of pharmaceuticals than for medical devices.[52] The reason why this pattern is not clearly visible in our data is most likely due to the fact that we have in our sample a large number of small start-up firms, both in the pharma and medtech fields.

An interesting dimension is whether the companies are concentrated on one development project only, thereby focusing their resources, or if they allocate resources to several projects – perhaps in different phases and areas – and, so to speak, 'put their eggs in several baskets'. We found that the majority of R&D-firms (75%) currently run 1-3 major product development projects, and thus, only one quarter of the firms have more than three projects ongoing.

3.3 Innovation output

Given the comparatively high R&D investments it is perhaps natural that almost all the responding firms consider themselves to be innovative (Figure 4).[53] It is clear that the innovation process (from idea to the finished product on the market) is by no means linear, that is, it is not a foreseeable process where input (e.g. in terms of R&D) always leads to the desired output. Instead, it is a complex process involving a set of different inputs and competencies. [54] Even so, it seems that the R&D investments made by the firms do contribute to the innovation output, with six out of ten firms reporting that they had introduced 2-10 new products in the past five years.[55]

With regard to type of innovation, roughly 80 percent of these firms work with *radical innovations*, that is, entirely new types of products or processes that bring great leaps in the improvement of performance. Approximately an equal share of firms report that they are involved in *incremental innovations*; these innovations being minor improvements to existing products and processes.[56]

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[51] This illustrates the research intensity of this industry and is also in line with our finding that many firms focus on radical innovation.

[52] See, e.g., OECD (1997) which reports the R&D intensities of the Biomedical sector measured as a share of total R&D expenses in total turnover. In pharmaceuticals (including biotech) this figure lies somewhere between 10% and 15%. For medical equipment it ranges between 3% and roughly 5%.

[53] Out of the 222 companies in the total population, 123 firms (or 55 percent of all firms) are carrying out R&D activities in the region. The data reported in this section is based on the firms that perform R&D who responded to the questionnaire (57 firms). These 57 firms, thus, make up almost half (46%) of all the R&D performing firms in the region.

[54] While we would refute a linear relationship between R&D investments and innovative output, it is in fact the firms investing heavily in R&D that consider themselves most innovative.

[55] n=57

[56] Since all of these firms can be assumed to carry out some type of innovation activity, this indicates that one fifth of the firms *only* work with radical innovations, i.e., they are devoting no effort at all to incremental improvements. A possible explanation of this observation is that these firms are still in an early phase of development and as such have no need yet to work on improvements for existing products.

There are only small differences between the different categories of firms (pharma, medtech and others).

Figure 4. Innovative output

Innovation output

The firms that perform R&D (N=123 firms)

• Consider themselves to be innovative	92% (n=56)
• Have introduced 2-10 products in the last 5 years	62% (n=57)
• Develop incremental innovations	81% (n=56)
• Develop radical innovations	79% (n=56)

3.4 Activities and roles in the value chain

The respondent firms are focusing on different types of value chain activities (see Table 3). This could reflect different strategies taken by the companies with regard to their role in the biomedical value chain, or the fact that they have reached different maturity levels. In other words, some firms are focused on early-stage development, while others embrace the entire integrated innovation and production process.

A number of firms also have several products in the pipeline. Some of these are in an early development phase while others have already reached the market. Taken as a whole, 13 percent of the R&D-active companies engage in consultancy and sub-contracting, half of the companies carry out pre-clinical research or other early-stage product development activities, and just under a third are in the clinical trials phase or late-stage product development. Remarkably, even though many of these firms are young, 38 percent of the R&D-firms perform mature product development. It is also worthy to note that almost three quarters of the R&D-firms have manufactured their own prototypes or products for the market.[57]

Respondent firms in the region that do not conduct R&D quite naturally show a different pattern. A quarter of these firm engage in subcontracting or consultancy, and a somewhat lower share than the R&D-active firms are involved in product development (e.g., for sales companies that utilise R&D performed by the parent company, or by other suppliers of finished products). Almost half of the firms state that none of the categories best describes their activities, which tells us that the questionnaire did not manage to encompass all the activities of the firms that are not doing R&D.

In terms of product introduction, a large majority of the responding firms say that they are well established in the market. In fact, most companies (some 75%) are active in several markets. Generally speaking, the most prominent geographical markets are either in Europe or North America. What is intriguing is that as many as four out of ten responding firms consider themselves to be a global market leader, or to belong to the top ten suppliers worldwide. A quarter of the firms are primarily focused on the Swedish market, and not surprisingly here is where we find many of the sales companies.[58] The regional market is of very limited importance.[59] Only one out of ten firms has not yet launched any product, and of these none indicates that it will introduce its first product within the

[57] An explanation as to why many firms are not engaged in manufacturing may be that these firms have not yet reached the market, or that they have outsourced production, or that they focus on services.

[58] Interestingly, roughly one in ten of the R&D-performing firms focus on the domestic market – this is in spite of the global character of the biomedical market. This may be partly a consequence of a marketing strategy whereby firms, following more traditional internationalisation patterns, are first trying to establish themselves in their home markets before taking the next step and going abroad.

[59] Only two firms have Western Sweden as their most important geographical market.

next 12-months. Four out of five firms that do not engage in R&D activities in the region state that they have several markets, yet more than half of them focus on the Swedish market; this differs greatly from the R&D-active firms.

Table 3. Activities in the value chain and in sales and manufacturing

Parts of the value chain in which the firm is active*	R&D-active firms (N=123)	Firms without R&D (N=99)
Sub-contracting/Consultancy	13% (n=56)	26% (n=19)
Pre-clinical/early development	48% (n=56)	37% (n=19)
Clinical trials/late development	29% (n=56)	16% (n=19)
Mature product development	38% (n=56)	21% (n=19)
Manufacturing	70% (n=56)	26% (n=19)
Other	13% (n=56)	47% (n=19)

Sales and manufacturing**	R&D active firms (N=123)	Firms without R&D (N=99)
Have products established on several markets	73% (n=55)	81% (n=21)
Are a globally leading supplier	25% (n=55)	16% (n=19)
Are a top-ten global supplier	18% (n=55)	16% (n=19)
Focus on the North American market	31% (n=55)	5% (n=20)
Focus on the European market	33% (n=55)	25% (n=20)
Focus on the Swedish market	11% (n=55)	55% (n=20)
Focus on the regional market	2% (n=55)	5% (n=20)

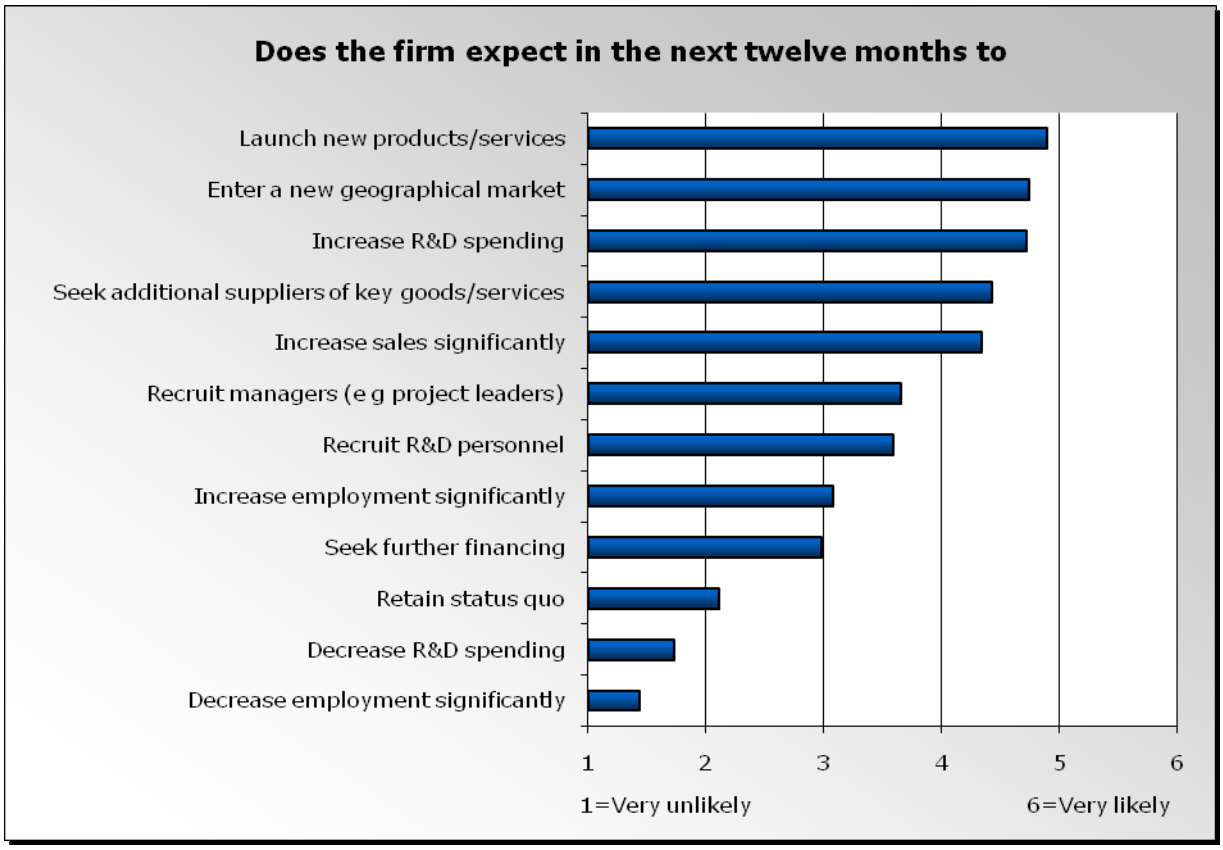
* Multiple choice and hence the sum is more than 100%.
** Due to truncation and that the possible reply "don't know" is not reported the sums might not equal 100%.

3.5 Expansion plans

The firms answering the survey tended to have an optimistic outlook as to their development in the near future. A majority of them expect to increase sales significantly over the next twelve months, to launch new products, and to enter new geographical markets (Figure 5). This will be accompanied by increased R&D expenditures, and the seeking of additional suppliers of key products and services. To realise this expansion, many companies report plans to recruit new staff, particularly managers and R&D personnel; however, the answers indicate that these signals regarding recruitment are not as strong as could be expected given their stated expansion plans. A possible explanation is that much of the necessary resources for expansion will be acquired externally, reflecting an "outsourcing strategy" that is common among young technology-based firms in the biomedical field.[60]

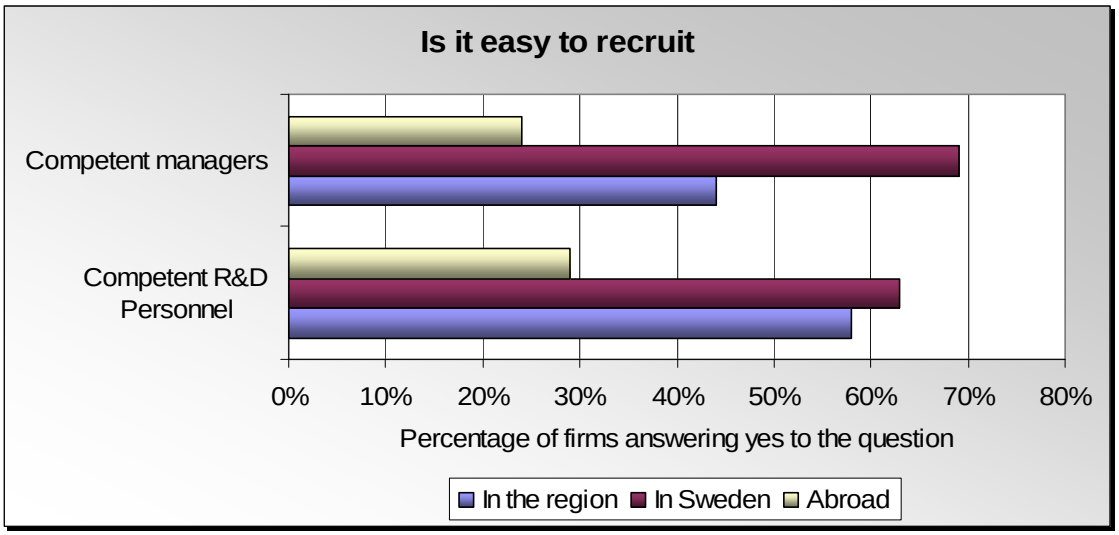
[60] See, for example, Laage-Hellman (1998, p. 31-33) for a discussion on the outsourcing of production activities in the biomedical industry.

Figure 5. Anticipated actions in the next twelve months



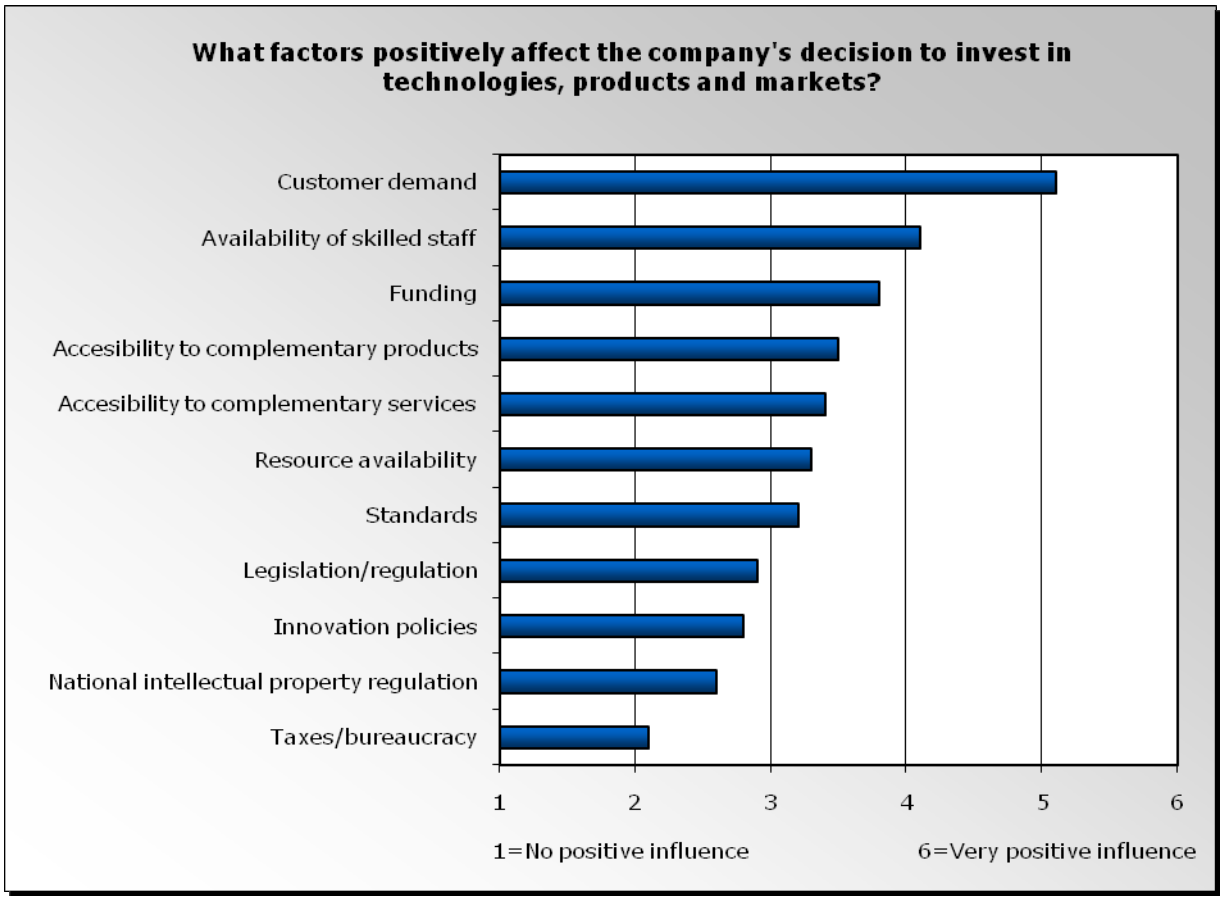
In the context of the firms' plans for additional recruitment, it is interesting to note that most respondents do not see any major problem with recruitment (Figure 6). This goes both for R&D personnel and managers. While most firms recruit from the entire Swedish labour market, they also feel it is fairly easy to recruit from within the region. Recruitment of personnel from other countries, on the other hand, seems to be more difficult, and this may be an area where the BMV programme could contribute.

Figure 6. Recruitment



Naturally, customers' demands are what drives expansion plans (see Figure 7), but the availability of skilled staff and of financing are also of prime beneficial importance. There is also some favourable influence arising from the accessibility of complementary products and services and other resources. Notably, legislation and regulatory standards as well as innovation policies and intellectual property (IP) regulation play a positive role, although conversely tax legislation does not encourage firms to invest.

Figure 7. Positive factors that influence investment decisions



3.6 View of the industry

Asking the biomedical companies about their perceptions of the industry or business they operate in reveals, generally, a very positive view. To start, the biomedical sector is viewed as having high growth potential – be it globally, nationally, or regionally (Figure 8). This is a crucial signal for the BMV programme to consider, investment in the expansion of the sector regionally. Second, as regards investment in the industry as it relates to starting firms, new projects, or activities, clearly the uncertainties and risks involved are perceived as high. This is a well-known feature of the sector, and was further confirmed by the survey; likewise, the existence of high barriers to entry is also confirmed. One can assume that this is due to the time-consuming and risky innovation process that typically characterises product and business development in the field. Even so, at the global level there are many firms entering the industry. This is in contrast to the Swedish and regional level where respondents believe new firm entry is considerably lower. Third, the perceived lower Swedish and regional firm entry rate is in line with the respondents' view that a critical mass of firms is lacking. One conclusion that can be drawn from this is that the ambitions of the BMV programme to speed up the formation of new firms and to stimulate the growth of existing firms is strongly supported by the biomedical firms in the region. The lack of a critical mass is one of the

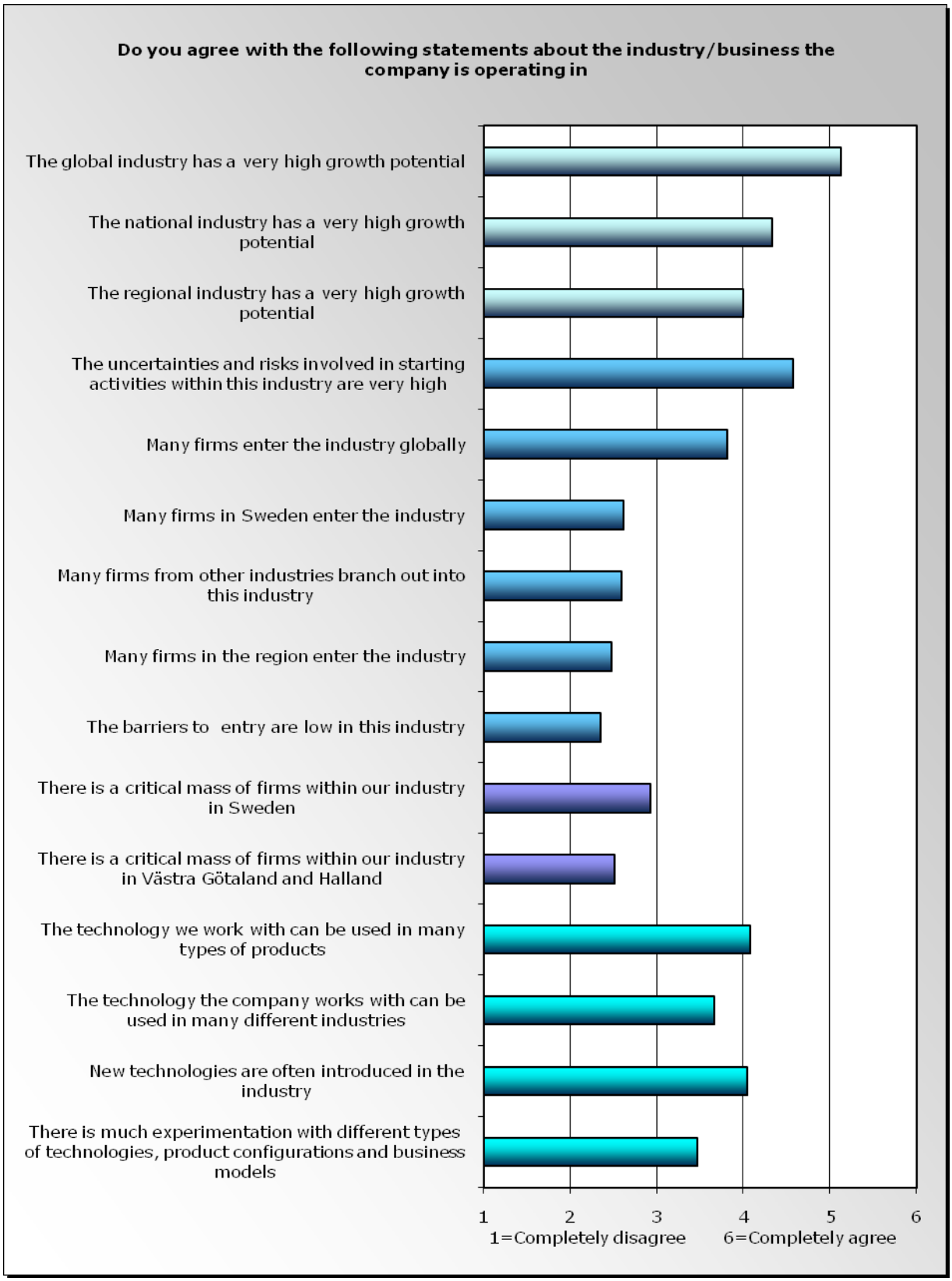
chief messages that was also stated quite clearly in our interview study (Andersson et al, 2007). Finally, many of the technologies in this area are generic in character and can be used in and by various products and industries. It is important not to overlook the fact that the frequent introduction of new technologies and the extensive experimentation with technologies, product configurations, and business models, speaks of the dynamic character of the industries involved.

The point above concerning technological uncertainties and experimentation is a fundamentally essential feature of the current industries. In consequence, it is vitally important to establish the legitimacy of scientific approaches, technologies, as well as products and firms. The survey aimed to capture to what extent the firms perceive such legitimacy to be in place; from the responses we can draw a number of conclusions.

- First, that legislative support is adequate, in that the companies' technologies and products work well within the existing standards and are well aligned with current legislation (Figure 9). These are significant traits that are necessary for firms and industries to be able to grow, and it is beneficial for the Swedish biomedical industry if firms feel that the legislative system is well-functioning.[61]
- Second, even though the biomedical field encompasses many new areas of science and technology, it does not seem as though the regional firms experience any great distance or difficulty in relating to society at large in this respect. In fact, the respondents perceive there to be a fairly high acceptance and understanding from their customers, financiers and the general public. Moreover, the firms work in areas that are frequently discussed by the academic community, in situations such as conferences. The reason for this interpretation may be twofold: Such legitimacy may be a sign that the innovation system is good at incorporating new knowledge areas and products; on the other hand, it may be a sign that the firms are working within more mature areas.
- Third, another explanation could be that the promotion of these technologies and products is perceived to be relatively weak. It seems that neither industrial nor academic actors, or lobbying groups or the media, fully assume this task. Against this background it is of consequence to note that there are indeed lobbying organisations in Sweden, for example SwedenBIO, the trade association of the life science industry, in recent years has actively lobbied the Government about the industry.[62] Curiously, though , SwedenBIO has relatively few members from the Göteborg region.[63]

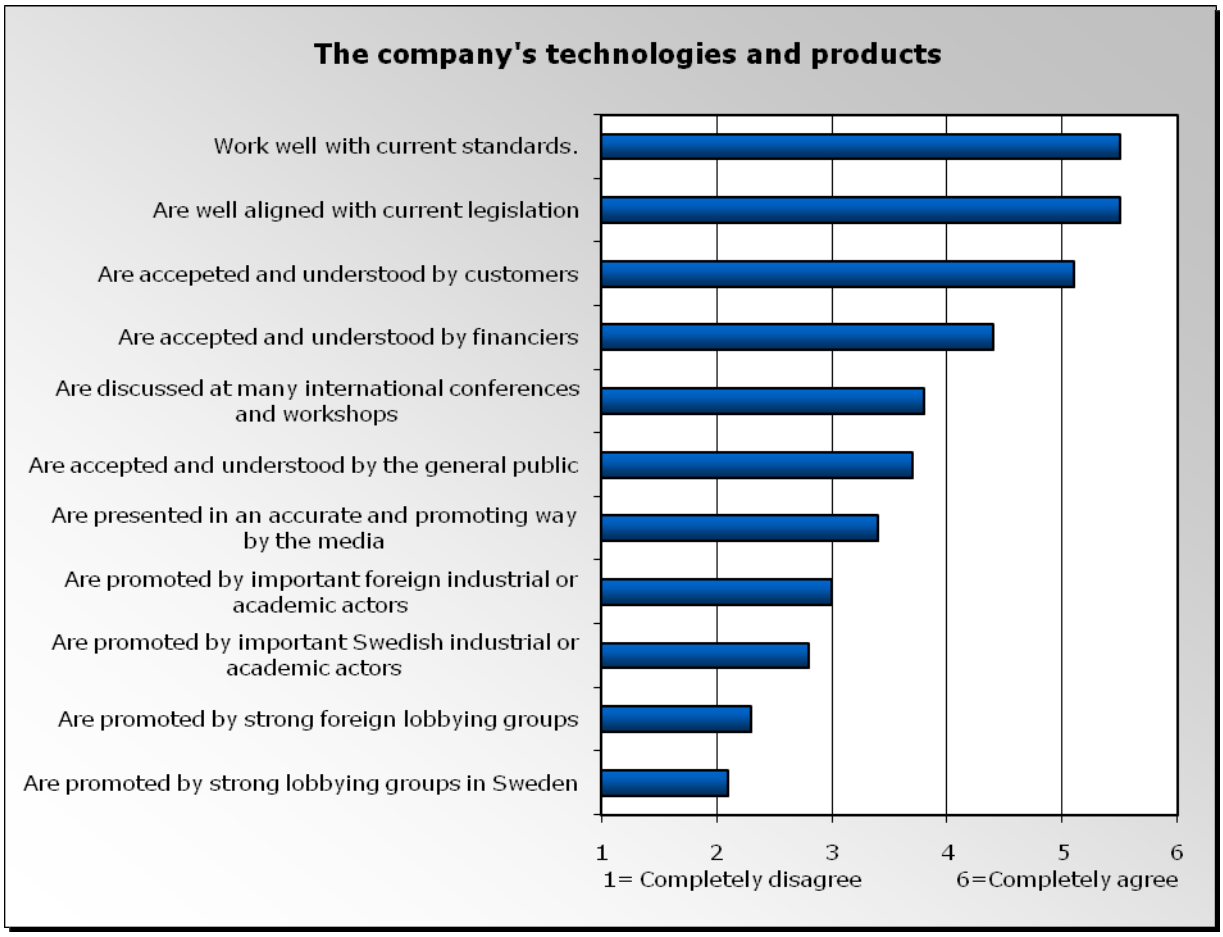
[61] This is an important question that is quite deserving of being explored in additional studies.
[62] See www.swedenbio.com.
[63] Source: presentation by SwedenBIO's CEO Per-Erik Sandlund at a seminar organised by GöteborgBIO on 9 October 2006.

Figure 8. Perceptions of the firm's industry or business[64]



[64] Note that there are no significant differences between the responses of 'all firms' as compared to the 'R&D performing firms' only.

Figure 9. Acceptance and alignment of the firms' technologies and products



4 Creation, diffusion and use of knowledge

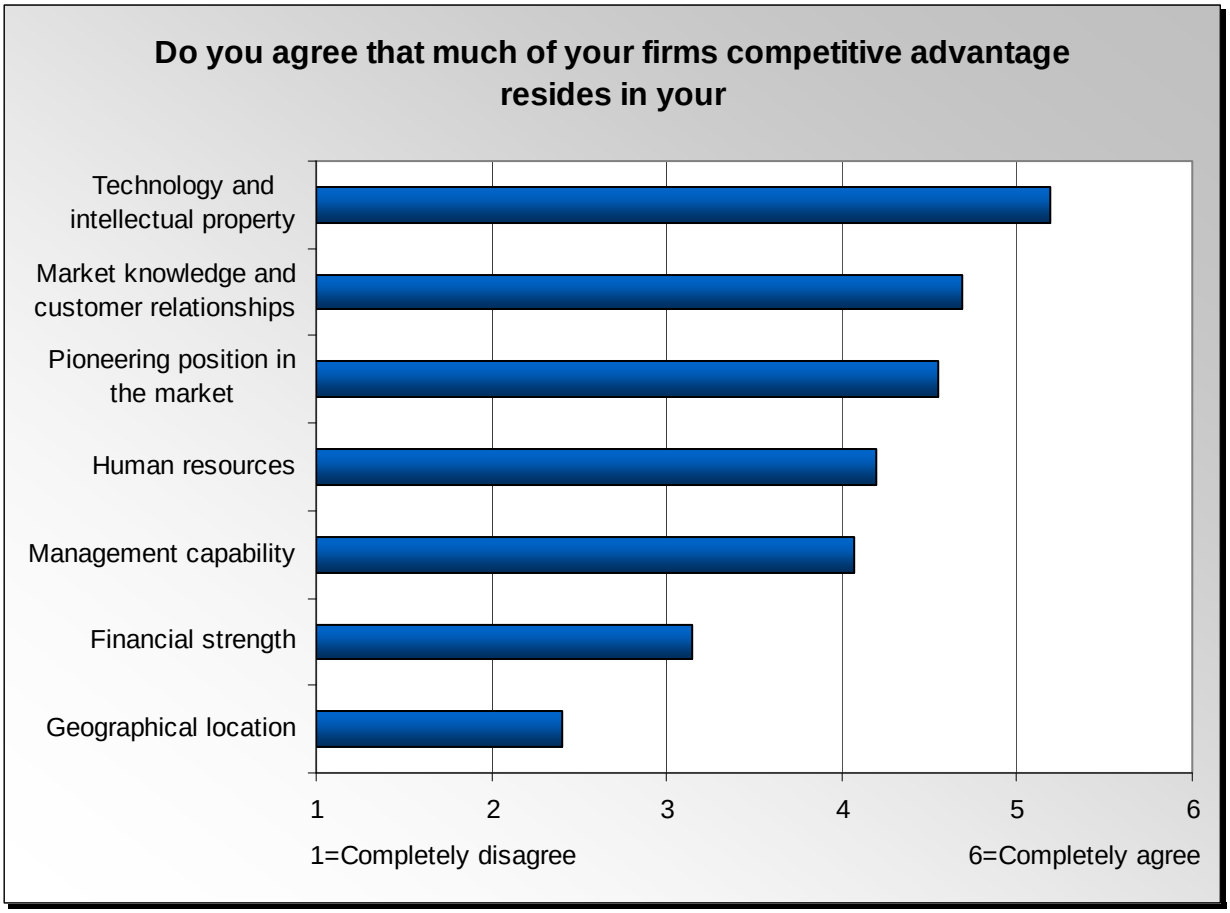
In this section we analyse the creation, diffusion, and utilisation of knowledge.[65] Specifically, we focus on which types of knowledge and what sources that the firms find crucial, what knowledge creation activities are performed in-house, and what the role of collaborative arrangements is. Finally, we discuss the location of different types of partners, and the role played by the region.

4.1 Competitive advantage and important types of knowledge

As is very apparent from the earlier section on firm activities, many respondents are R&D-performing firms and consider themselves to be innovative. It is therefore not surprising that given the question of what constitutes the companies' competitive advantage, technology and intellectual property come out as the most vital assets (see Figure 10). This holds true for the pharmaceutical and medtech sectors as well as other companies. Nearly as important are the companies' market knowledge, their customer relationships, and their pioneering position in the market. Their human resources and their management capabilities are also vitally important, while the company's financial strength seems to be considered less a competitive advantage. Interestingly, geographical location is not perceived by the respondents as highly increasing the competitive advantage. This means that the respondents do not feel that their location in Western Sweden, in and of itself, has a major *direct* effect on their competitiveness. Nevertheless, as we will come back to later in the report, there are regional characteristics and knowledge sources that are of foremost importance to the companies' development.

[65] If not otherwise stated, the data used and presented in this section pertains to the R&D performing companies (57 out of the 78 firms that answered the questionnaire).

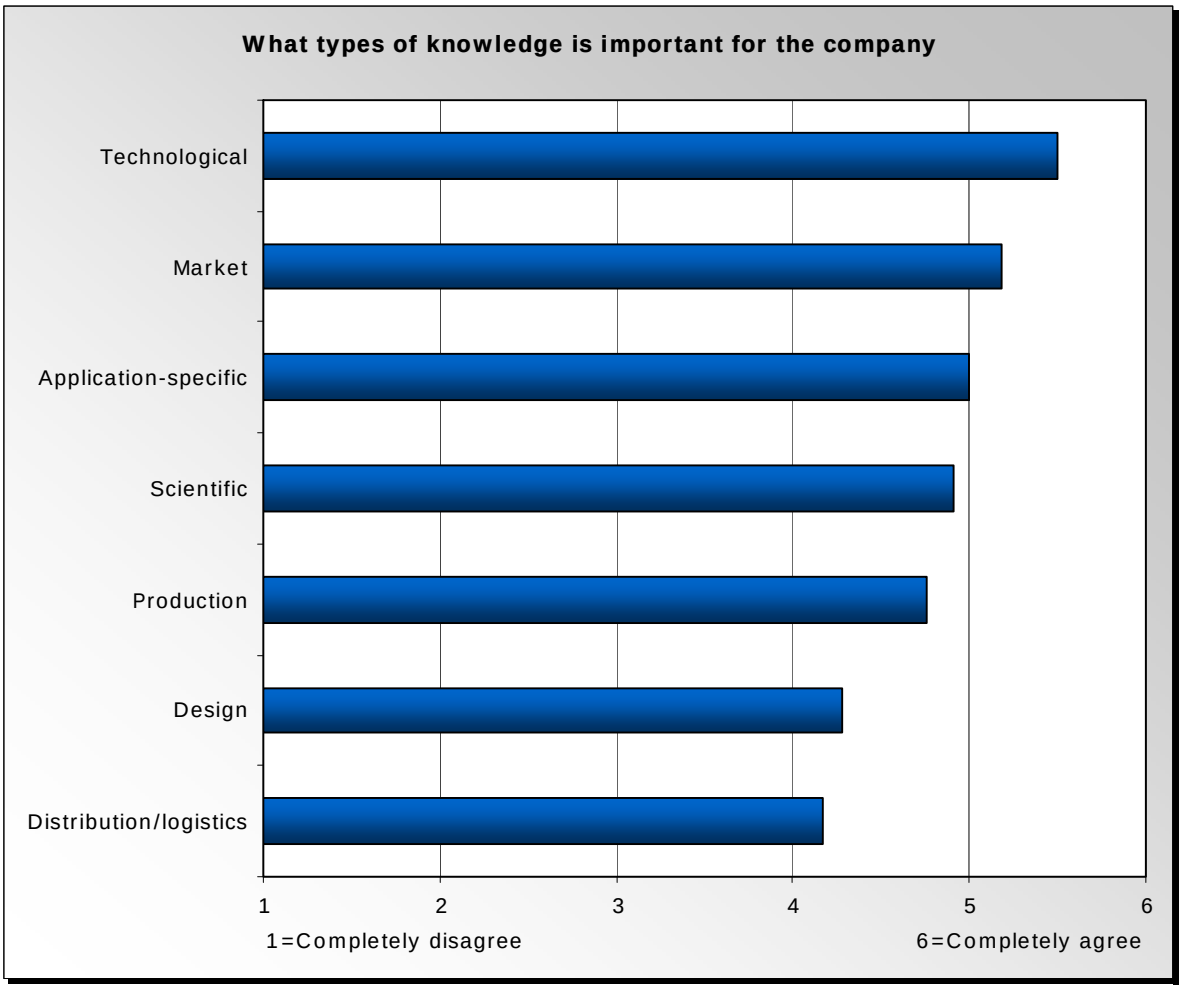
Figure 10. Sources of competitive advantage [66]



To build and retain the firms' competitive advantage, and in order to innovate and grow, there are a number of different *types of knowledge* that the firms need to access. From a regional perspective it is essential that these knowledge-needs be understood, so that it can be determined to what extent these can, and should, be met on a regional level. The categories of knowledge that the biomedical companies found to be most important are: technological and market (see Figure 11). Other key knowledge areas for R&D-performing companies are application-specific knowledge in addition to scientific knowledge and production knowledge, with a somewhat lower weight placed on distribution/logistics and design.

[66] N=123, n_{mean}=56

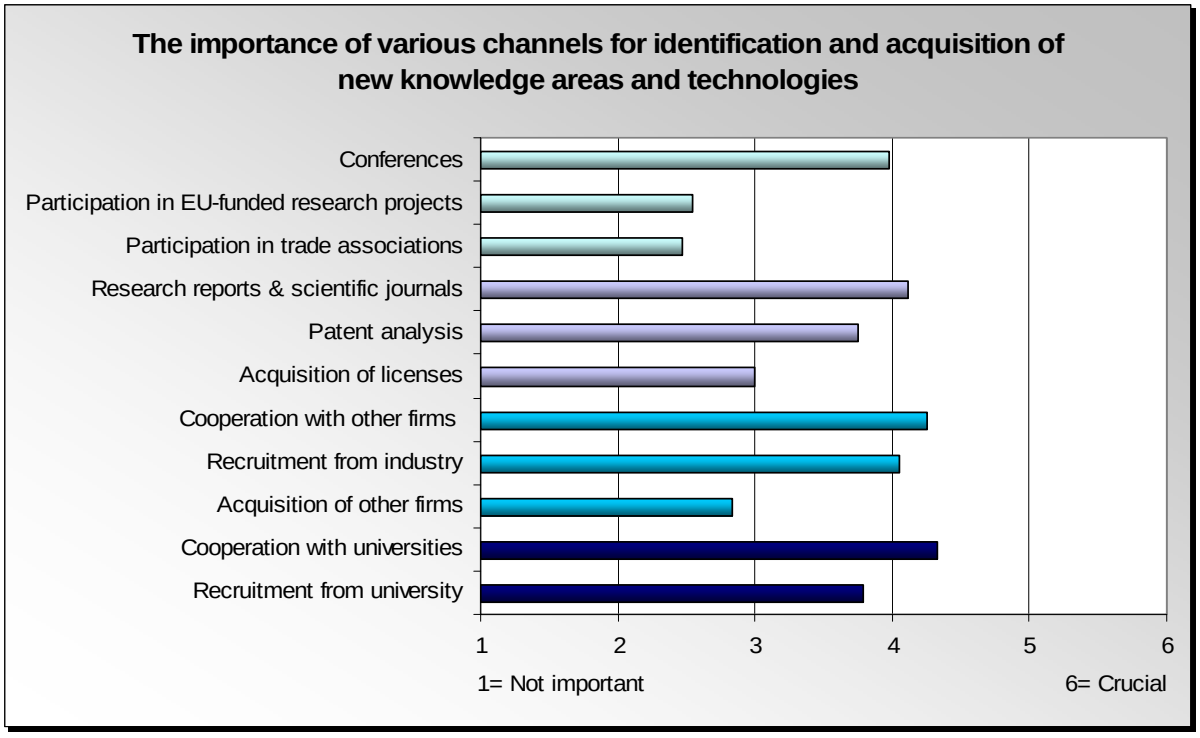
Figure 11. The importance of different types of knowledge[67]



These various forms of knowledge are identified and acquired through a variety of *sources*, or channels. The firms were asked what channels they used in order to *identify new knowledge areas and technologies*, and what channels they used to *acquire new knowledge, technologies and competencies* into the firm. This distinction between identification and acquisition is crucial, as the mere awareness of knowledge does not mean that the company has, in practice, acquired the knowledge or absorbed it into its own knowledge. A number of interesting observations should be highlighted (see Figure 12). First, one channel alludes to the firms' *participation* in various situations, such as conferences, trade associations or EU-projects. The firms have both identified the new knowledge areas, and brought them into the company through such channels. Whereas trade associations and EU-projects are of moderate significance, the respondents' participation in conferences has proved an important channel for information and learning. Second, there are many sources of *codified knowledge*, be they patents, licences, or scientific publications; the firms denote the acquisition of licenses to be of only moderate interest, but patent analysis as more momentous. In particular, the analysis of scientific reports and journals is a major source for identifying and acquiring new knowledge.

[67] N=123, n_{mean}=54

Figure 12. Importance of different types of sources of knowledge



Third, a crucial channel used to identify and acquire knowledge is through *contact and collaboration with other companies* in various locations. Also, knowledge spill-over can accrue from recruitment processes, further indicating the importance of having a critical mass of biomedical firms in the region, or nation, within which personnel can circulate. Indeed, a pooled labour market is highly relevant to knowledge spill-over. Firm acquisition, on the other hand, is not a source that is pointed out as significant by the respondents. In our survey, it could be that due to the smaller size of the responding firms, making them less prone to acquire other companies.

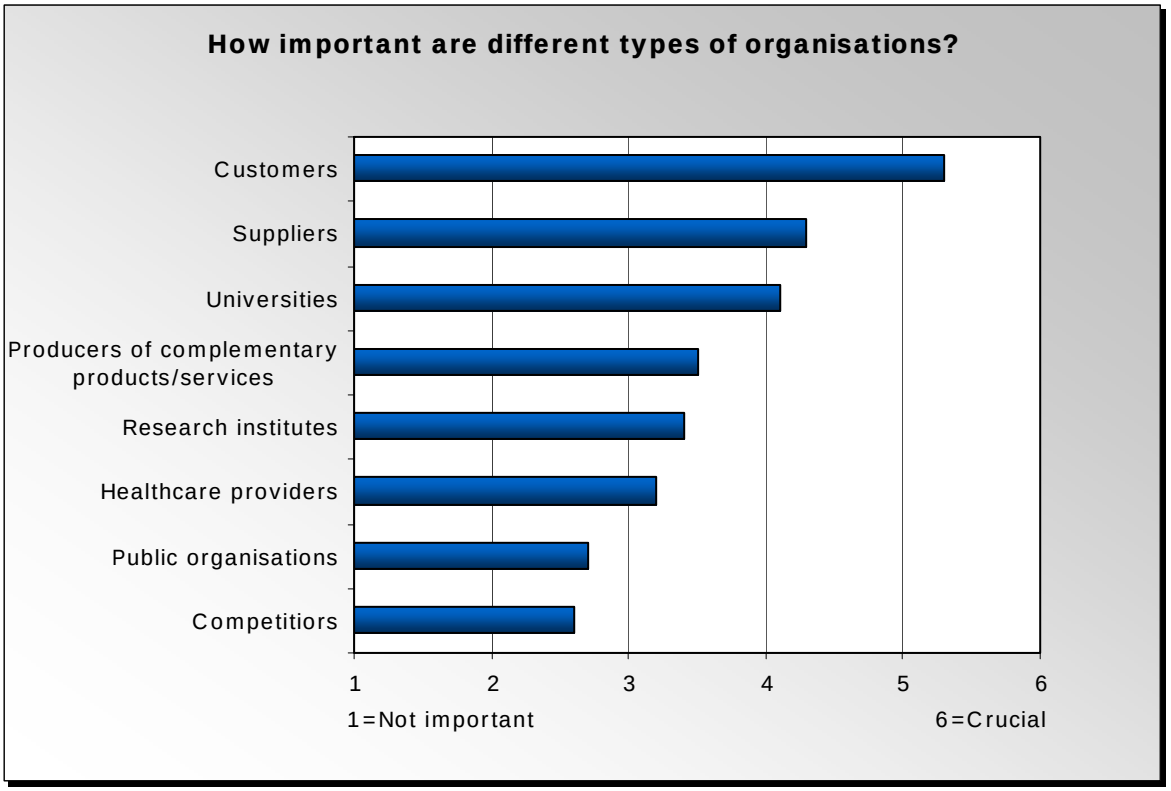
Fourth, *university relations* of various kinds are essential for knowledge identification and sourcing. What did grab our attention was that in spite of the popular notion that there is a limited flow of personnel between industry and academia in Sweden, the respondents claimed that recruitment from universities was a fairly important channel for knowledge acquisition. These findings, which show the firms' relationships with universities, confirm the scientific character of this industry and the important role played by academic research as a source of new knowledge for biomedical firms. Furthermore, the firms seemed to imply that *direct* collaboration with universities is considered the most effective way for both identifying and acquiring knowledge, as compared to more indirect means of technology transfer. Against this background, the emphasis of the BMV programme on university-industry relationships, and network-building, seems to be a wise choice of strategy. However, these findings do not say anything about the importance of the region's own universities, relative to universities situated in other parts of Sweden or abroad. This is a key issue that we will come back to later in our discussion about the companies' collaboration patterns.

In conclusion, we can see that various types of collaboration and interaction are important, be it with universities or other firms. This interaction can be in the form of direct collaboration, or of a more indirect nature such as through conferences. In addition, codified information (via scientific reports and journals) is useful. However, the weight of trade organisations and EU-projects in importance seems to be of a much lesser magnitude.

4.2 Type of partner, reasons for collaboration and volumes

Turning specifically to the companies' R&D activities, according to the respondents' estimates, on average two thirds of these activities are carried out completely in-house (without the involvement of external partners).[68] There are, however, large variations among the firms, with some firms having less than 30 percent of their R&D in-house (16% of the firms) versus, for example, those with more than 70 percent in-house (59% of the firms). There are no significant differences between firms of different sub-sectors, such as pharma vs. medtech. Rather, such differences seem to depend on a firm's strategies and phases of development. It is interesting that while only one firm stated that it did not perform any part of its R&D in collaboration with external partners, the majority of respondent do have a rather minor share of external R&D in comparison to their in-house activities. This seems to be a relatively low figure for external collaboration when compared to results obtained in other studies.[69] This type of strategy, that of engaging in primarily in-house development efforts, places large demands on recruitment and internal training, and again indicates the importance of a well-functioning educational system and labour market.

Figure 13. Relative importance of different types of partners[70]

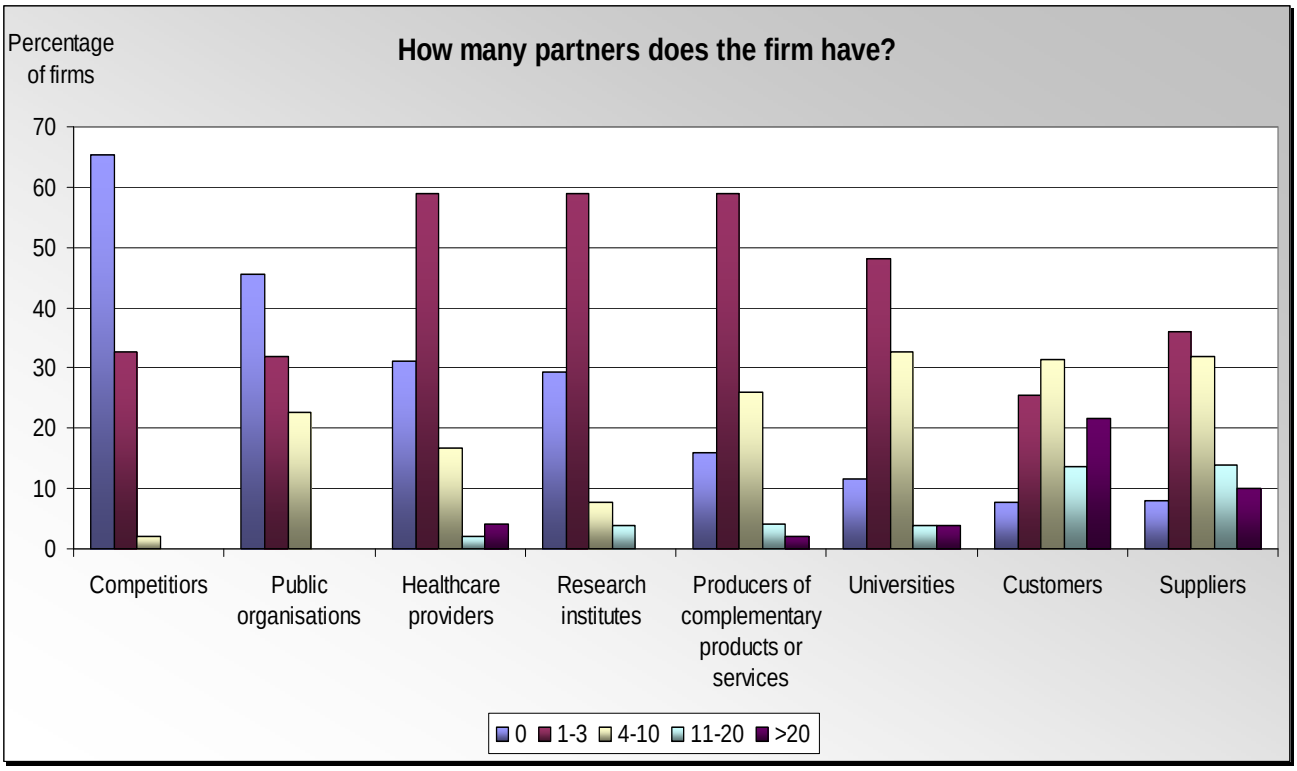


In an analysis of the variant forms of collaboration – be it for R&D, production, marketing, distribution, etc. – it is clear that firms have a wide range of partners: customers, suppliers, producers of complementary goods and services, competitors, health care providers, universities, research institutes, and public organisations. In summary, Figure 13 shows that the firms see their *customers*,

[68] Note, that even if a company runs an R&D project in-house, knowledge obtained from various external sources may be extensively used.
[69] For example, Håkansson (1989) reported, based on a cross-sectional study of Swedish firms from different industries, that roughly 50 percent of all development work involved close collaboration with various external partners.
[70] N=123, n=50

significantly, as their *most important* type of partner,[71] as followed by suppliers and universities. Competitors are seen as their least important partner. We can also see below, in Figure 14, that the firms have listed customers and suppliers as their *most frequent* partner, with a greater share of the respondents having more than three partners. Again, interaction with competitors is less common, with a significantly lower number of partners.[72]

Figure 14. Number of different types of partners[73]



Thus, *customers* are seen as by far the most vital type of partner. In fact, whereas very few firms keep an arm's length distance from the customers (8%), a fourth of the firms state that they currently collaborate with 1-4 customers, 45 percent have 4-20 such partnerships, while almost a fourth have more than 20 collaborations ongoing. Interestingly, while many collaborations may have a market focus, 73 percent of the firms sometimes, or often, engage customers for the purpose of scientific projects and publications, although this is less so for patenting activities (20% of the firms sometimes involve customers). It is, of course, a well-known fact that within the biomedical industry customer input is key to accomplishing timely and successful innovations,[74] and it is therefore encouraging to see that the companies in Western Sweden engage heavily with their customers.[75]

[71] N=123, n=56, p=0,05
[72] N=123, n=49, p=0,05
[73] The survey question was formulated as 'Please estimate how many organisations of different types your company collaborates with'.
[74] It is well known from the literature that collaboration with customers and suppliers is a central feature of innovation in many industries. This includes, for example, broad economics-based studies of innovation such as Freeman (1982), Rosenberg (1982), Dosi (1988), as well as the more focused literature on industrial networks and marketing, exemplified by, among others, von Hippel (1988), Håkansson (1989), Biemans (1992), and Håkansson and Waluszewski (2002).
[75] When it comes to the number of counterparts that the firms collaborate with, our data shows that for most categories the majority of firms have only 1-3 partners. However, when we look at collaboration with customers and suppliers

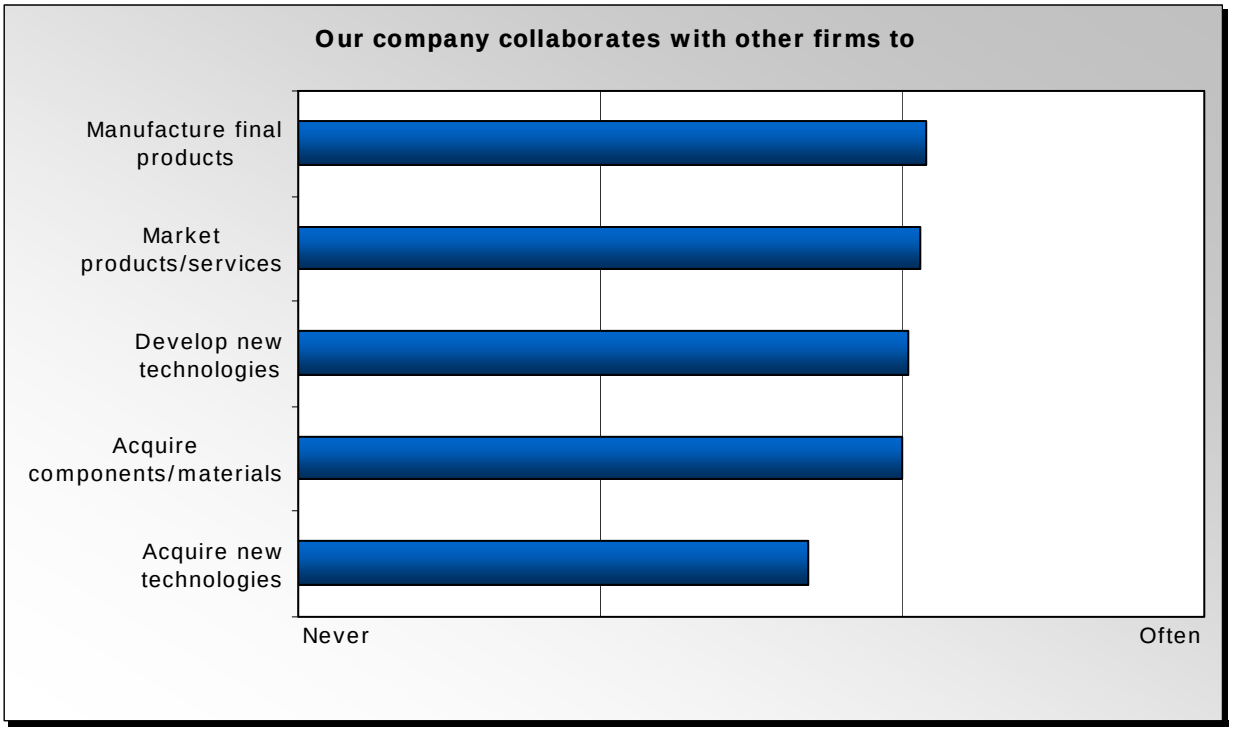
The high importance placed on business relationships as resources for technological development are well in line with the previously mentioned finding that most of the firms in our sample are well established in the market.

Also *suppliers* take on a prominent role as partners (rated 4.3 on a 6.0 scale), while providers of complementary products and services are seen as somewhat less important (rated 3.5) and competitors rarely function as key partners (rated 2.6) (see Figure 13).

University collaboration is imperative for the responding firms (rated 4.1), while *research institutes* (rated 3.4) and *health care providers* (rated 3.2) play a smaller collaborative role. For many biomedical firms, the health care institutes are the buyers of the products. The exceptions are primarily biotech supply firms (whose customers are researchers or other biomedical firms) and firms specialising in selling research services or technologies to industry (e.g., certain drug discovery companies).

In an analysis of the *reasons* for collaboration with different partners, it is clear that the biomedical companies in the region have a number of motives for collaborating with *other firms*, no one motive being significantly more important than any of the others. They seek corporate partnerships for co-operation in the marketing of products and services, to co-manufacture products or outsource manufacturing, and to co-develop or acquire new technologies (see Figure 15).

Figure 15. Reasons for collaboration with other companies

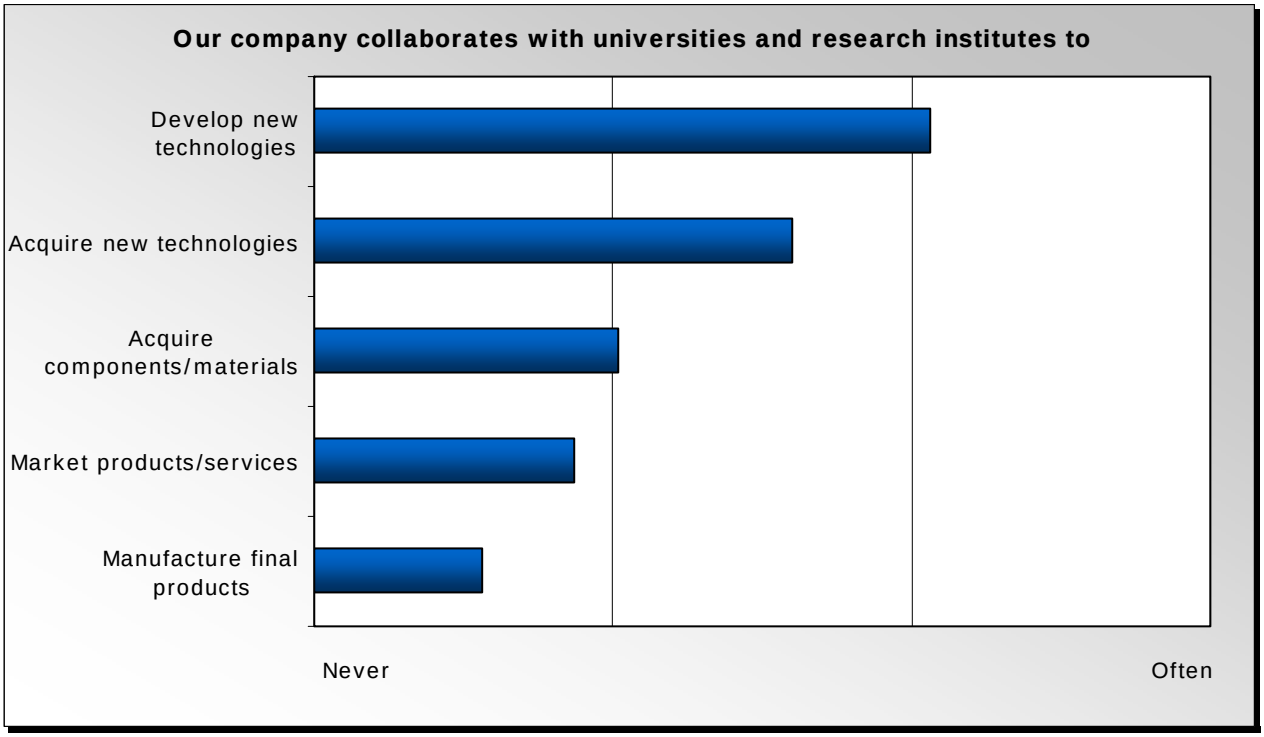


The reasons for collaboration with universities and research institutes are dominated by: development, and the acquisition of new technologies (see Figure 16). Additionally, such partnerships may be used for the sourcing of components and materials. Perhaps it is somewhat surprising that co-operation with the aim of marketing products or services comes up on the list, but this may be

their partners are more numerous, on average roughly nine and seven respectively. There are a significant number of firms collaborating with more than ten customers or suppliers. In other words, there is a great deal of variation amongst the firms.

connected to the role of university researchers acting as the legitimisers of scientific approaches and technologies. For example, often biomedical firms co-publish and present papers at academic conferences with academic researchers. This may be a step not only to co-developing science and technology, but also to gaining greater acceptance through their connection to well-reputed research teams and opinion leaders. Of course, this could also be due to the fact that university researchers are sometimes customers of the company's products. Also worth noting is the small, yet noteworthy role of academic actors in the manufacturing of products. A possible explanation for this is that some research-based companies, at least in an early phase of their development, are dependent on specific, high-tech apparatus that are located at the universities. As is shown by our interview study, small companies very much appreciate that they can gain access to advanced equipment which they otherwise could not afford to buy themselves.

Figure 16. Reasons for collaboration with universities and research institutes[76]

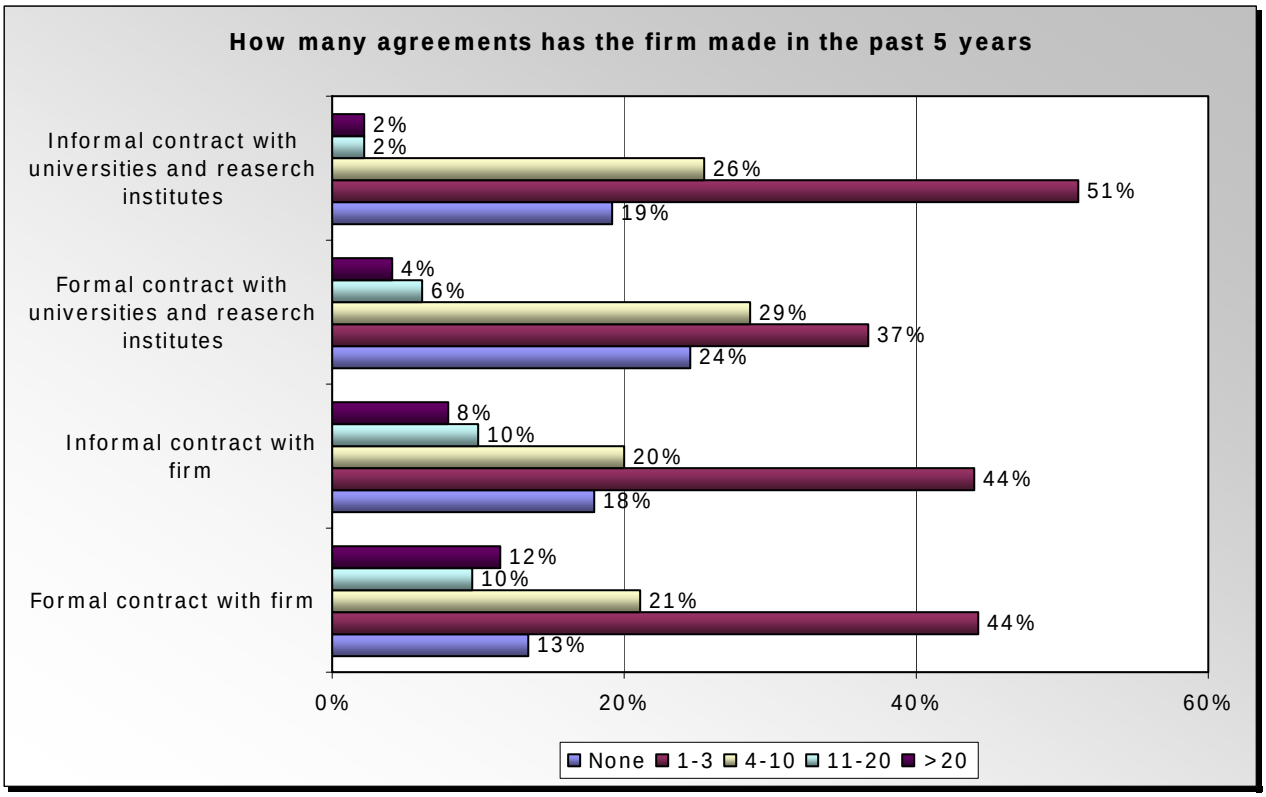


In terms of the *variety* and *volume* of collaborative partners, we saw in Figure 14 above that there is a large variation in the number of partners. What our statistical analysis reveals is that the most frequent types of collaborative partners are customers and suppliers. Many firms also have a number of partnerships with producers of complementary products and services, at times this could be understood as another form of 'supplier'. This indicates that in the biomedical industry, customers and suppliers are not only actors in the transaction chain, but are also seen as collaborative partners, necessary for product and market development. Intriguingly, almost 90 percent of the firms have collaborations with universities, and 70 percent with research institutes. This aptly illustrates the key role research organisations take in the biomedical innovation process. Additionally, health care providers connect with 70 percent of the companies. Only just over half of the companies see public organisations as partners; this may be an indication that there is room for public organisations to take on a more direct role in firm innovation. Not many companies set up any form of partnerships with competitors.

[76] Based on all firms conducting R&D, N=123, n_{mean}=46

Informal and *formal* agreements are about equally frequent (Figure 17), and this goes for universities and research institutes, as well as for firms. Predominately, the respondents have 1-10 agreements, with few having more than 10 agreements.

Figure 17. Number of agreements made in the past five years



The results reported in this section coincide with the picture that we obtained in the interviews with 13 selected companies (Andersson et al, 2007). These companies display very different patterns of collaboration, both with regard to the number and type of partners that they interact with. On one extreme, we found a biotech supply firm having some 150 collaborative relationships. On the other extreme, one of the medtech companies said that it has no R&D collaboration at all – with the exception of having an informal contact network with a local hospital. It is noteworthy that so far this company has not been successful in launching new products onto the market. There may be different reasons for this failure, of course, but one could speculate that this could have something to do with this lack of co-operation.

Our interviews indicate that the differences in interaction patterns, in terms of partner type and in purpose of co-operation, are very much related to the stage of development the company has reached.[77] As one would expect, R&D-based biomedical companies that are in an early phase tend to be more focused on collaboration with universities, university hospitals and other research organisations. When a company starts growing, it becomes more important for them to establish collaborative relationships with other types of partners, including customers/users (others than those possibly involved in the early phase), suppliers, contract manufacturers, authorities, distributors and financiers. These relationships are needed in order to access complementary resources and competencies the company needs for its further development and growth. If a company is an academic spin-off with strong ties to a nearby university, it may also need to broaden its scientific base by establishing collaborative relationships with research groups in other parts of the world (e.g., to

[77] This also confirms what we know from previous studies. See e.g. Laage-Hellman (1993).

access complementary technologies or to promote its own solutions and products). Some of the resources the companies need are of a rather general character, such as skilled labour, competent managers and money. Other resources are of a more technological or product-specific nature. It can be specialised equipment for research or production, suppliers of specialised goods or services, or potential customers with specific applications.

These observations illustrate, in accordance with the criticism of the linear view of innovation,[78] that investments in research are not enough to support science-based industrial development. In order to build a regional innovation system that helps firms to grow, public policy must also address the other needs that companies have. This can be done, for example, by supporting the creation of new resources within the region or by stimulating interaction among regional actors with complementary assets. Another way to support firm growth is by helping them to establish collaborative relationships outside the region. As we see it, this kind of thinking is very much in line with the strategy pursued by the BMV programme. Thus, many of its activities are focused on commercialisation, and are aimed at supporting interaction both within the region and with outside actors. This is, in our opinion, a wise strategy.

4.3 Publication and patenting

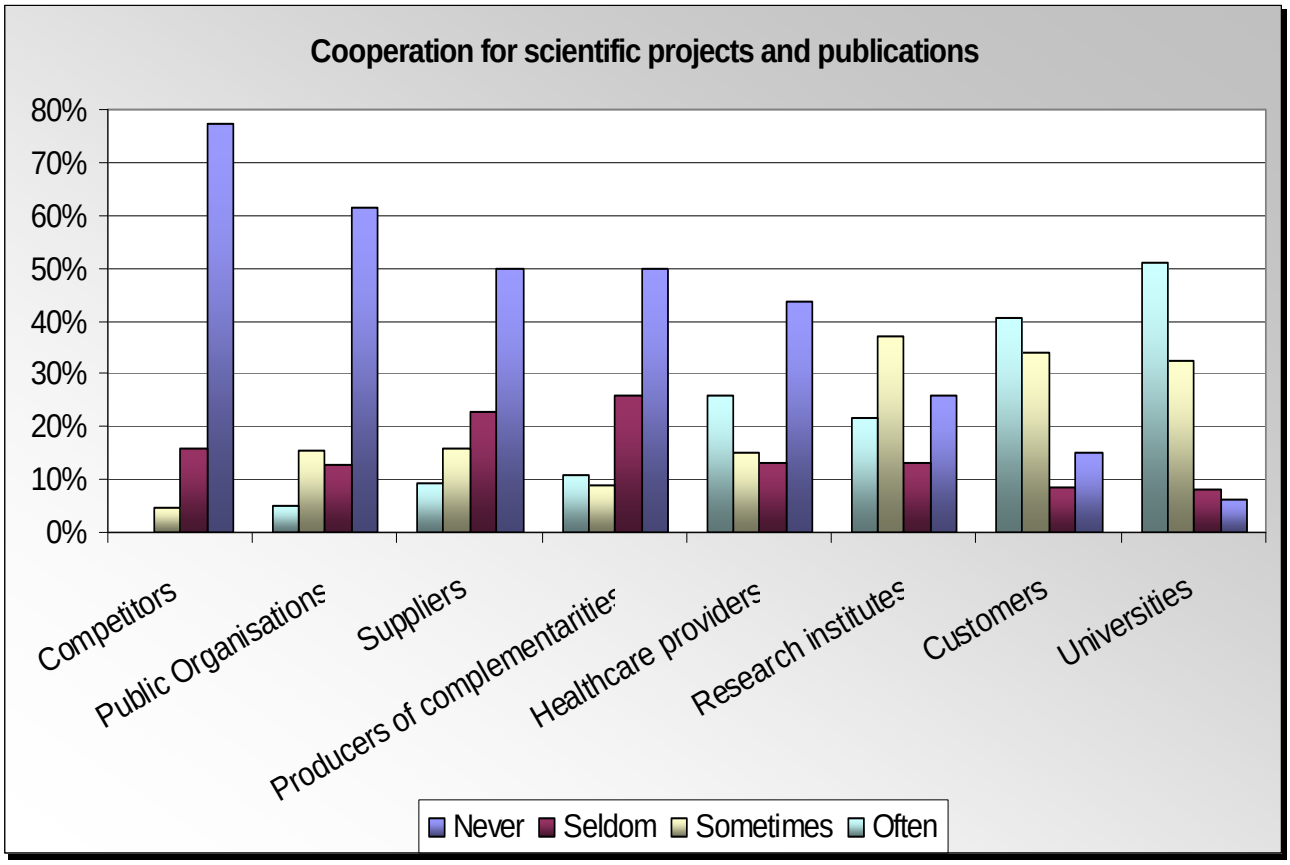
With science and technology being core knowledge areas for the biomedical companies we have surveyed, it is not surprising that as many as three quarters of the R&D performing firms publish in scientific journals.[79] They do so for strategic reasons, to legitimise their technology, to gain clinical and market approval, but also to access knowledge and attract highly skilled researchers.

Patents are seen as strategically important, as a competitive tool, and crucial for legitimising their technology; accordingly six out of ten companies have patented.[80] It is noteworthy that firms claim that the need for secrecy, or the high cost, does not prevent them from publishing or patenting – something that is often claimed in the public debate. As a result of these activities, more than half of the respondents feel that their companies have made key scientific contributions.

The firms report that they feel the need to strengthen their competence in scientific projects, publications and patenting. One way to do this may be through collaborative efforts, and therefore we analysed with whom the firms collaborate on scientific projects and publications. Clearly universities are imperative, but customers as well, indicating that the companies link up to state-of-the-art research at the same time as connecting to market needs (see Figure 18). Collaboration is apparently less common in relation to patenting activities, and the only partner who has been denoted as somewhat important is the regional university.

[78] See e.g. Kline and Rosenberg (1986).
[79] The answers for the R&D performing firm were: 20% had no scientific publication in the past 10 years, 24% had 1-3 publications, 29% had 4-10 publications, and 21% had more than 10 publications. (6% answered ‘don’t know’)
[80] 22% of the respondents hold 4-10 patents, 41% have 1-3 patents and 18% have zero patents.

Figure 18. Co-operation for scientific projects and publications



5 The importance of the region

The BMV programme is a regional initiative aiming to strengthen the innovation system for biomedicine in Western Sweden. In such an endeavour it is crucial to understand at what times the region can play a role of importance, and what features of the region function well, and could be reinforced. Therefore, first, we will discuss how the companies view the region, both in terms of why they chose to locate there and what they consider to be the region's most attractive traits. Second, we scrutinize to what extent partnerships are regional in character.

5.1 Views of the region

It is clear that the most prominent of the reasons why firms located in the region was that the founders (individuals, research groups or firms) were from the region. This is true for 87 percent of the firms. There may thus be personal reasons for the location, or the reason may be a connection to a parent organisation; with 43 percent of the responding firms being spin-outs from regional universities, and 21 percent spin-outs from regional companies. Curiously, even though financiers, for example venture capitalists, have not played a major role in firm foundation, until the 1990s (see section 3) and even though many firms find it difficult to find financing, the closeness to founding financiers do seem to be of great importance. In fact, 42 percent of the respondents give this as a main reason for their choice of location. Another vital – and complementary – factor contributing to the choice of location has been that key customers (17%) were located there. Alternatively, subsidies granted for locating in the region seem to have had only a minor impact (8%), as did the prevalence of key suppliers (6%).

Table 4. Why the firms are located in the region[81]

The founders are from the region	87% (n=54)
A spin-out from a regional university	43% (n=51)
A spin-out from a regional company	21% (n=47)
Financiers are/were located in the region	42% (n=48)
Key customers are/were located in the region	17% (n=47)
Received subsidies for locating in the region	8% (n=45)
Key suppliers are/were located in the region	6% (n=47)

What is it then that makes companies stay in the region, that is, what features of the regional environment are considered to be well functioning? There are a number of different aspects of the regional environment, structure, and dynamics that work well – and some that work less well (see Figure 19).[82] A general observation concerning the responses to this survey question is that there do not appear to be any dimensions with which the companies are very pleased: No dimension scores above 3.8 on a 6.0-point scale. Instead, one could say that on most dimensions the firms consider the region to be "okay", but not more. Thus, the discussion below should be seen in this light, where 3 on a 6-point scale could be seen as satisfactory/reasonable, but not as good.

First, the firms seem to feel that the regional innovation policies are satisfactory,[83] and they think it is relatively easy to establish a new firm within the region.[84] Second, the proximity to universities seems to be of importance and the firms think it is reasonably easy to collaborate with university researchers. Third, the labour market functions acceptably. There is a sufficient supply of engineers in particular, but also of R&D personnel and managers. In fact, given a direct question, about 60 percent of the firms think that it is easy to find competent R&D personnel in the region or in Sweden, while less than a third find it easy to recruit from abroad. The situation is somewhat different when it comes to recruiting managers, 69 percent of the companies easily recruit from Sweden, but only 44 percent from the region, and 24 percent from other countries. This is an interesting observation in its relation to the efforts of the BMV programme to create a cohort of biomedically related managers through the GIBBS educational programme.

Fourth, the presence of a competent biomedical industry is acknowledged as important. However, the firms are of the opinion that there could be more knowledge spill-over and synergies from collocations with other biomedical actors and more knowledge spill-over. The actors only moderately agree that there is the presence of a cluster, or a critical mass of firms. This relates back to the issue of the labour market, where the pooling of labour is considered passable but certainly not excellent. The perceived lack of a critical mass of firms also relates to the firms' perception that access to suppliers is only moderately good. Indeed, while 26 percent of the firms have found regional suppliers without difficulty, 50 percent easily found them on a national level, and 74 percent abroad. Also, access to regional customers is not prominent and a regional market does not seem to be the main positive feature of the region. Fifth, the companies feel that their technology and products are reasonably accepted by central stakeholders. Finally, as regards access to complementary resources and especially seed or VC financing, this is considered somewhat of a problem for the region.

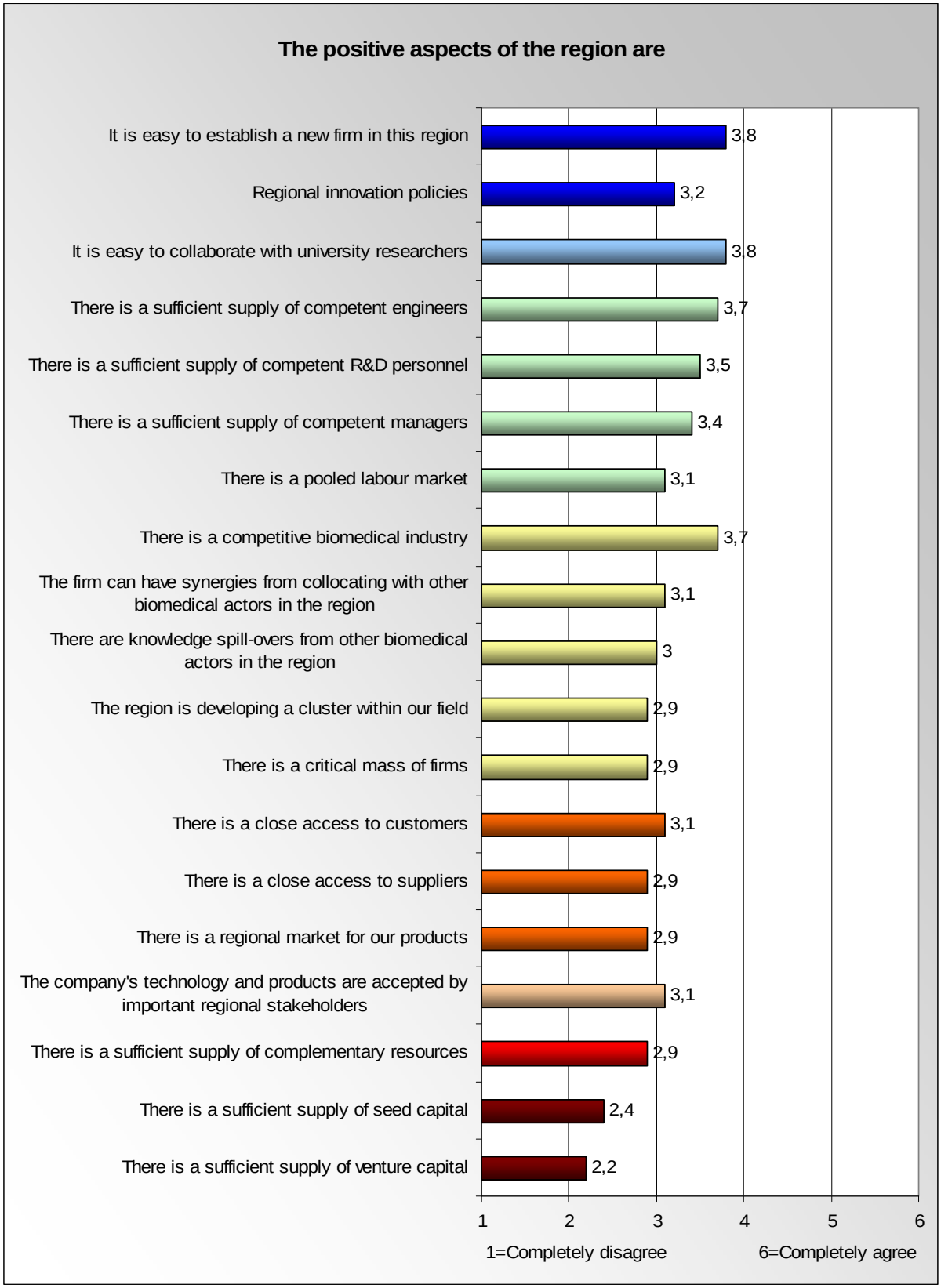
[81] N=123. Based on R&D performing firms only.

[82] The questions posed were "The positive aspects of the region of Västra Götaland and Halland are that…." where 1 denotes the answer 'completely disagree' and 6 denotes the answer 'completely agree'. Note that there are no significant differences in the views of firms with R&D activities and those without R&D.

[83] On average the firms give this aspect a value of 3.2 on a 6-point scale, see Figure 19.

[84] Note that on another survey question, more than half of the R&D-active firms feel that it is reasonably easy, or even easy, to establish a company.

Figure 19. Positive aspects of the region of Västra Götaland and Halland [85]



Relating to the issue of a lack of a sufficient critical mass of firms in the region, the respondents believe that the entry into the region of additional biomedical firms would be very positive for the

[85] N=123, n_{mean}=47

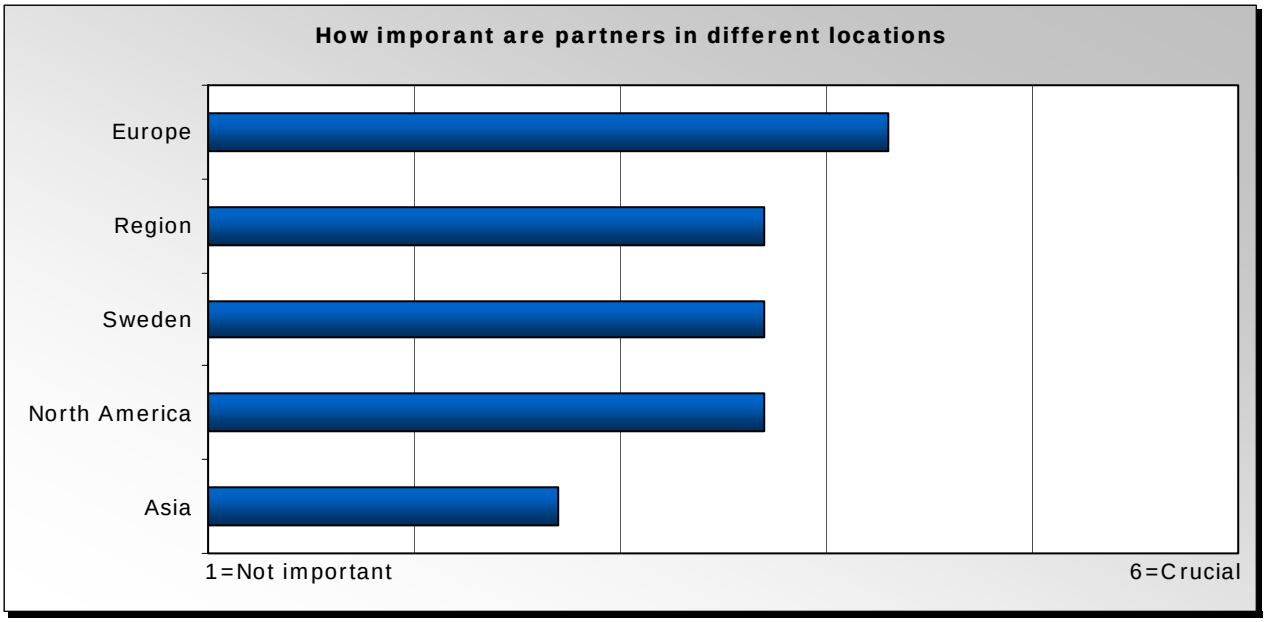
region and for them as companies.[86] They see a number of potentially positive effects. First and foremost, they feel it would most likely lead to more collaboration, and contribute to an increased information flow among firms enhancing knowledge spill-over. It would, for example, attract firms that can supply specialised intermediate goods and services. Second, a larger cohort of biomedical firms would create a pooled labour market for R&D personnel and managers, and attract expertise from other countries. While re-cruitment within Sweden has not been singled out as a key problem (see discussion above) a pooled labour market is still considered very helpful. Perhaps more urgently, the recruitment of foreign person-nel has been stressed as as being more difficult, and attraction of such staff is very useful. Third, the companies think the existence of a critical mass would give the sector increased political power which would lead to an enhanced public awareness and legitimacy of their technologies and products; this would allow them greater ease in influencing legislation and policy actors. However, a critical mass is not, to the same extent, believed to create a regional market; perhaps this is a result of the fact that most companies are already well established in several markets, and that markets within the biomedical field are usually of a global character.

5.2 The location of partners

In the analysis above nothing has been said about whether the firms' partners are regional, national or foreign. This is a vital issue with regard to external collaboration: where different partners are *located* and how the selection of partners is affected by geographic proximity.

The firms were given the direct question asking how essential partners from different locations were. They responded that there were no significant differences as to the value of the regions: Sweden, Europe, or North America. Although there is an indication that partners in Europe are valued the most (Figure 20), while partners in Asia are considered of least importance.

Figure 20. The importance of partners in accordance to their location[87]



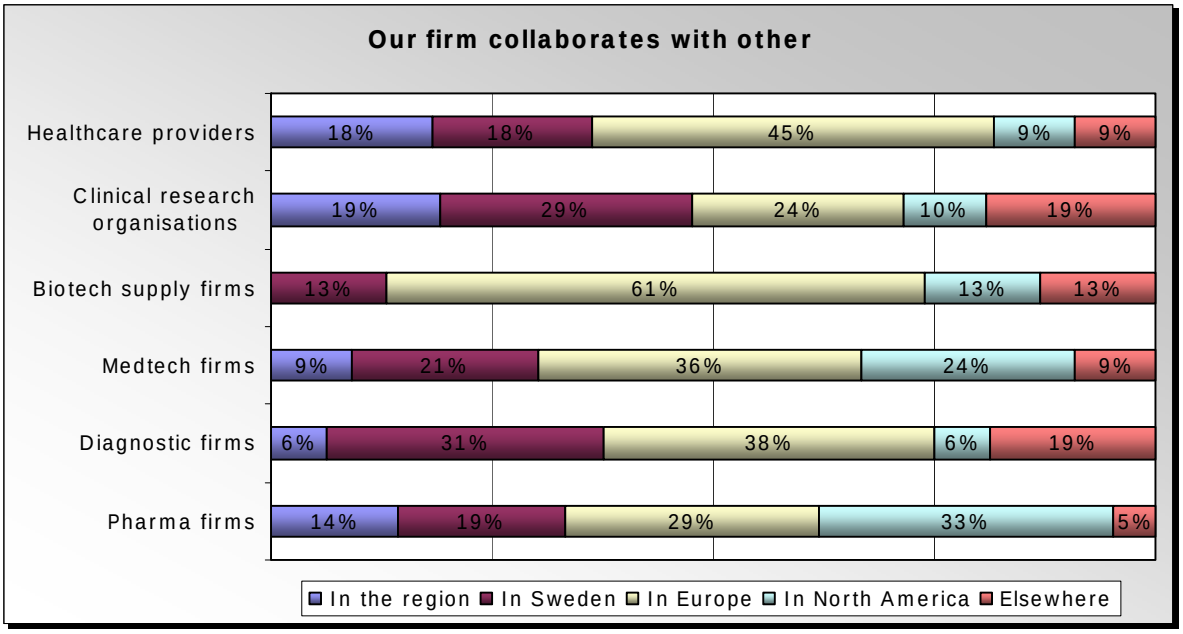
After analysing the specifics of the collaborative patterns and asking the companies in what location they primarily have their various types of *non-academic partners*, it becomes readily apparent that it is the health care providers, CROs and pharmaceutical firms that are of foremost importance on

[86] The question posed was 'For our company it would be positive if more firms enter the biomedical field in Sweden because…'. Note that there was little difference in the relative importance of the various reasons.
[87] N=123, n_{mean}=51

the regional level (Figure 21). What might be found somewhat surprising is the fact that there is very little intra-regional co-operation with medtech or diagnostics firms, and none whatsoever with the biotech supply sector, even though these groups together make up the bulk of the regional biomedical industry. This is certainly a finding that calls for further analysis and perhaps action. Partnerships with Swedish firms – outside of the region – are more frequent. About a third of the respondents collaborate with Swedish (non-regional) diagnostic firms and CROs, and about a fifth with medtech or pharmaceutical firms or with health care providers. In general, the Swedish partnerships are thus relatively frequent, but they are primarily established with non-regional actors. The most dominant type of partnership is the European (non-Swedish) partnership, especially with biotech supply firms, health care providers, diagnostic and medtech firms, pharmaceutical companies, and CROs. Non-European co-operation is predominantly with pharmaceutical companies and medtech companies, but also with other types of partners.

Once we cross the boundaries of Europe, partners from North America are the most pronounced. This is quite logical since the USA is the dominant market worldwide for biomedical products. The interview study showed that many of the somewhat larger medtech and biotech supply firms regard North America as their key market. This also means that it is crucial for them to collaborate with American partners, i.e. customers/users who can either be health care providers or other firms. It seems that for the younger, or smaller, firms European partners are relatively more important. Generally speaking it is probably easier for these firms to start developing their businesses in Europe, and then grow later on by entering the larger, more distant and challenging North American market. This indicates that helping younger and smaller firms to establish themselves in North America may be a feasible task for supporting organisations in the region. One may raise the question whether the BMV programme should have a role to play in this regard.

Figure 21. The main location of partners (industrial and health care)[88]

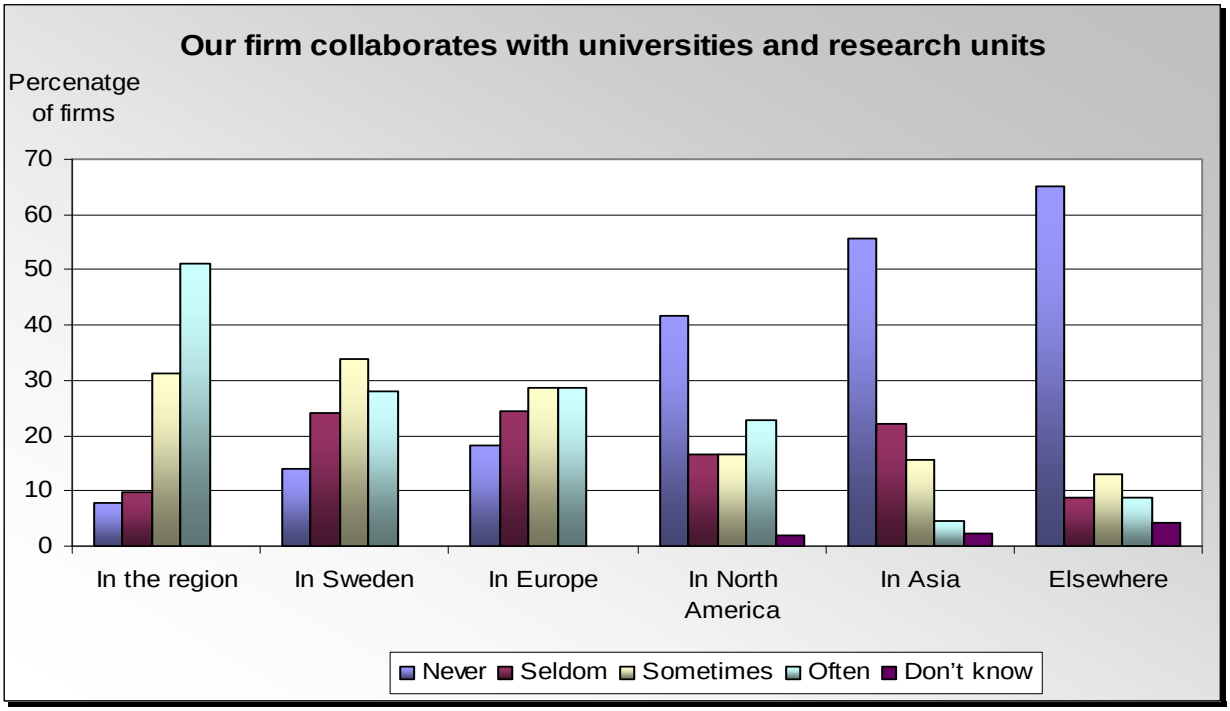


As for the location of *partnering universities and research institutes*, the pattern here is different in that these are more often local relationships. Thus, the region plays a more essential role for these types of collaboration, especially when compared with the other types of partnerships discussed

[88] The question posed was as to where each type of their partner was primarily located, thus they were to give the most important location for each category of collaborative actor. N=123, n_{mean}=23

above (Figure 22). From the point of view of regional development, this is something to take advantage of and to further promote. Additionally, about a third of the firms *often* collaborate on the national and European level, and another third *sometimes* do; while co-operation with North American partners is somewhat less frequent. Academic partnerships in Asia or elsewhere in the world are uncommon.[89]

Figure 22. Location of partnering universities and research institutes[90]



In relation to the aim of the BMV programme in supporting the development of the innovation system, our survey shows that while regional partnerships are indeed influential today, they are not the primary type of collaboration for most firms. Above all, the regional partners that come into play are universities and research organisations, on top of which are health care providers, CROs and pharmaceutical firms.[91]

To give an example from the interview study, the managing director of one pharmaceutical firm, which is a university spin-off, says that for his firm, proximity is not a major criterion in their selection of R&D partners. Thanks to modern communication technology, it has become less significant where the partners are located. Instead, partners are chosen on the basis of competence and price. Another university spin-off reports that all its R&D partners but one are situated abroad.

A chief finding, of course, is the importance of collaboration with the two universities in the region – for the purpose of identifying and acquiring new knowledge. One possible interpretation is that the innovation system functions well from this point of view, indicating that this is a feature that should be strengthened further and exploited – e.g. by spinning out more firms and stimulating

[89] Given the rapidly increasing investments being made in biotechnology by several Asian countries – such as Japan, South Korea, Singapore, India and China – there are strong reasons for Swedish firms to become more active in that part of the world. Thus, Asia is not only a growing market for biomedical products but also an increasingly important source for new technologies.

[90] N=123, n_{mean}=44

[91] As for the collaboration with pharmaceutical firms, it is reasonable to assume that the partner in most cases is AstraZenca, since there are not so many other firms in this sub-sector.

academic researchers to increase their contacts with existing firms (or vice versa). Another possible interpretation is that the firms are too focused on regional collaboration and therefore need to broaden their interaction patterns to include more academic partners from other parts of Sweden or abroad. However, given their obviously outward looking approaches to collaboration with industrial and health care partners, the companies do not give any impression of being too locally focused. Rather, the explanation for the observed pattern is as follows: many companies are founded on inventions and research findings that originated within the two regional universities, with whom they maintain close relationships (e.g., for further developing the technology). In order to successfully bring their products to the market, and then to grow, the companies need to establish other types of collaborative relationships (with customers, distributors, suppliers, etc). Due to the limited size of the region these "asset-providers", in most cases, have to be found outside of the region.

As an illustration of this pattern, the R&D manager at a medtech company told us that collaboration with universities was crucial for them at an early stage, in order to build up the scientific knowledge base, but has become less important over time. Today, their main development partners are suppliers and clinicians, especially those who can act as opinion leaders. For his company, contacts with regulating authorities in different countries are also very useful, since they may help to stimulate demand. Thus, one of the purposes of their current collaborations is to build up a market for the unique product developed by this firm, and it is natural that these activities take place outside the region.

In addition to the possibility of acquiring knowledge, the local universities constitute particularly vital resource providers for the smaller firms. Some interviewees representing such firms emphasised the great value of being able to use unique research facilities owned by the universities. This mainly concerned the use of advanced scientific instruments that the companies cannot afford to buy – at least not in the short term. To support the development of small firms, regardless of whether they are university spin-outs or not, it is thus imperative that the universities pursue a policy which means that they are open to this kind of interaction. For these firms, it is an obvious advantage if these resources are available in their local environment. To go outside of the region to get access to them may prove to be too costly or complicated.

6 Towards an expanding biomedical innovation system

In this section we begin by summarising the key findings from the study as they relate to firm formation and growth. We then conclude the report by discussing some of the implications of these findings for future work developing the innovation system.

6.1 Key findings and conclusions

There are a number of findings to be highlighted from the survey of the regional biomedical companies and the accompanying interviews. Biomedicine, or biosciences more broadly, is characterised by a high degree of dynamics, and intensive competition based upon knowledge development and technological innovation. In such fields the *formation of new firms* is a key element in the renewal process (along with industrial and economic development) through which new science-based knowledge is brought into practical use. Interestingly, the respondents perceive it to be relatively easy to start new companies in the region, and it is obvious that firms do not encounter any large region-specific hindrances in this regard. This must not necessarily be seen as a positive sign, as one thing that many respondents complained about is the lack of regional seed financing. Obviously, in this area there is room for policy-action in order to facilitate the start-up process, even though the issue of who should provide the money is an all-together different matter.[92]

[92] In the planning process preceding the BMV programme the possibility of starting a seed capital fund was discussed. However, ultimately this proposal was not included in the action plan, since at the time there were other parallel initiatives to strengthen the supply of capital in the region. Some of them have been realised, such as the Investment Fund's opening of a local office in Göteborg, while others were not pursued.

Also, our survey data confirms that regional universities – that is, primarily the University of Gothenburg and Chalmers University of Technology – have played a decisive role in the history of the establishment of firms. Indeed, a third of all respondents, and almost half of the R&D-performing companies, characterise themselves as university spin-outs (USOs). These numbers encouragingly show that the universities, at least to some extent, do take on an entrepreneurial role be it intentional or not. This does not mean, however, that academic entrepreneurship in the region cannot be further improved (e.g., by improving the incentives to start companies and by further developing the universities' support systems).

A number of conclusions can be drawn regarding the USO process in the region. First, the existence of strong academic research in several fields constitutes a precondition for the spin-off process. Second, one of the strengths of the region is the existence of well-functioning incubators, in particular one that is dedicated to biomedicine (within the Sahlgrenska Science Park). The BMV programme established this incubator, and is now supporting its expansion and further development.

Third, the incubators are part of the publicly funded regional support system directed at academic entrepreneurship. There have been some complaints from company managers, and also from university researchers, that this support system is too fragmented and too difficult to understand; it is true that there are many public actors involved. In Göteborg, in addition to the two incubators/-science parks we find *inter alia*: GU Holding, GUFI,[93] Chalmers Invest, Chalmers Industriteknik, Innovationsbron Väst, Business Region Göteborg, and CONNECT Väst.[94] The BMV programme is, in itself, one of the supporting actors. Although we believe in the strength of pluralism, giving potential founders several alternatives, there is a need to simplify the support system, and perhaps even more decisively, provide greater transparency regarding as to the roles different actors have, and how these can supplement and co-operate with each other.

Fourth, in order to successfully start up new companies based on academic research, there is a need for competent managers who have a thorough understanding of the biomedical innovation process. The survey data confirms that management capability is indeed a chief competitive factor (see Figure 10). At the same time, there does not seem to be a sufficient supply of competent managers within the region (see Figure 19). It is therefore prescient that the BMV programme has established GIBBS, which is a master-level school of entrepreneurship focused on biomedicine. Although it is still run on a small scale, this must be seen as one of the strengths of the region – especially when it comes to firm formation. The students work with real business-development projects, which may in themselves result in new companies – of which there are already several examples. Furthermore, despite their limited experience the graduates have a background suitable to working with other start-up ventures.[95]

One fifth of all responding companies characterise themselves as corporate spin-outs (CSOs). While there is no general rule as to what can be considered a sufficient or superior contribution to entrepreneurship from the current stock of firms, it is quite possible that spinning off more companies from those firms already established represents an opportunity to develop the region's biomedical industry (and the innovation system as a whole) that has not been fully exploited. In fact generally speaking, established firms have a key role to play as a source of new firms through the CSO process – for example, 20 percent of all IPOs (initial public offering) on the Stockholm Stock Exchange are divestment spin-offs.[96] In our case, the large biomedical firms are of special interest, since they may have R&D projects or businesses that are not perceived to fit future strategies. Companies like AstraZeneca do periodically reconsider their project and business portfolios and may decide to cease certain activities, or to temporarily place some activities outside the firm's

[93] GUFI is the University of Gothenburg's unit for research and innovation service.
[94] In the region there is a third incubator called Brewhouse Innovation. It focuses on creative industries such as music, film, media and animation.
[95] For more information about GIBBS see http://www.entrepreneur.chalmers.se/gibbs/
[96] Wallin (2007, p. 44).

scope. With suitable support from regional policy organisations, initiatives may be taken, for example, by the BMV programme to ensure that such activities remain in the region and are further developed in a new setting. For example, the project may be transferred to another firm, or organisation, or taken as starting point for the establishment of a new company.[97]

In order for the industry and the innovation system to prosper, it is not enough to merely create new firms; needless to say, to achieve the desired effects, firms have to grow. Yet *growth* does not follow automatically upon firm formation – which in turn creates challenges for business managers, policy-makers and other actors concerned. As a matter of fact, the bioscience industry in general is characterised by a relative absence of growing firms.[98] In Sweden, known for its large number of biotech firms, industry specialists and policy-makers frequently express concern about the slow growth rate.[99] Obviously, there are many difficulties and problems biomedical and other biotech firms have to overcome in order to grow and become prosperous.

While we have not explicitly analysed the growth patterns, our findings give some insight as to the needs of the companies and the prerequisites for economic growth. In general, the respondents see themselves as technologically strong. Also, the R&D intensity (measured as a percentage of total cost) is high, even though the large volume of small firms means that it is moderate in absolute numbers, with a large majority of firms spending less that 10 man-years on R&D. Notably, this cohort of companies has a number of projects in the pipeline, and there is a relatively even distribution across the product development phases. It is interesting that as a group they feel that they have a relatively strong position in their market, where one quarter claim to be a globally leading supplier, and one fifth say that they are among the top ten firms in the world in their specific market segment. In accordance with these positive indications, the respondents' views on expansion are also encouraging, with most firms having plans to launch new products, enter new markets and increase sales significantly during the next twelve months; they also plan to increase R&D expenditures and seek additional suppliers. Curiously, recruitment plans are not as strongly pronounced, but this may to some extent indicate their reliance on outsourcing strategies; nor do the companies have strong intentions to seek additional external financing during the coming year.

Obviously, many aspects related to firm growth seem to work well, indicating that there are few imminent problems with, for example, regard to legislation or regulation. Also constructive is that the firms seem to have good relations with competent customers and knowledgeable financiers. On the other hand, one of the worrying signs, from a job-creation point of view, is the companies' own statements that they do not plan to recruit new personnel to any major extent. This may indicate that their optimistic expansion plans will not result in the creation of so many new jobs, at least not in the responding firms. Possibly, new jobs may be generated in other firms, such as contract manufacturers or suppliers of goods and services (thanks to multiplier effects).

The answers indicate some weaknesses in the region that may affect future growth. In particular, the lack of a critical mass of firms is seen as a major drawback. Furthermore, despite the moderate need for new financing, the lack of regionally-based venture capital is perceived as another weakness. The respondents also point to the absence of dedicated lobbyists, both at the regional and national level as another shortcoming, their possible interpretation being that stronger efforts to promote and legitimise the industry's interests could have positive effects on growth.

We can conclude that the companies do not see their specific location in the region of Western Sweden *per se* as a major competitive advantage. This does not mean, however, that the regional characteristics are unimportant for firm growth, but merely that the companies do not highlight them. In practical terms, the firms do collaborate with many regional partners and source knowledge from the region. Thus, by providing the firms with a supportive environment, where they can

[97] To mention a couple of historical CSO cases, the current Mölnlycke Health Care is a spin-off from SCA, and Cochlear Bone Anchored Solutions is a spin-off from Nobel Biocare (initially named Entific Medical Systems).
[98] See Brink (2007) for a discussion on the specific setting of bioscience-based industries.
[99] Sweden ranks number four in Europe in terms of the number of biotech firms (see e.g. Ernst & Young, 2004).

gain access to valuable resources (knowledge, staff, capital, R&D partners, suppliers, etc.), the regional innovation system can be turned into a decisive factor. The BMV programme, as a tool to unite and mobilise key regional actors (such as the two universities, Region Västra Götaland and Business Region Göteborg), therefore has a central role to play, not only by stimulating firm formation but also by helping existing firms to grow.[100]

A precondition for their growth is that the firms can gain access to knowledge and other resources that they need for the development of their business. This study particularly focuses on the key process of knowledge creation, diffusion and use. By investigating knowledge flows and collaboration patterns we have measured how the firms are connected to other actors in the value chain and how well the regional innovation system functions in this respect. Our data shows that firms have the majority of their innovative activities in-house. This is positive in the sense that it illustrates that companies have the internal strength and capability to run complex projects. Conversely, given the crucial importance of external collaboration for successful innovation this result might indicate a weakness in the innovation system – in that the firms rely too much on internal knowledge, leading to the potential risk that they be less open to knowledge impulses and learning from outside. However, three points have led us to be less concerned about this finding. First, the survey results, as well as our interview data, show that in practice external collaboration is of crucial importance to the companies. Second, when a project is run in-house there may be a tendency among respondents to understate the importance of external knowledge sources feeding the project. Third, as we have seen, many of the new firms are spin-outs from universities or larger companies. Since many of these firms still have some of their founders as co-owners, they may receive valuable resources as input from the parent organisation without perceiving this as external collaboration.[101]

Concerning the importance of different types of partners, our data shows that business relationships with customers and suppliers are used not only for purely commercial purposes but also, in many cases, as a resource for technological development. This manner of partner is usually located outside the region, which is quite understandable given the small size of the region and the companies' need to establish strategic partnerships in different geographical markets. Universities are also very important as partners, and collaborating universities are most often regional. This observation illustrates that the regional universities not only play a key role as a breeding ground of new firms, but also provide highly valued co-operative opportunities for firms, both new as well as old ones. Research – in contrast to later stage product development – usually involves a higher amount of tacit (not codified) knowledge, which presumably contributes to the explanation as to why geographic proximity and face-to-face interaction are relatively more essential when it comes to academic collaboration (as compared to customer and supplier collaboration).

The survey data indicates that generally, collaboration with health care organisations is not attributed high importance (see Figure 13). This is rather puzzling since for many biomedical firms, health care is a key category of customer. We may however assume that user-oriented co-operation with health care institutes is covered by the respondents' answers regarding the importance of customers.[102]

The observation that intra-regional collaboration with medtech and biotech supply firms is relatively rare is not surprising. Both these sub-sectors encompass a broad range of technologies, products and applications; yet, at the same time, firms tend to be highly specialised in particular niche products. Except for the biomaterials field, where there is an existing cluster, it is probably difficult for

[100] In the next section, we will return to a discussion regarding possible measures to be taken in order to pro-actively influence the innovation system and stimulate growth.
[101] One should therefore be cautious about drawing too far-reaching conclusions based on these numbers. Nonetheless, in our further studies of the innovation system there may be a need to analyse the extent of collaboration in more detail.
[102] The result may indicate that there is a potential for increased collaboration with hospitals, e.g. in the region. But this is something that needs to be followed up more closely in our further research.

most firms to find a suitable industrial partner within the region. To find and gain access to complementary resources they have to search for partners in other parts of Sweden or abroad, which they do. For the regional innovation system there presents an opportunity to invite additional actors to locate in the region – in order to fill the role of supplying complementary products and technologies to existing firms, and to aid in the creation of a "cluster" around specific applications or technological areas.

6.2 The way forward

In this concluding section, we would like to point out some of the opportunities for developing the innovation system.[103] Clearly an innovation system, as it is defined in this study, is a complex entity. Even when restricted (like here) to a certain sector and a certain region there are many actors involved, directly and indirectly related to each other through a web of relationships. In addition, there is a range of important institutional factors affecting the different key processes taking place in the system. In this report we have characterised the biomedical innovation system in Western Sweden from the perspective of firms operating in the region. Among the key processes taking place in innovation systems, our main focus has been on the creation, diffusion, and use of knowledge – especially knowledge emanating from R&D; this is a crucial function of the innovation system, and in different ways affects its enduring industrial development. In essence, the understanding of the creation, diffusion, and use of knowledge is at the heart of the very objective of the Vinnväxt initiative BMV, as it aims to support and kindle the development of the regional innovation system for the purpose of long-term industrial development, job creation, and economic growth. There are ambitious goals to position Western Sweden as one of Europe's leading biomedical regions. The companies in the region, existing ones as well as new ones, have an important role to play if these goals are to be realised.[104]

Starting with the issue of *firm formation*, we can see a number of possibilities. First, it should be possible to exploit the existing entrepreneurial role of the universities, in order to create new academic start-ups. To stimulate this process, incentives and support structures should be further improved. Measures aiming to raise researchers' general awareness of commercial possibilities and their understanding of the process and its requirements (e.g. IP issues) can be assumed to have a stimulating effect on firm formation (as well as on other commercial forms of research findings, e.g., licensing to existing firms). We know that both within the Sahlgrenska Academy and Chalmers there are promising initiatives moving in this direction. Also, career structures and incentives as well as available resources need to be aligned with this move by the universities towards academic entrepreneurship, in order not to compromise the universities' other roles of scientific research and teaching. For instance, in some circumstances researchers could get various forms of credit from their employer for involvement in firm formation, and different types of career paths could be contemplated. Furthermore, consideration of innovativeness and interest in commercialisation when recruiting new people to research positions may, in the long term, have positive effects on academic entrepreneurship. There is also a great necessity for providing researchers with professional assistance to help them evaluate the commercial potential of scientific findings and to formulate interesting product ideas that can be tested – for example, by using those with dedicated competencies as well as laboratory facilities provided through the support system.

Second, we would like to repeat that the possibility of spinning out new firms from established companies should be explored. For example, are there ongoing R&D projects that could – perhaps for a limited time period – be broken-off from the parent company and combined with other complementary resources in the innovation system?

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[103] To what extent the BMV programme itself should take responsibility for implementing suggested measures is an open question, and we refrain from addressing it here.

[104] With its focus on companies this study gives only a partial picture of "the real innovation system" (with all its actors and complexities). Hopefully though, this picture will contribute to the understanding of the system and by so doing help policy-makers and others concerned shape their own actions in a fruitful manner.

Third, the possibility of enriching the innovation system by attracting Swedish or foreign firms to establish their activities in the region should be pursued. Such attempts must be built upon the strengths of the region. Biomaterials and cell therapy – where there are existing or emerging clusters that include both academic and industrial actors – are areas where the region can offer entering firms an attractive research and innovation environment. In the cardiovascular field there is also strong academic research, but there is no company cluster; instead, the presence of AstraZeneca's R&D unit in Mölndal, as a potential and very capable partner, can be seen as a definite strength. This raises the question to what extent AstraZeneca is interested in supporting the establishment of new firms in the region, for example, different types of research companies or service providers.

Fourth, product ideas and inventions do not only come out of academic or industrial research (pre-clinical or clinical). In the context of the practical health care operations, creative personnel may come up with good ideas for new products, typically in the field of medical devices. Sometimes such ideas are picked up and further developed by existing suppliers with whom the personnel has connections. In some cases, however, the inventors (or idea providers) may be interested in participating in or contributing to the start of a new company. While we have no data on this phenomenon from our study, it seems that this kind of commercialisation process is quite rare in the region, and we would like to hypothesise that there is the potential of utilising the health care system better as a source for new products, and even of new companies. Such innovations may not (always) have the same technological level as research-based innovations, but they can have a sales potential that should not be disregarded. Up until now, the support for new businesses has focused mainly on academic entrepreneurship, and rightly so. However, as we hinted earlier, we think that it could be worthwhile to direct more attention to health care as a source for innovation.[105]

Turning now to the issue of *growth*, the study quite favourably shows that the prerequisites for the continued growth of the biomedical industry are almost all in place. Regrettably, however, a critical mass of firms is still lacking, which must be seen as a major inhibitor. This proves how crucial it is both to increase the number of firms, and support and drive the growth of existing firms. To make the latter happen, there needs to be improvement in the availability of venture. There are already several VC-firms present in the region, but it would be an advantage if more VC-firms opened their offices here. For example, attracting internationally leading VC-firms who specialise in life sciences to come here would result in many benefits, be they in the form of money or expertise in the biomedical business. We do not know if such a scenario is realistic, but it should be worthwhile to investigate.

Despite the companies' moderate plans to recruit new personnel, there is no doubt that the availability of skilled staff is a key driver of investments and growth; especially given the lack of a critical mass, it is of utmost importance that the labour market functions well. Policy measures aimed at increasing the mobility of employees within the biomedical innovation system would therefore be a welcoming sign. Examples of this could be the providing of a "meeting place" for people working in the region's life science sector, GöteborgBIO (i.e. the communication platform of BMV) can stimulate contacts and relationship-building, this in turn can lead to higher mobility – both within the industry and between industry and academia.

Growth is going to have to come primarily through increased sales in foreign markets. The internationalisation of firms is therefore a key prerequisite for further growth. Of course, it must be up to each individual firm to design its internationalisation strategy and to implement it. However, especially for the smaller firms, public support actors could have a role to play by helping firms to expand abroad. It is not only about supporting the firms' marketing activities. Helping them to

[105] The PUMA programme in the County of Jönköping is a successful example of how health care-based innovation can be promoted (Laage-Hellman, 2006).

establish R&D-related contacts in key markets (such as the US, for example) might also be useful, since technological collaboration may pave the way for future sales in that country.[106]

The pharmaceutical sub-sector is in a unique situation given the total dominance of AstraZeneca. How this part of the innovation system develops depends a great deal on what happens at AstraZeneca in Mölndal. For quite some time the company has had a broad interface with the region's universities, and in particular with the Sahlgrenska Academy with which the company is running a large number of co-operative projects. From the perspective of the innovation system this relationship is a key asset. AstraZeneca is now interested in getting academic researchers to stay involved for longer in the drug development process, and has taken some initiatives in that direction. This must be seen as a positive sign that will create opportunities for new developments and strengthen the innovation system as such.

An important question for the future is whether it is possible in this region to create a cluster of drug developing firms that besides AstraZeneca would include a number of smaller firms. It is part of AstraZeneca's overall R&D strategy to collaborate with small firms that can provide new technologies, especially in the biotech field. For the research unit in Mölndal it is reasonable that such partners primarily have to be found elsewhere. But from the perspective of developing the regional innovation system, it would be valuable if such partnerships could be established within the region. One possible scenario is that the currently evolving collaboration with local research groups creates opportunities to involve local biotech firms that can provide specific technologies or specialised services. In at least one project, AstraZeneca is already working with a university spin-out specialising in certain types of research tools. This arrangement could be taken as a role model. One possible barrier to the creation of this kind of development is that the volume and scope of the region's research in the field of modern cell and molecular biology is relatively limited.

We have now identified a number of opportunities that would serve to further develop the innovation system, but of course there are also some threats, or risks, that could jeopardise a positive development. Let us look at some of these possible threats. First, given the industry's dependence on the regional universities, a weakening of the universities' research base would undoubtedly lead to negative consequences both for firm formation and growth, at least in the long term. Conceivable events that could cause such a situation are the disappearance of key people, failure to compete for research grants, and major setbacks in prioritised research fields.

Second, several of the key companies are, to a lesser or larger extent, owned by foreign investors or belong to foreign groups (e.g., AstraZeneca, Astra Tech, Nobel Biocare and NeuroSearch). The fact that these companies are controlled from abroad entails some risk for the region. For example, the owners may decide for a variety of reasons to move certain activities out of the region – with, accordingly, the resulting negative consequences for the innovation system. Generally speaking, the more attractive the research and innovation environment the region can offer, the lower will be the risk of any type of corporate flight. In all fairness it should also be pointed out that there are many advantages associated with foreign ownership. For instance, the foreign owners may contribute valuable resources, knowledge, and experience that contribute greatly to the strength the company and accelerate its growth

A third possible threat has to do with the actions or inactions of the respective managements of the universities and the university hospital. A well-functioning environment of academic entrepreneurship presupposes full support from the managements. If they take measures or send signals that reduce the researchers' willingness or opportunity to engage in commercialisation, this would effect the innovation system by slowing down firm formation and making it more difficult to establish fruitful university-industry interaction. Though, luckily for now, this is but a hypothetical threat as the current trend in the academic world is of an opening up of universities to society, and a greater

[106] PRIMERA in Umeå is an example of a regional business development programme in the medtechmedtech field where the support of internationalisation has been used for the purpose of stimulating the commercialisation of research results (Laage-Hellman, 2006, p. 40).

contribution to the more effective use of research results. A related, but more specific threat, is the possibility that these key regional actors fail to join forces in their support of biomedical innovation (an extension of the above mentioned complaints about the fragmented support system). Experiences from the BMV programme indicate that there is a need to improve coordination and co-operation between the different units engaged in the support of innovation. After all, the region is relatively small and therefore necessitates joint action in order to optimise the use of available resources. If this cannot be made to happen, there is the risk that too many parallel and competing support activities will lead to inefficiencies and poor results.

Similar to the impact of the managing and organising of the universities, the actions or inaction of those responsible for making decisions concerning the health care system may create threats to as well as opportunities for the commercialisation of biomedical inventions. The question is: to what extent does the organisation of the health care system support or hinder the employees to engage in collaboration with industry? It seems that in this region the role of the health care system in the innovation system needs to be clarified. The health care system has control over an extremely central resource for biomedical research, that is, a large patient base. From an innovation point of view, it is essential that this resource can also be used in commercially-oriented R&D projects.

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Appendix 1 Methodology

The survey was constructed for the purpose of measuring the region on three dimensions; 1) to map the biomedical firms and their activities, 2) to measure their knowledge flow and creation, and 3) to investigate their perceptions of the region. The data collection was carried out during the second half of 2006 using Survey Generator, a web-based, on-line survey tool provided by Alstra AB (www.alstra.se). The target population consisted of all "biomedical firms" active in the region. The term biomedicine is here used in a broad sense. It means that the population included firms involved in development, manufacturing or marketing of the following product categories: pharmaceuticals, diagnostics, medical technology (incl. aids for disabled persons), "biotech supply" (biotechnology-based tools for R&D and manufacturing), and contract/clinical research services. This is indeed a broad definition. That is why many firms covered in this study do not label themselves as "biomedical".

These differences are due to the fact that it is not fully clear how to delineate the population. While many firms are easy to identify and classify as biomedical, there are others that are positioned on the border depending on the definition. These include, for example, suppliers of more general-type products or services to the "true biomedical firms" and firms whose business is only marginally directed at the medical field. We have tried to not include these firms, although some firms in this category may have received the questionnaire without responding. Likewise, we have tried to exclude firms performing health care or rehabilitation services (in contrast to manufactured products). Given the profile of the BMV programme, we have chosen not to include these firms in the survey, although it can be argued that they belong to the innovation system.[107]

As a starting point for identifying firms and email addresses we used a list of firms provided by Business Region Göteborg (BRG).[108] It contained details concerning 416 companies. However, this list was very extensive, and after scrutiny it was discovered that a fairly large number of companies had to be eliminated for various reasons. For example, it was discovered that some of these firms did not fall within the scope of our study, while others were no longer active within the region (e.g. due to bankruptcy or transfer of operations). At the same time, we complemented the list by adding other firms that we identified through various means. This includes, for example, Vinnova's cluster study of the Västra Götaland Region and the County of Halland,[109] and information about newly established spin-off companies obtained from science parks in Göteborg. The culmination of these processes was that we ended up with 222 companies on our list.

The first distribution of the questionnaire took place in late June 2006, this was followed by reminders every second week, for eight weeks. Since the initial response rate was unsatisfactory, a letter was sent in August to all firms that had not responded. This was followed by contacting firms individually by phone and email. This latter effort was primarily directed at firms that, according to our knowledge, performed R&D activities in the region, and therefore were considered to be especially interesting given the study's focus on innovation. The data collection was finalised in the end of December 2006. At that point in time, 78 firms had completed the questionnaire. This gave us a 35 percent response rate.

It can of course be questioned as to what the 222 companies in our population actually represent. Our ambition was to cover as many biomedical firms as possible (i.e. a total investigation). While the total response rate was 35 percent (78 companies), there was a 46 percent response rate (57 companies) from the R&D performing firms. This is probably a reflection of the fact that our efforts

[107] It would be possible to collect complementary data about the innovation system by making a survey directed at health care providers in the public and private sectors. However, there are no such plans at present.
[108] BRG is a regional organisation jointly owned by thirteen municipalities in the greater Göteborg area and dedicated to the support of industrial development.
[109] See Vinnova (2005).

to increase the response rate were directed at these firms. This means that our sample is not fully representative of the population, there is some bias towards R&D performing companies.

It can be noted that AstraZeneca's R&D unit in Mölndal is one of those that have not responded. This is understandable given the large size of this R&D unit. Since the company is involved in so many and varied R&D activities, it is difficult for one or a few persons to give a complete answer to many of the questions. We feel, however, that due to its size AstraZeneca has such a dominant position in the innovation system that its role and position have to be analysed by means other than this survey.

We have conducted a non-response analysis where we investigated three variables: number of employees, age, and main activity (i.e., whether the firms work with pharmaceuticals, medical technology or other products). For *companies with R&D*, the analysis shows that for all three variables (with significance level p=0.05) the firms that have responded differ from those that did not. If we look at *all firms*, we find that regarding age and number of employees the firms can be said to come from the same distribution, but that they differ with regard to activity (p=0.05).

We must conclude from this non-response analysis that in regards to R&D-performing firms, for which certain analyses have been carried out separately, the results obtained were not necessarily valid for the whole population of such firms. For all firms there was less difference between respondents and non-respondents. However, there are some differences with regards to activity, and this should generate some caution as to generalising the results to the whole population.

In addition to the complexity of its structure and processes, the innovation system is constantly evolving over time. It is difficult to catch many of the dynamic mechanisms through which the system evolves with the type of survey we have used. However, it is our intention to carry out a follow-up study after 2-3 years. This will give us an excellent opportunity to address the issue of innovation system dynamics. It will also provide an opportunity to study the effects of the BMV initiative (acknowledging the potential difficulties of distinguishing the effects of the BMV initiative from other influencing factors).

Appendix 2 Firms included in the survey

A+ Science
ABIGO MEDICAL AB
ACTIVE CARE SVERUP AB
AD MediCal AB
ADAPT COMFORT AB
Aidera
ALK SVERIGE AB
Almagest Pharma
AMBRIA DERMATOLOGY AB
ANALYCEN NORDIC AB
ANALYTICAL STANDARDS AB
AnaMar Medical AB
ANATOMICA AB
ANGIOGENETICS SWEDEN AB
Apoteket
Appeartex
Arcam AB
ARTIMPLANT AB
ASTRA TECH AB
AstraZeneca R&D Mölndal
AVANCO AB
AXEL ERICSSON MEDICAL AB
B.I.M.A. Plastteknik AB
BAYER AB
Beiersdorf AB
BELLMAN & SYMFON AB
Biovitrum AB (previously Arexis AB)
BIOMÉRIEUX AB
BIOPOLYMER PRODUCTS OF SWEDEN AB
Bioreagens
Bladhs Medical AB
Boazul Medical AB
BOHUS BIOTECH AB
BREAS MEDICAL AB
Breis & Company AB
BRÅNEMARK INTEGRATION AB
BSN MEDICAL AB
CACAN SVERIGE AB
Capio Diagnostik AB
Care of Sweden AB
CARLAB Läkemedelsforskning AB
CARLS-BERGH PHARMA AB
CARMEL PHARMA AB
Cast Medical AB
Cellartis AB
CELLECTRICON AB
CELLMATRIX AB
Cenger Scandinavia AB
Cerbo Trollhättan AB
CIVO Bioscreening
COATECH LAB AB
Cochlear Bone Anchored Solutions (previously Entific Medical Systems)
CODAN TRIPLUS AB
COLOPLAST AB
Comfort Medical AB
COMPRIMO AB
Cook Sweden AB
DAB DENTAL AB
DCG Nordic AB
Decon Wheel AB
Denator
DENTAL IN SWEDEN AB/Trollhätteplast AB
Dentirol AB
DERMATEMP AB
DETEKTOR AB
DIAGNOSTICA & ANALYS SERVICE, FRIBERGER
Diffchamb
Digitales, AB
DPC SCANDINAVIA AB
DuoCort
DX Plastic AB
Einar Egnell AB
Elos Medical AB
Enurad AB
Esshå Elagentur AB
EuroPharma Sverige AB
EUTECH MEDICAL AB
FERNO NORDEN AB
Fisher Scientific GTF AB
Food Diagnostics
Fujirebio Diagnostics (previously Canag Diagnostics)
FÖRBANDSMATERIAL AB
GESTENCO INTERNATIONAL AB
GETINGE AB
GETINGE SKÄRHAMN AB
GLAXOSMITHKLINE AB
GN RESOUND AB
GOT-A-GENE AB
GOTHIA MEDICAL AB
GRAMTEC INNOVATION AB
Guldmann Sverige AB
Göteborgs Plast AB
HAEMOCHROM DIAGNOSTICA AB
HAMMARPLAST MEDICAL AB
Handelshuset Medic i Borås AB
HANDICARE SVERIGE AB
HEA MEDICAL AB
HEINE SCANDINAVIA AB
HELA PHARMA AB
HIGHTECH VISION S.C.I. AB
HISTOCENTER-SKANDINAVISKT CENTRUM FÖR HISTOLAB PRODUCTS AB
ILS LABORATORIES AB
IMEGO AB
Incisivium
Ingenjörsfirman Björn Bergdahl AB
INGENJÖRSFIRMAN JAN-ÅKE HALLÉN AB
INSTRUMENTA DIAGNOSTISKA OCH KIRURGISKA AB
INTEGRATION DIAGNOSTICS AB
INTEGRUM AB
INVITRO RESEARCH AB
Jasco Scandinavia AB

JÄGSTENS SJUKVÅRDSPRODUKTER AB
Kom i Kapp - Rehatek AB
KOVALENT AB
KRONANS DROGHANDEL AB
LABINETT LAB AB
LabRobot Products AB
LAYERLAB AB
LEICA MICROSYSTEMS AB
LGC Promochem AB
LIFECORE BIOMEDICAL AB
Liko
MA SERVICE AB
Mastercare AB
MEDARTUUM AB
Medical Equipment Development AB (MEDAB)
Medicross AB
MEDIEL AB
MediRum AB
MEDISERA AB
Medrad
MENTICE AB
MICROMED AB
Micropos Medical AB
Midorion
Millicore
Millipore/NovAseptic
Minicrosser AB
MULTID ANALYSES AB
MUNDIPHARMA AB
MÖLNLYCKE HEALTH CARE AB
NANOXIS AB
NEOVENTA MEDICAL AB
NeuroSearch AB (previously Carlsson Research)
NIDACON INTERNATIONAL AB
NOBEL BIOCARE AB
NORDIC MANAGEMENT OF CLINICAL TRIALS (NMCT) AB
Nordic Med - com AB
NORDIC MEDICAL ADVISOR
Nordiska Handels & InnovationsRådet AB
NOVAMETRIC AB
Nya CAS Clean Analytical System AB
OCTEAN AB
ORGANON AB
Oscar Instrument AB
P & B Research AB
Panafarma
PHARMADULE EMTUNGA AB
Pharmasurgics
POLYVALK AB
Prevas
Prolab
Promimic AB
qbTech AB
Q-SENSE AB
QUALISYS MEDICAL AB
ResMed Sweden AB
RTI ELECTRONICS AB
SACS MEDICAL GÖTEBORG AB
Salubrious AB
SAMBA SENSORS AB
SCA Personal Care
Scantec Lab AB
SDS Biosciences KB
Servo Med AB
Sinclair Pharma
SKANDINAVISKA GENETEC AB
SKF
SMITH & NEPHEW AB
SMK Skövde Maskinkonstruktioner AB
SOLVAY PHARMA AB
SORBENT AB
SPOTFIRE AB
STRAUMANN AB
Sunrise Medical AB
Supinator/Radings AB
SURGICAL SCIENCE AB
SWE EAGLE AB
Swedish Ceramic Institute/IVF
SVENSKA ANTEK INSTRUMENTS AB
SYLAK AB
SYSMEX DEUTSCHLAND GMBH, FILIAL SVERIGE
Tamro AB
TAMRO HEALTHCARE AB
TAMRO MEDLAB AB
TATAA BIOCENTER AB
TECAN NORDIC AB
TENDERA AB
TERUMO SWEDEN AB
TEXON MEDICAL AB
THERA-TECH
Topcon Scandinavia AB
TREMEDIC INTERNATIONAL AB
Tremi AB
TRIOLAB NORDIC AB
TURMIDAS AB (Ally-Tec AB)
UNFORS INSTRUMENTS AB
Unident AB
UTANDNINGSTESTER I SVERIGE AB
VARBERGS PRECISION AB
WASA MEDICALS AB
Velosense Biodiagnostics
Wennbergs
VICORE PHARMA AB finns i Uppsala
VITAFLO SCANDINAVIA AB
Vitaform
VITROLIFE Sweden AB
Vivolux
V-tech AB
Zimmer Scandinavia AB (Nordic Medical Supply)