FORA

Towards fact-based cluster policies

Learnings from a pilot study of Life Sciences in the Baltic Sea Region

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Foreword

This report concludes an extensive analytical project conducted under the auspices of BSR InnoNet, initiated and financed by DG Enterprise and Industry of the European Commission. The analytical work was performed under the leadership of FORA as BSR InnoNet's Work Package 4. The purpose of the analytical process has been to establish a factbased footing on which to base cluster policies.

In this study the aim has been to develop and test a method for international benchmarking of clusters. Which clusters demonstrate the best performance, and is there a link between performance and clusterspecific framework conditions? The answers to these questions provide a basis on which to conduct factbased cluster policy.

The analysis described in this report is the first of its kind. There has been no previous systematic benchmarking of cluster performance and clusterspecific framework conditions. The method was applied to life science clusters in the Baltic Sea Region (BSR). It is hoped that the analysis will contribute to a wider debate on clusters' special framework conditions and will pave the way for further factbased cluster analysis.

The analysis was performed by a FORA team comprising Jørgen Rosted, Andreas Blohm Graversen, Markus Bjerre and Henrik Lynge Hansen. David Boysen Nielsen, Tobias Ritzau-Kjærulff and Tobias Christensen provided research, data extraction and calculations. Jakob Øster, an external consultant, helped develop the questionnaire used to query life science enterprises. Marie Degn Bertelsen managed the analytical work from the start of the project in 2006 until January 2009.

Under the leadership of Martin Hvidt Thelle, Copenhagen Economics provided a source of professional sparring and econometric analyses. Copenhagen Economics jointly authored chapter 4 of the report and was responsible for appendix 9 with reports of econometric analyses.

Monitor Group, under Pedro Arboleda, acted as sparring partner on questions of international benchmarking of cluster performance beyond the Baltic Sea Region. Monitor Group supplied data material for chapter 5 of the report.

The Danish Enterprise and Construction Authority co-funded the project.

As part of the analytical process, a database was constructed containing data for employment and real wages in 1085 clusters in the BSR and 23 indicators for cluster-specific framework conditions for life science clusters in the BSR. The database is documented and has been used in five reports and seven working papers, cf. appendix 10.

Executive summary

Clusters are important drivers of the economic wealth of regions and countries. Clusters are formed by global competition and successful clusters drive both employment and productivity in their regions. This study confirms other cluster studies in illustrating that higher cluster specialisation and higher productivity go hand in hand and that higher productivity and real wages in clusters go hand in hand with higher real wages in local industries. This is the reason that clusters are seen as a source of wealth creation in economic regions and why there are political interests in cluster initiatives.

The global knowledge economy will change cluster formation. In the industrial era, competition on efficiency and cost reduction was a dominating force in cluster formation. In the global knowledge economy companies compete on innovation and they will engage more and more in global knowledge sourcing and global innovation alliances. But at the same time companies will also be more and more engaged in local knowledge creation and knowledge sharing as important sources for innovation.

The increasing competition in innovation and the growing importance of knowledge will transform clusters; it will happen gradually in very complex processes, but we can already see that existing clusters erode and new more specialised clusters emerge, and that companies in these new and more specialised clusters will be heavily involved in both global and local collaboration.

The policy implications of this transformation are of key interest to policy makers.

It becomes more and more obvious that access to high quality human resources and specialised knowledge is an even more important business parameter in the knowledge economy; and that even the biggest companies need to collaborate on knowledge creation and sharing. A new and more important role of innovative entrepreneurs in regions' innovation capacity also attracts greater attention. On the political scene there is increasing interest in smart regulation and intelligent public demand as drivers of innovation.

The importance of these new forces has already been crucial for policy considerations of regions' and countries' horizontal business and framework conditions. The purpose of this study is to investigate whether these new framework conditions also play a role at a cluster level. Is there a connection between cluster performance and new cluster specific framework conditions? If the importance of cluster specific business conditions and the connection between cluster performance and cluster specific framework conditions can be verified a basis for fact based cluster policy has been created.

It is a very ambitious task and there are few examples to learn from.

In this study a possible connection between cluster performance and cluster specific business conditions is tested on data for life science clusters in the Baltic Sea Region. The study is part of the BSR InnoNet initiated by DG Enterprise, European Commission, in order to boost innovation in Europe.

The study is concentrated on the six biggest life science clusters in the Baltic Sea Region: Greater Copenhagen, Greater Stockholm, Schleswig-Holstein (Kiel), Greater Helsinki, Western Sweden (Gothenburg) and Southern Sweden (Malmö-Lund). The six clusters employ close to three quarters of the employed within life science in the Baltic Sea Region. Data has been collected for both cluster performance and cluster specific framework conditions.

Cluster performance is measured by employment, average real wages and innovation, and there is a close connection between all three indicators. Productivity is measured in terms of estimated multifactor productivity from company accounts and average real wages industry statistics. Indicators for innovation are collected from a survey study and data has been collected for frequency and extent of both incremental and radical innovation. The result demonstrates clearly that there are close links between innovation and productivity – with life science companies with the highest multifactor productivity also innovating most.

Innovative capacity is strongest in Greater Copenhagen and Greater Stockholm which at the same time are the regions most specialised in life science. The life science cluster in Greater Copenhagen is the most innovative, biggest, and most specialised – and it also has the greatest increase in employment.

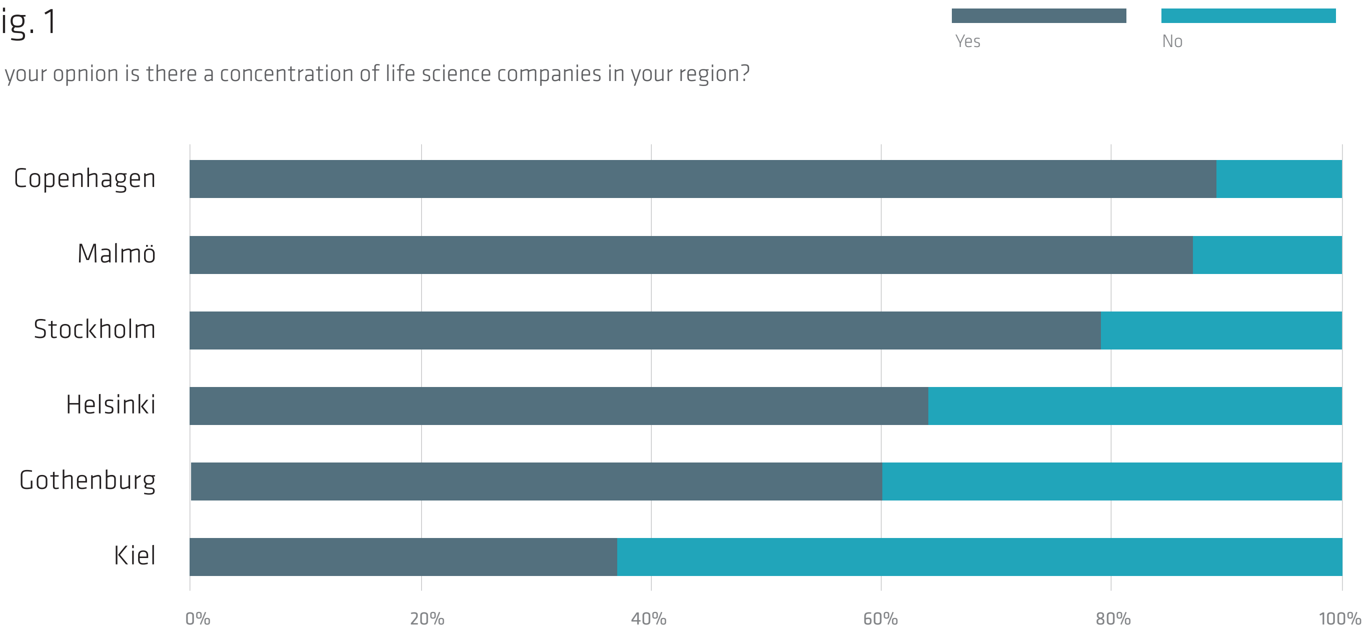
Data for framework conditions is solely collected from a survey study and expresses companies' evaluation of the cluster specific framework conditions in the region. Data has been collected for four policy areas: Access to human resources with skill and competencies relevant for life science, availability of knowledge of importance to life science, entrepreneurial activities of life science start-ups, quality of public regulation and the importance of public demand for innovation in life science companies. All four areas can to some degree be affected by policy but companies and institutions also have a major role to play in creating the best possible regional business conditions for the life science cluster.

Collaboration on innovation and research among companies in the same cluster might be an important factor in clusters' innovative capacity. Data has therefore also been collected on the companies' view on the importance of being part of a cluster and the extent of collaboration within the cluster. Policy cannot directly affect collaboration among companies but there can be an indirect impact from policy support of cluster organisations.

The survey data has revealed that enterprises in the regions acknowledge that they are located in a region with a strong concentration of life science firms. That is particularly the perception in Greater Copenhagen and Malmö-Lund region, also known as Medicon Valley, where nearly 90% believe there is a concentration of life science companies, cf. figure 1.

Fig. 1

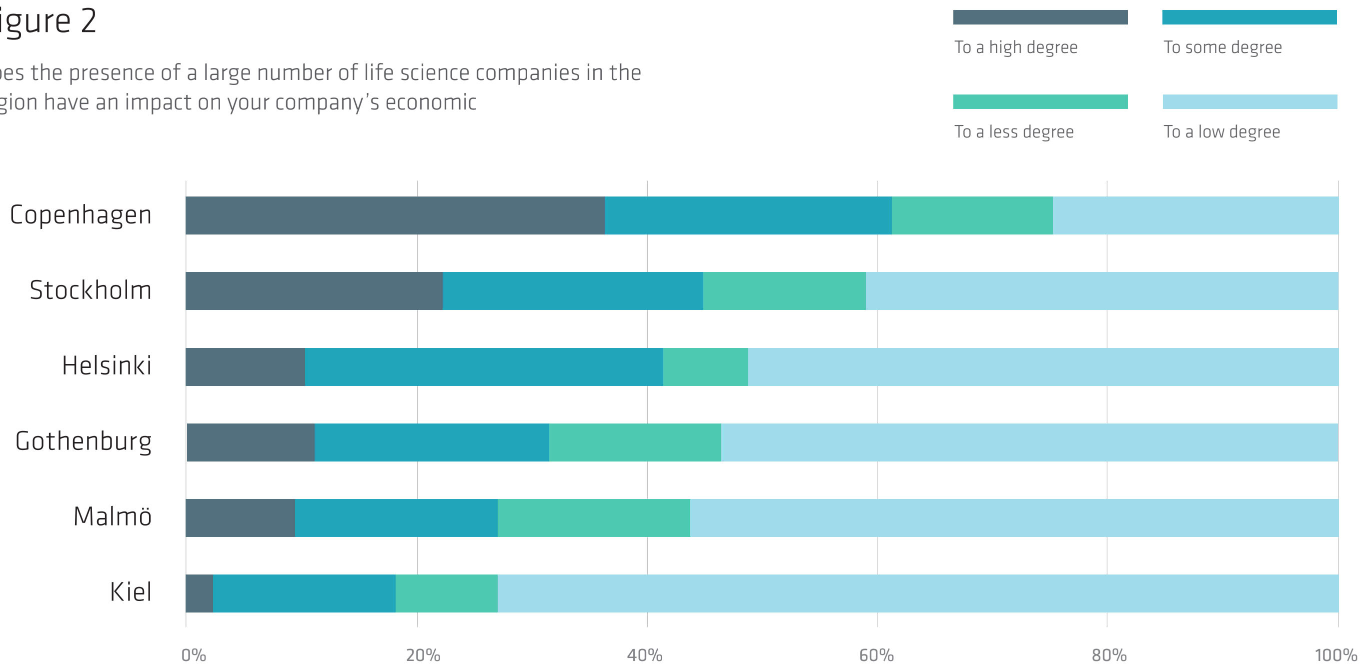
In your opnion is there a concentration of life science companies in your region?



That companies acknowledge they are part of a cluster is important but it is more important if they acknowledge that clustering matters. This is to some extent the case in the Baltic Sea Region especially in Greater Copenhagen where more than 60% of firms respond that the concentration of firms in their region is important to their economic performance, cf. figure 2.

Figure 2

Does the presence of a large number of life science companies in the region have an impact on your company's economic



Furthermore the study shows that the presence of many life science companies in the region is indeed leading to higher productivity. This conclusion is based on a firm-level econometric estimation, which shows that cluster concentration (represented by the localisation quotient) is a significant and positive factor explaining the variation in firm-level productivity performance. This is contrary to some other studies which claim that cluster concentration has no measurable impact on productivity.

The results illustrate that at a fundamental level the policy may support performance in life science enterprises. Through cluster formation and development a geographical concentration of firms leads to better economic performance.

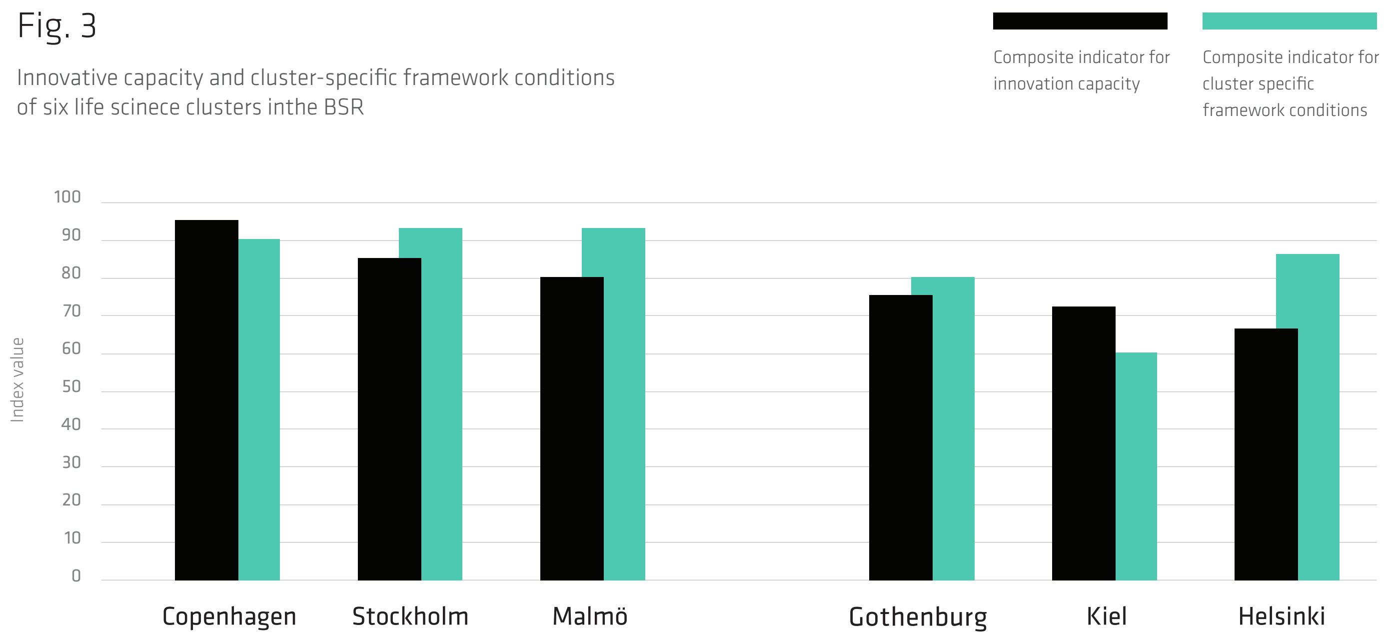
The performance indicators illustrate that the six life science clusters in the Baltic Sea Region can be ranked according to their performance and that the ranking is fairly robust and independent of which of the performance indicators – employment, productivity or innovation – is given the greatest weight. The three best performing life science clusters in the Baltic Sea Region are Greater Copenhagen, Greater Stockholm and Malmø-Lund, while the performance of the three other clusters, Western Sweden (Gothenburg), Schleswig-Holstein (Kiel) and Greater Helsinki is weaker.

The indicators for business conditions illustrate that overall the framework conditions are very similar in Greater Copenhagen, Greater Stockholm and Malmø-Lund with the framework conditions in Greater Helsinki and Western Sweden (Gothenburg) lagging a little behind. Only the business conditions in Schleswig-Holstein (Kiel) seem to be significantly weaker.

With the survey data showing similar business conditions in the five Nordic clusters, i.e. with companies evaluating the framework conditions in the same way, it becomes difficult to test the hypothesis that the best performing clusters have the best framework conditions. But by dividing the six life science clusters in the Baltic Sea Region into two groups, one can illustrate that the best performing group also seems to have the best framework conditions, cf. figure 3.

Fig. 3

Innovative capacity and cluster-specific framework conditions of six life scinece clusters inthe BSR



More detailed analysis on firm level data underlines the importance of cluster specific business conditions. Firm level analysis shows that companies which collaborate on innovation and research also have the highest level of innovation and furthermore that companies which collaborate also have the most positive evaluation of the framework conditions.

So even if fairly similar framework conditions in the six life science clusters make it difficult to reach a more definite conclusion on the importance of cluster specific business conditions at the regional level, a study of firm level data suggests that cluster specific business conditions matter. Hopefully further studies on a broader data basis can confirm this result.

The main purpose of this study has been to investigate a possible connection between cluster performance and cluster specific framework conditions – and thereby create a foundation for fact based cluster policy, and not to investigate possible policy implications and recommendations. However, it would appear that companies' overall evaluation of the framework conditions seems rather sceptical if not negative.

Companies were asked to evaluate business conditions in their region on more than 20 questions, answering on a four point scale from a high degree to a low degree. A surprisingly high number of companies evaluate important framework conditions in their region as satisfactory only to a lesser degree or a low degree. This could be an indication of insufficient political priority in the Baltic Sea Region to work with life science clusters' business conditions.

The model that forms the basis for this investigation can also guide policy considerations. It can be used to identify the best performing clusters in the world and identify clusters which could be relevant for benchmarking. Based on benchmarking, peers could be chosen and peer reviews could give inspiration on which framework conditions to improve and how to do it. As an appetiser, the study illustrates how the five Nordic life science clusters perform in relation to the best performing US life science clusters.

Chapter I

Clusters are important to wealth

What is a business cluster?

A business cluster is a group of companies which have chosen to locate in the same economic region because it offers certain competitive advantages.

They can be related enterprises operating in the same sector and competing for the same market and therefore drawing upon the same regional resources. The related companies can simultaneously compete and collaborate with each other, and both activities can enhance their competitiveness.

Cluster formation can also take place between companies who are in different segments of the same value chain and who enjoy certain efficiency benefits by locating in the same place. The same applies to specialised consulting companies, who can clearly benefit from locating near their clients.

Clusters do not necessarily consist only of business enterprises. There are many examples of public or semi public knowledge and educational institutions locating in the same region as those enterprises that are users of the knowledge and graduates they produce.

It is the market and competition in the market that form clusters. Many of the conditions that are important to companies differ from region to region; for this reason, competition means that business specialisation is different between regions.

Business clusters are in a constant state of change. Some clusters or parts of clusters are on the decline, while other clusters or parts of clusters are on the rise – and new clusters may be emerging. The changes that occur in clusters happen slowly and over time in highly complex relationships of which no one has a complete picture.

Cluster formation takes place only in traded industries and sectors, which is very easily explained. By their nature, traded industries produce goods and services which can be transported and sold on the global market – as opposed to local industries which must have a local presence to be able to produce and sell their goods and services. Thus traded companies – unlike local companies – make strategic decisions on where to locate, which is why clusters form only within traded industries.

How are business clusters identified?

Some business clusters are so high profile that they determine the identity of a region. That is the case with San Francisco and the high tech cluster in Silicon Valley, with Los Angeles and the Hollywood movie cluster, and with the financial business clusters of London and New York. In recent years London and New York have also become known for their growing clusters in the creative industries.

In this study the aim has been to develop and test a method for the international comparison of clusters. Which clusters demonstrate the best performance, and is there a link between performance and cluster specific framework conditions?

When the aim is to compare clusters, there must be a method of unambiguous identification. There are several different methods of identifying clusters across regions. In this study a method is used to identify clusters on the basis of employment statistics, cf. box 1.1.

Box 1.1 Identification of business clusters via regional employment figures

The method is used, for example, to identify business clusters in the United States[1].

First, the United States is divided into a number of economic regions, and for each region employment data is stated at the most detailed industry levels. It can then be calculated which industries most frequently locate in the same economic region. By an iterative process it is possible to find the cluster code that produces an appropriate number of large clusters and minimises employment in very small clusters.

For example, how should the life science cluster in the United States be defined on the basis of industries in order to find a suitable number of large life science clusters in a relevant number of regions and smallest possible employment in small life science clusters in the other American regions?

For each cluster in each region it is then possible to calculate a location quotient which expresses cluster employment in the region in relation to average cluster employment throughout the United States. If the location quotient is 1, the region is neither overspecialised nor underspecialised in the cluster concerned.

In the United States the method identified 41 cluster groupings, and the most successful regions have up to five – some even more – clusters in which the location quotient is significantly higher than 1. The most successful regions have the highest employment in large, specialised clusters and the lowest employment in small, underspecialised clusters.

[1] Michael Porter, "the Economic Performance of Regions", 2003, Regional Studies, vol. 37.

The method was applied to American data, and the computed categorisation of clusters was subsequently applied in Europe in connection with the establishment of the European Cluster Observatory, which tracks employment in 38 cluster categories in 259 European regions[2]. For the purpose of this study of clusters in the Baltic Sea Region (BSR) it was found expedient to set up the BSR cluster database. The same categorisation of clusters was applied as by the European Cluster Observatory, and employment and real wage data was collected for 35 clusters in 31 BSR regions[3].

Why are business clusters interesting?

In the United States, employment in traded industries accounts for just under 30% of total employment, and real wages are significantly higher in clusters (65%) than in local industries[4].

Something of the same picture is to be found in the BSR. Global industries employ just over 30% of the workforce and pay higher real wages – although the difference in real wages is not nearly as pronounced in the BSR as in the United States. In the BSR, real wages in global industries are on average 20% higher than in local industries.

The reason may be that companies in the United States have for a long time had the advantage of serving a large American market, something that has not been available to Europe and the BSR, where domestic markets have been much smaller and the common internal market within the EU is still in the process of development, which can explain why European clusters are less specialised and therefore have a lower productivity[5]. A second explanation could be that countries bordering the Baltic have – or have had – a different social model with regulations or traditions which have minimised the wage difference between traded and local industries. This study will not provide the explanation but it does make a small contribution to understanding the differences in a later chapter in which real wages in the largest life science clusters in the BSR are compared with life science clusters in the United States, see chapter 5.

One consequence of the fact that global competition and differences in business conditions produce a difference in business specialisation between regions, of course, is that those regions which house the largest and most productive clusters will also be the regions enjoying the highest level of prosperity. This is why cluster formation is attracting so much interest in business policy circles.

2 See www.clusterobservatory.eu.

3 FORA, "Summary Report BSR InnoNet WP4", 2008, www.foranet.dk. Certain adjustments were made in the categorisation used for clusters in the BSR compared to the categorisation used in the European Cluster Observatory. One effect of this is that the number of cluster categories in each region has been reduced from 38 to 35. The report gives a detailed account of the method used to identify clusters in the BSR.

4 Michael Porter, "Clusters, Innovation, and Competitiveness: New Findings and Implications for Policy", 2008, www.isc.hbs.edu/pdf/20080122_EuropeanClusterPolicy.pdf.

5 Christian Ketels, "Clusters, Cluster Policy, and Swedish Competitiveness in the Global Economy", 2009.

What is the significance of business clusters in the Baltic Sea Region?

The thinking behind business clusters is based on the supposition that there are defined economic regions, with a common labour market within which labour moves freely, and companies operate within close proximity of each other, permitting them naturally to compete and collaborate. Economic regions thus have a natural geographical dimension – but there is no sure way of determining the geographical extent.

In the United States, national accounts are based on an economic estimate of economic regions, while the European national accounts, Eurostat, draw much of their data from administrative units[6]. In keeping with European Cluster Observatory practice, the economic regions in the BSR cluster database are based on the Eurostat classification, giving the BSR 30 economic regions. Under Eurostat classification[7], Denmark remains one economic region and – in terms of population – much bigger than the other regions. It would appear doubtful that Denmark can be classified as one single economic region with a common labour market and close contacts between companies. For the purposes of this study, therefore, Denmark has been classified as two regions. Greater Copenhagen, comprising the metropolitan area and Region Zealand, and the rest of Denmark. The study thus covers 31 economic regions with a total population of between 800,000 and 3m people.

As a starting point, the study investigates whether there is a connection between business specialisation within the BSR and productivity. Business specialisation was measured in terms of the location quotient[8], and productivity was measured in terms of average real wages.

As has been the case in other cluster analyses, there is a significant link in the BSR between business specialisation and real wages. The more specialised a cluster is, the higher the average real wage, cf. fig. 1.1.

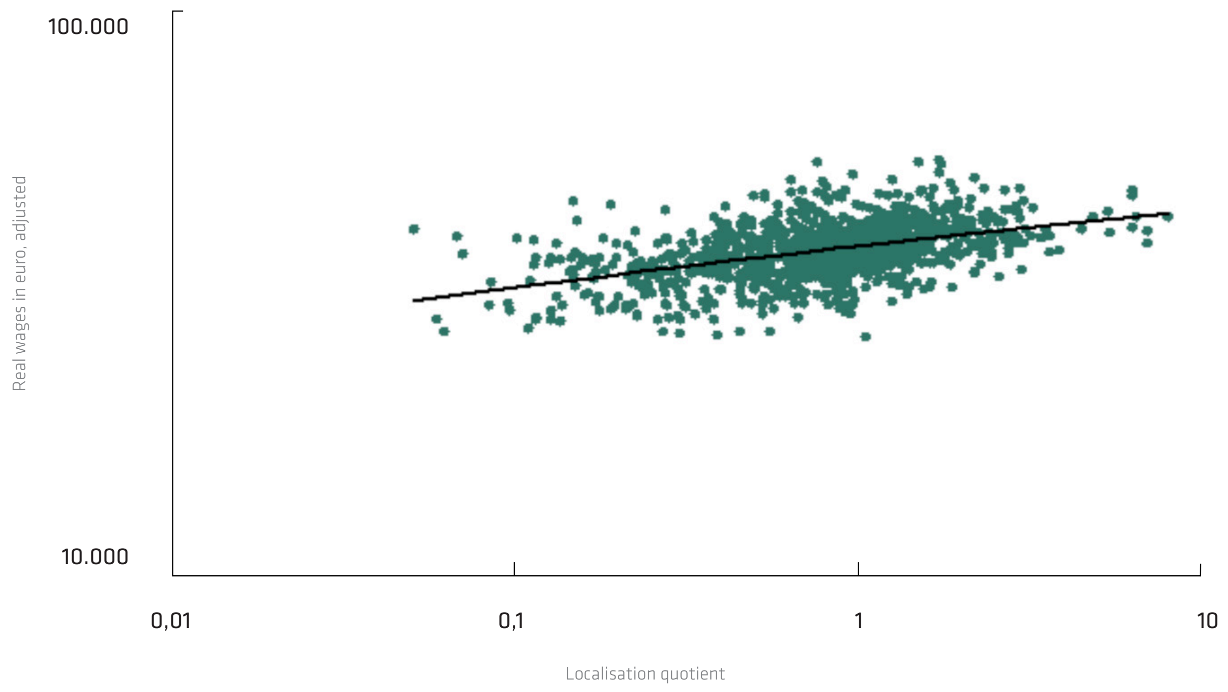
[6] "Boundaries of the normative regions are fixed in terms of the remit of local authorities and the size of the region's population regarded as corresponding to the economically optimal use of the necessary resources to accomplish their tasks", Eurostat, European regional and urban statistics – Reference guide, 2005.

[7] The Observatory uses Eurostat's statistical classification NUTS II.

[8] Location quotient (LQ) is an expression of how much employment there is in a cluster category in a given region in proportion to what might be expected in terms of the size of the region.

Fig. 1.1

Higher real wages in clusters with a high concentration



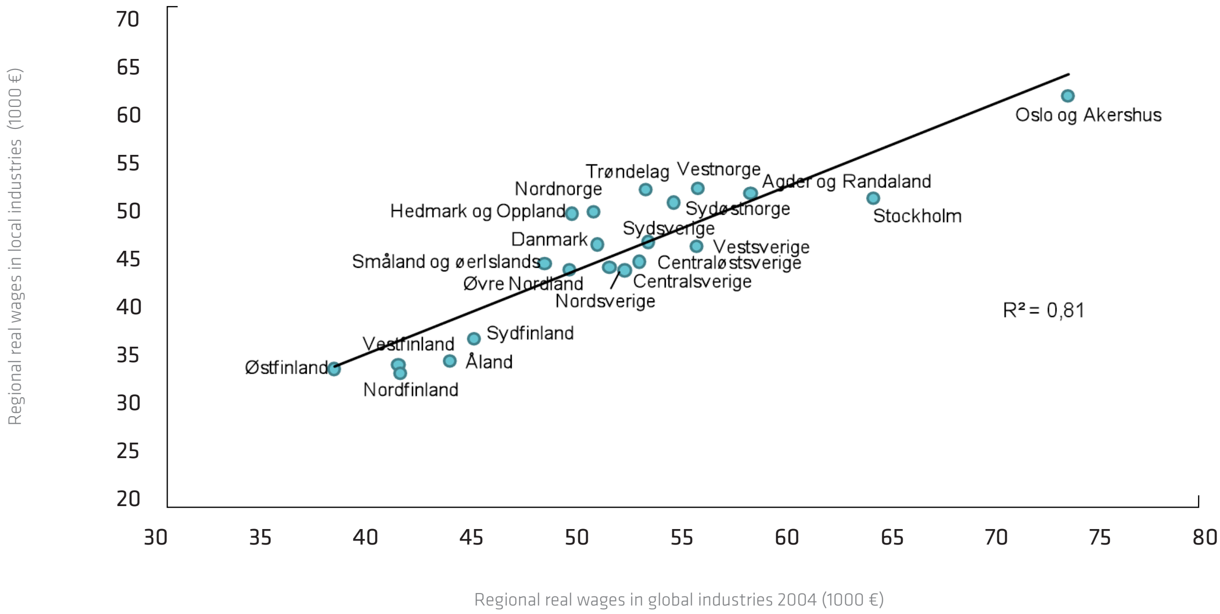
Note Each data point represents one regional cluster. The connection has been adjusted for regional effect, cluster effect and time effect in a fixed effects model. The slope coefficient equals 0.07, which means that a 10% increase in specialisation increases real wages by 0.7%. The effect of specialization will be greater in some clusters and smaller in others. The axes are in logarithms.
Source Copenhagen Economics, 2008, "Har stærke klynger betydning?", based on BSR cluster database.

In earlier cluster analyses a positive connection was also found between real wages in traded industries[9] and local industries . Just such a connection is also found in the BSR, cf. fig. 1.2.

[9] Michael Porter, "The economic Performance of Regions", 2003, Regional Studies, vol. 37.

Fig. 1.2

Compatibility in real wage levels in traded and local industries.



Note To some extent, Oslo is an outlier, helping to boost R2. If Oslo is excluded from the comparison, R^2 falls to 0.76.

Source Copenhagen Economics, 2008, "Har stærke klynger betydning?", based on BSR cluster database.

There is a supposition in cluster theory that global competition leads to cluster formation in traded industries, which boosts productivity and transforms the traded industry clusters into drivers of economic prosperity. As a region's traded industries compete for labour with local industries, economic success for the region's traded industries helps to enhance the efficiency of local industries– which are then able to pay a higher level of real wages.

Statistical tests with cluster data for the BSR show that this supposition also applies to clusters and regions in the BSR but – as always – in statistical analysis it must be emphasised that tests can be conducted to identify a significant correlation – but not to determine the causal relationship.

Cluster formation in the global knowledge economy?

The emergence of the global knowledge economy will doubtless influence cluster formation in the future – but the exact nature of the influence is more difficult to forecast.

Globalisation generates larger markets and more competition, which by itself will promote cluster formation. And in Europe it will almost certainly promote specialisation and cluster formation as the internal market more and more establishes itself.

There are also features of the global knowledge economy which point in the direction of a reduced or at any rate a different form of cluster formation.

In the industrial economy, companies competed on production costs and efficiency, leading to segmentation in the value chain with efficiency benefits arising from geographical proximity, which was one of the key drivers of cluster formation. Outsourcing reduces the need for cluster formation, and the production that remains in the affluent countries will probably take place in global value chains with only a very limited slice of production remaining in the affluent countries themselves. Thus one of the industrial economy's key reasons for setting up clusters will be diminished or rather will be transferred to those countries that will compete in the manufacturing industries of the future.

In the global knowledge economy, companies in affluent countries will increasingly find themselves competing on innovation and the creation of new solutions to global challenges. In the race to innovate, enterprises will find themselves becoming more and more dependent upon global knowledge sourcing, and much of the innovation will take place within global innovation alliances. A development that will make it less important where companies are located – because wherever they settle, they will still have to take their place in global value chains and global knowledge sourcing.

There are nevertheless signs that clusters are also forming in the global knowledge economy – but the drivers have changed. New clusters appear to be arising centred on the R&D departments of major companies and on universities with the knowledge and graduate production essential to enterprises.

Cluster formation continues apace through company startups, which can be spin offs from major companies and universities, and in the form of foreign companies setting up development enterprises to gain access to the hidden knowledge that it cannot obtain in any way other than to have a geographical presence.

It could be argued that in the global knowledge economy, existing clusters will gradually be eroded and replaced by new specialised clusters in which member companies will join intensively in global knowledge sharing – but will also take advantage of local knowledge building and knowledge sharing.[10]

[10] FORA, New Nature of Innovation,2009, www.newnatureofinnovation.org

Is there room for cluster policy?

Whether there is room for cluster policy and, if so, how it is to be planned is something that has been debated at length.

It is generally agreed that clusters arise because of competition on the market – but the extent to which differences in business conditions play a part in cluster formation and whether it is possible and appropriate to exploit those difference in launching cluster policy is still being discussed.

Statistical analyses of cluster formation have not yet brought us closer to a solution. Many analyses demonstrate the economic importance of cluster formation but few focus on whether there is room for cluster policy, cf. box 1.2.

Box 1.2 Economic importance of cluster formation

Many economists have quantified the importance of geographical concentration. A study of the literature shows that there are many empirical studies of cluster effects. These studies indicate that doubling the size of a cluster (generally measured as employment in a given sector in a given region) increases productivity by between 3-8%.

Vernon Henderson was one of the first to use enterprise data to estimate cluster effects. He found a positive and significant effect on productivity – approx. 8% – when regional employment increased by 10% in the American high tech industry.

A more comprehensive study of French company data, undertaken by Martin, Mayer and Mayneris and covering all manufacturing industries revealed a much smaller effect on clusters: a 10% increase in employment in adjacent companies in the same industry raises company productivity by 0.4-0.5%.

So the cluster effect is also positive in the French data – although only modestly so. The authors conclude on this background that "costly policy measures designed to increase the size of specific clusters do not represent a policy that is supported by French empirical results." They continue, however, by saying that it remains to be shown whether cluster policy within clusters of a particular size can enhance collaboration, knowledge exchange and knowledge building.

The analysis of cluster data for life science enterprises in the BSR conducted as part of this study is one of the first analyses that link enterprise data for productivity, innovation and framework conditions within a cluster, cf. chapter 4.

The analysis shows that those companies within a cluster which judge the framework conditions to be good actually collaborate more, are more innovative, and record higher productivity. Thus the study illustrates an indirect connection between cluster policy and productivity which has not previously been identified.

The statistical analysis of enterprise data for life science companies in the BSR also shows a markedly positive and significant effect of cluster concentration. When life science employment in a region of the BSR increases by 10%, productivity among the companies concerned rises by 0.5%, see appendix 9. That result tallies well with other research relating to productivity effects in the life sciences, cf. box 1.3.

Box 1.3 Spil-over effects within the life sciences

In a detailed analysis of the development of productivity and knowledge sharing in US drug companies over a 10 year period, economists Furman, Kyle, Cockburn and Henderson asked the question: Have the effects of spill-over played any part in productivity? And are they genuinely local?

The answer to both questions was Yes. The American researchers from Duke University showed that pharmaceutical companies benefit from research results achieved worldwide but that the effect of research undertaken in the local area was twice as great. They show, in other words, that many companies throughout the world benefit from research conducted, for example, at Copenhagen University but that pharmaceutical companies with research laboratories in the Copenhagen area benefit most.

Analyses carried out as part of this study show a clear effect of cluster formation on company productivity, which coincides well with other research into the importance of cluster formation, but it must be emphasised that various empirical studies produce widely differing results – and there are also studies which demonstrate very little effect.

Investigations conducted as part of this study are among the first empirical research that investigates the connection between cluster formation, productivity, innovation and framework conditions. The investigations support the hypothesis that there is room for cluster policy, and that it is to some extent possible to base cluster policy on evidence based data, cf. chapters 3 and 4.

CHAPTER II

Preparation of the life sciences pilot study

In this study it has been the intention to apply the definition and demarcation of clusters recognised by the European Cluster Observatory, which should make it possible to compare life science clusters in the Baltic Sea Region (BSR).

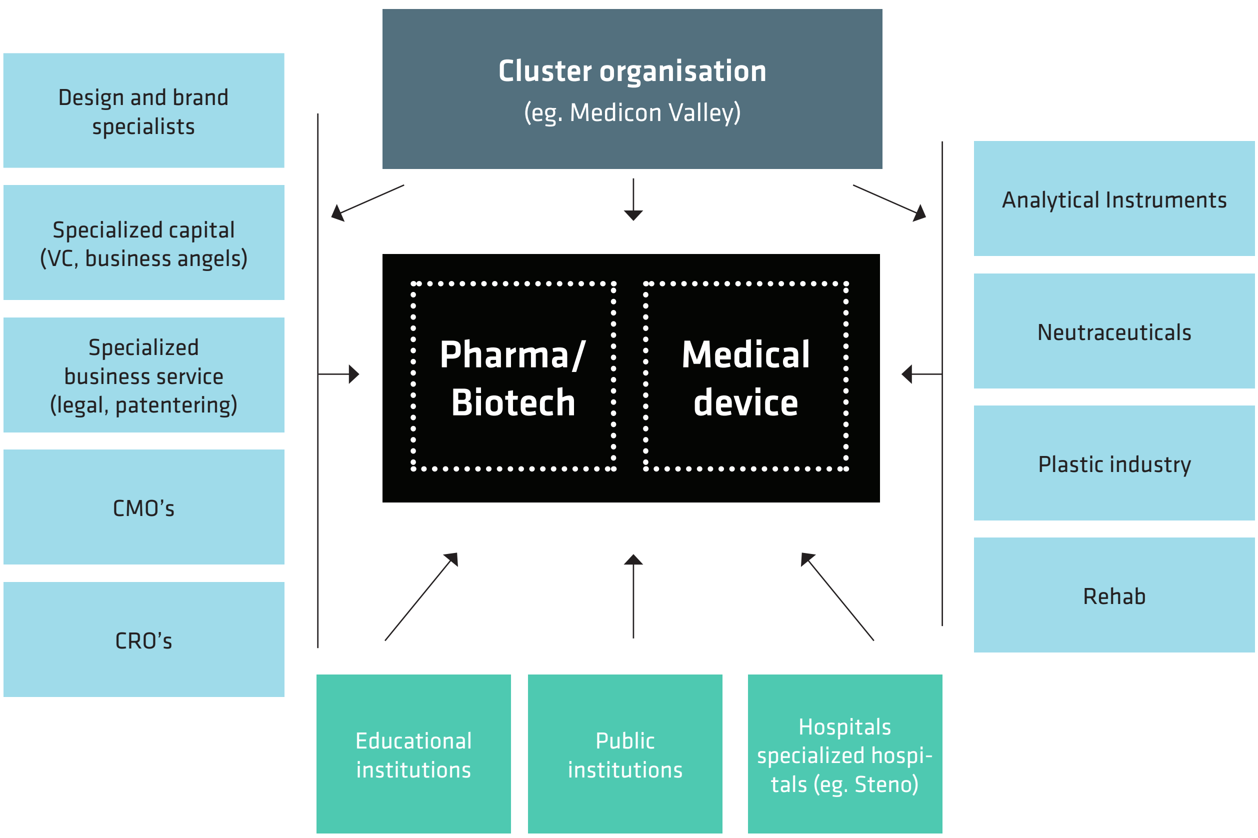
In the European Cluster Observatory the life science cluster comprises two subclusters: a biopharmaceutical cluster including biotech and a medical devices cluster. The biopharmaceutical subcluster is defined by three industries: manufacture of basic pharmaceuticalproducts, manufacture of pharmaceutical preparations, and manufacture of perfumes and toilet preparations. The medical devices cluster is defined by the industries: manufacture of medical and surgical equipment and orthopaedic appliances and manufacture of invalid carriages. In this context, employment in the life science cluster is computed across regions. But it was found that parts of related service industries and knowledge institutions are not covered by the data, cf. box 2.1.

[11] Annemarie Munk Riis, "Life science klyngedata i BSR: Beskriver de danske tal den klynge vi kan observere", 2008.

Box 2.1 The life science cluster in Greater Copenhagen

A study of the life science cluster in Greater Copenhagen shows that the core of the cluster is made up of enterprises in pharmaceuticals, biotech and medical technology. Surrounding this core of companies is a group of service industries and knowledge institutions which have specialised in life science and become part of the cluster[11], cf. fig. 2.1.

Fig. 2.1 Features of the life science cluster in Greater Copenhagen



But the life science cluster in the European Cluster Observatory was not found to be directly suitable for investigating life science clusters in the BSR. This is particularly due to the definition of the biopharmaceutical subcluster. According to the European Cluster Observatory, the three largest European biopharmaceutical clusters are located in Paris, Milan and Barcelona. A closer analysis of the composition of clusters in the BSR and Paris, Milan and Barcelona shows, however, marked differences in the composition of subclusters. In Paris, Milan and Barcelona the manufacture of perfumes and toilet preparations, account for nearly one third of the cluster's employment. In the BSR, far fewer people are employed in this industry. In the BSR, the number of employees working on the manufacture of perfumes and toilet preparations, is less than 10% of the workforce engaged in the biopharmaceutical subcluster. In the six largest life science clusters in the BSR, perfumes and toilet preparations, occupy less than 5% of the employees within biopharamceuticals.

As a result, the life science cluster in this study is excluding manufacture of perfumes and toilet preparations. With this definition it is possible to make a useful comparison of the size of life science clusters within the BSR and internationally.

As already shown, the statistical definition of life science does not embrace all players in the clusters, cf. box 2.1. But it is expected to include the group of companies that make up the core of the cluster.

This expectation was examined in more detail by comparing employment figures in the BSR cluster database, which is based on industry statistics compiled by Statistics Denmark, with a detailed – bottom up – study of companies which, as defined, can and should be included in the life science cluster in Copenhagen[12].

[12] Annemarie Munk Riis, "Life science klyngedata i BSR: Beskriver de daske tal den klynge vi kan observere", 2008.

Based on the members' register of trade organisations and interviews with key individuals in the cluster, it has been possible to gain an overview of companies in the life science cluster in Copenhagen. These statistics have been compared with the companies listed in the Statistics Denmark trade register and correspond to the cluster definition in this study.

The comparison between the bottom up figures and the cluster definition used showed a convincing connection with the pharmaceuticals companies, while there were certain problems in relation to biotech and medical devices. All relevant biotech enterprises are not included in the Statistics Denmark register and therefore are not represented in the data obtained from the BSR cluster database. But the problem has been solved for future research: in the most recent update of industry statistics biotech has been classified as a separate industry.

A few companies which regarded themselves and were regarded by other companies as enterprises in the medical devices cluster had been placed – by the Statistics Denmark sector statistics – in other industries.

The difference between the two sets of data – bottom up and the BSR cluster database – showed an overall difference of 15% of employment. That is a substantial deviation which, it is to be hoped, can be reduced in future research if clusters are given closer attention in the organisation of industry statistics. The view is taken, however, that the difference is not so serious as to invalidate the possibility of comparing clusters.

Cluster comparisons will be made on the basis of cluster performance measured in employment, real wages and innovation and on cluster specific framework conditions.

Indicators of cluster specific framework conditions

There are many indicators for benchmarking horizontal framework conditions for innovation across national boundaries; this makes it possible to draw a fairly detailed picture of the framework conditions for innovation by using existing available data . This is not the case with the benchmarking of cluster specific framework conditions. Available indicators sufficiently detailed to provide a picture of cluster specific framework conditions are almost non existent.

It has therefore been necessary to collect and process data especially for this study in order to form an impression of the cluster specific framework conditions, and the choice has been between constructing detailed indicators on the basis of existing register data or basing the analysis on survey data[13].

[13] FORA's InnovationMonitor uses 197 indicators for benchmarking framework conditions for innovation in most OECD countries.

Some register data is available which lends itself to the purpose. For example, patent data. There is also detailed data relating to university graduate production divided into various professional subjects. But it is quite resource intensive identifying which subject areas are relevant for life science clusters and ensuring that data is comparable across countries and regions.

But there is no register data on the quality of graduate production; a survey would therefore in any event appear to be necessary for that purpose.

The view in this project has been that it would be most appropriate to base the analysis exclusively on survey data. As will be apparent, survey data is not without its problems. And in future analyses the choice would probably be also to include register data.
A survey was conducted among 855 companies in 11 life science clusters in the Baltic Sea Region. The 11 regions are the six largest plus Oslo, Denmark West, Finland West, Hamburg and Rostock.

As it has not been possible to obtain accounting data on companies' economic performance from the Baltic countries and Poland, survey data for cluster specific framework conditions was not collected for these regions.

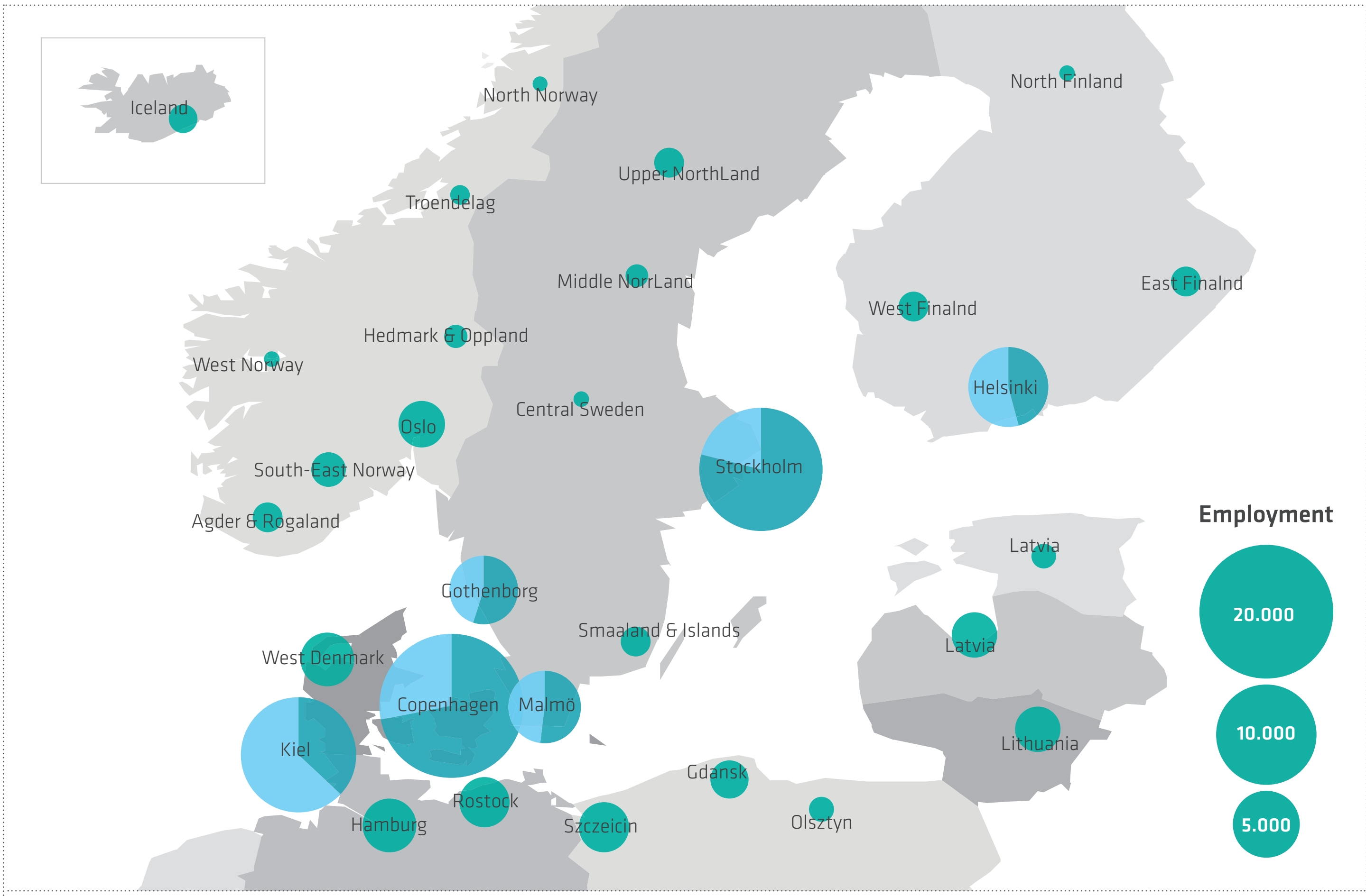
The survey was conducted by telephone; the questions were closed. Enterprises were asked to respond to a total of 52 questions which were designed to form a picture of the company's assessment of the cluster specific framework conditions within five identified policy areas: human resources, new knowledge, entrepreneurial activity, regulation and public demand, and co operation among enterprises, cf. appendix 2 and chapter 3.

Identification of life science clusters in the Baltic Sea Region

A total of 102,000 people are employed in the life sciences in the Baltic Sea Region (BSR). But employment is distributed very unevenly between the 31 regions . The three largest life science clusters – Copenhagen with 22,000 employees, Stockholm/Uppsala with 17,000 and Schleswig Holstein (Kiel) with 14,000 – represent more than half of the life science employment pool in the BSR. The three next largest clusters – Helsinki, Sweden South (Malmö) and Sweden West (Gothenburg) – have between 5,000 and 7,000 employees.

Altogether, the six largest life science clusters have 70% of life science employment in the BSR. The remaining clusters are quite small, cf. fig. 2.2.

Fig. 2.2 Employment in the life sciences in 31 regions in the BSR



Biopharma Medico Biopharma & Medico

Note The regions are grouped according to the Eurostat classification of regions used to produce regional statistics. Regions are at the NUTS II level, i.e. with populations of between 800,000 and 3m inhabitants. But NUTS II regions Stockholm and Östra Mellansverige have been combined for the purposes

of this study on the grounds that the life sciences in Stockholm and Uppsala are judged to be one single integrated life science cluster. And to an increasing degree, the two NUTS II regions on either side of the Øresund, Region Hovedstaden (in Denmark) and Sydsverige (in Sweden), operate as one integrated cluster with a common cluster organisation (Medicon Valley Alliance) and an increasingly integrated labour market. But it is the view that framework conditions in Denmark and Sweden respectively remain so different that the two regions can comfortably be analysed separately.
See appendix 1 for details of cluster and regional definitions.
Source BSR cluster database, 2009

As indicated, the purpose of this study is to compare the performance of life science enterprises with cluster specific framework conditions. This can be done either by having individual companies as analysis objects or by benchmarking at cluster level. Both procedures have been used.

When an individual enterprise is an analysis object, its economic performance is compared with the company's perception of the cluster specific framework conditions without reference to the region in which the company is located.

Analysis at the cluster level assumes the ability to construct meaningful average figures. What is the average performance of cluster enterprises? And what is the average perception of the region's cluster specific framework conditions?

Constructing useful average figures requires a certain critical mass. If the cluster is too small, the responses from individual companies can have a very high leverage on the calculated average, and it can be difficult to achieve a representative selection of enterprises in the survey conducted to collect data on companies' perception of the cluster specific framework conditions.

For these reasons, analysis at cluster level has been carried out on the basis of only the six largest clusters with a minimum of 5,000 employees. And the same applies to the analysis of enterprise data.

The result of the study at cluster level is shown in chapter 3 and the result of the study at enterprise level is shown in chapter 4. Figures from chapter 3 are shown in appendix 4 with data from the five smaller life science clusters in Oslo, West Denmark, West Finland, Hamburg, and Mecklenburg-Vorpommern (Rostock).

Chapter III

Test at cluster level

Mapping the innovative capacity of clusters

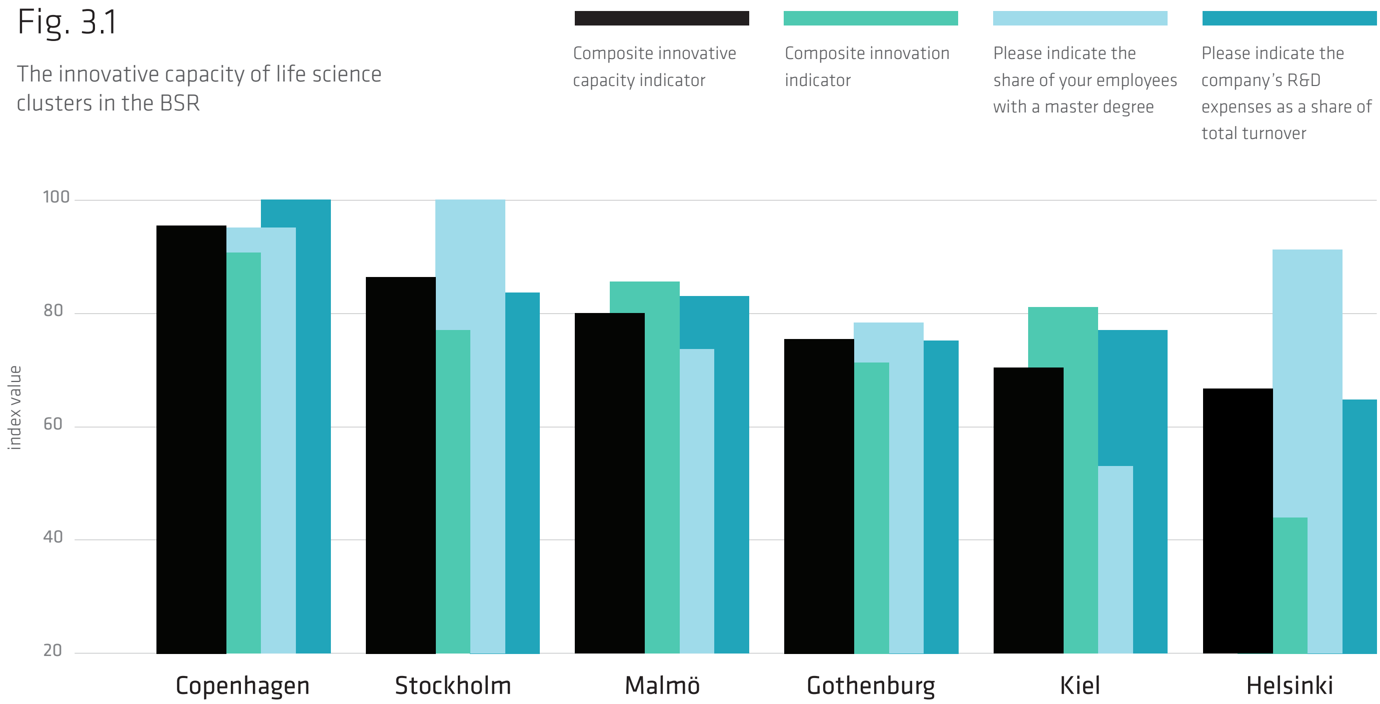
There are many parameters which can measure how well clusters perform. Employment and productivity are two important measures of performance, which are also applied in this study (see later), but it is also important to include a measure of the innovative capacity of clusters. It is of crucial importance to know the extent of clusters' innovativeness in order to assess how well they are managing – and how they will do in the future. The life science cluster in Copenhagen, for example, is currently the largest life science cluster in the Baltic Sea Region (BSR). But if the life science cluster in Copenhagen is less innovative than its peers, it is by no means certain that it will still be the largest in 5 10 years. Just how innovative clusters are is something no one has an overall picture of at present. There are no statistics to draw upon.

Measuring the innovative capacity of life science clusters is not a straightforward process. To obtain as robust a measure as possible of innovation capacity, it is necessary to examine a range of indicators in order to illustrate companies' innovativeness in an overall indicator. First and foremost, the current level of innovation in a cluster – i.e. the extent to which the cluster's member companies innovate at present – would be an appropriate indicator. Moreover, the innovative capacity of life science clusters depends very much upon the available number of knowledge workers and investment in research and development. So these two parameters have also been included. A composite indicator for a cluster's innovative capacity is thus calculated on the basis of three components: the current extent of innovation, the number of knowledge workers, and the level of R&D investment. A survey was conducted in order to obtain data for all three indicators.

The composite indicator shows that the life science cluster in Copenhagen is the most innovative life science cluster in the Baltic region. Companies in Copenhagen lead on two of the three innovativeness indicators, and the region's place as the most innovative is therefore robust. It is only in terms of the number of knowledge workers that Stockholm has a slightly higher level, cf. fig. 3.1.

Fig. 3.1

The innovative capacity of life science clusters in the BSR



Note The composite indicator is calculated as a simple average of the three underlying indicators – also shown in the figure. The indicators' original values are in proportion to their maximum in order to enhance comparability across the indicators. Appendix 5 provides a more detailed account of the indexation method. The measure of innovation is a composite indicator of the extent of incremental and radical innovation respectively. Incremental innovation describes the development and optimisation of existing products and services, while radical innovation relates to the exploration of brand new platforms or concepts previously unknown within the company. The ranking of regions in terms of the composite indicator for innovation is relatively robust, see below.

At the same time, the indicator shows that Stockholm is the second most innovative region in the Baltic region and the most innovative region in Sweden. This is linked especially with the large number of knowledge workers in Stockholm. But special emphasis should not be placed on the internal ranking of the Swedish regions, as the differences are small compared with the uncertainty of the data.

Innovation capacity is lowest in Kiel and Helsinki but these two clusters score quite differently in their sub indicators. Investment in R&D in the life science cluster in Kiel is significantly higher than in Helsinki and on a par with the Swedish clusters, while the number of knowledge workers is substantially lower in Kiel, the proportion of knowledge workers in Helsinki being high and almost equal to that of Copenhagen, which should be no surprise because Finland is renowned for having many knowledge workers in the private sector[15]. In spite of this, however, the level of innovation in the Finnish life science cluster is modest compared with the leading clusters.

The different scoring results in individual indicators in Kiel and Helsinki make it difficult to rank the two clusters. In addition, the difference between the three best clusters – Copenhagen, Stockholm and Malmö – is relatively small. It would not, therefore, seem possible with any certainty to rank the six clusters. There would, however, appear to be justification in arranging the clusters in two groups: Copenhagen, Stockholm and Malmö representing the most innovative clusters, while Gothenburg, Kiel and Helsinki are the least innovative clusters. This is further confirmed by a more in depth analysis of innovation, see below.

[15] FORA, Nordic Innovation Monitor, 2009, www.foranet.dk.

Radical and incremental innovation

In any study of innovation it can be interesting to distinguish between incremental innovation and more radical innovation. Incremental innovation is the development and optimisation of existing products and services, while radical innovation focuses on entirely new platforms or concepts which can provide the source of long term growth for companies.

Radical innovation provides companies with completely new platforms, concepts or business models which later become the seedbed of incremental innovation activities. In other words, radical innovation is essential to a company's existence in the long term. To optimise the value of radical innovation it is usually crucial to follow up the process with continuous improvement of brand new products and services – which is what incremental innovation is all about. Those companies which understand the link between the two activities and successfully pursue a policy of both radical and incremental innovation have the best possibility of achieving a strong market position[16].

In some cases it can be difficult to distinguish between incremental and radical innovation. When, for example, does innovation become so vital to the future innovation activities of a company that it should be described as radical? Obviously there is a grey area. Which makes it difficult to measure incremental and radical innovation. But it does not diminish the importance of doing it. The more companies in a cluster that focus on undertaking radical innovation, the greater the innovation capacity of the region is perceived to be.

[16] Kim & Mauborgne, Blue Ocean Strategy, 2005.

[17] For example, official joint European innovation statistics "Community Innovation Survey" (CIS), www.ec.europa.eu/eurostat.

Mapping incremental and radical innovation

Distinguishing between incremental and radical innovation in a survey is a completely new phenomenon compared with earlier investigations of companies' innovation activities[17].

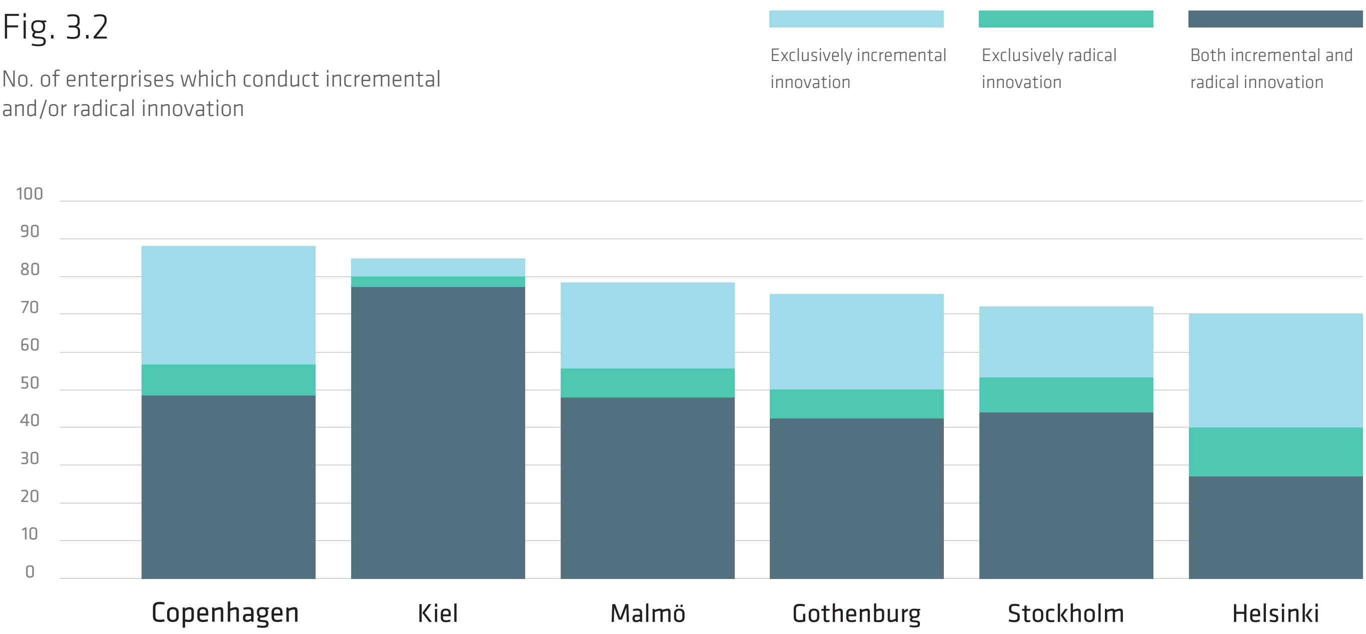
A special questioning technique was developed to distinguish between incremental and radical innovation. In the survey, incremental innovation is defined as a process of continuous optimisation, improvement and development of existing products and services, and companies are asked whether they have engaged in incremental innovation. They are then asked whether they have carried out radical innovation, which is defined as the development of completely new products, solutions, platforms and concepts never previously seen in the company and which can generate long term growth. This method of questioning makes it possible to divide companies into four groups: Companies which are not active innovators, companies which exclusively carry out incremental innovation, companies which exclusively undertake radical innovation, and finally companies which engage in both incremental and radical innovation. The investigation also makes it possible to form an opinion about the extent of companies' innovation, what proportion of a company's products and services have been subject to incremental innovation, and what percentage of sales stems from recently completed radical innovation.

It is therefore possible to obtain a deeper insight into companies' innovation efforts than earlier studies of innovation have revealed – by asking about the extent of both incremental and radical innovation.

The survey results show that many companies actively promote innovation. In Copenhagen, Kiel and Malmö 80-90% of companies actively engage in innovation, and in Gothenburg, Stockholm and Helsinki the figure is 60-75 %. The survey also shows that the majority of those companies that engage in innovation do so at both a radical and an incremental level, cf. fig. 3.2.

Fig. 3.2

No. of enterprises which conduct incremental and/or radical innovation



Note Incremental innovation: "Companies optimise, improve and develop their products and services on a continuous basis; this is called incremental innovation. Has your company carried out incremental innovation in the past two years?" Radical innovation: "Companies develop completely new products, solutions, platforms or concepts never previously seen in the company and which can be the source of long term growth; this is called radical or market shaking innovation. Has your company carried out radical innovation in the past five years?"

In Copenhagen 25% of companies engage exclusively in incremental innovation, while 10% work exclusively with radical innovation. The picture was the same in the other regions, apart from Kiel, where only a very few companies engaged exclusively in either incremental or radical innovation.

Biotech is part of the life science cluster. Most of the companies in the biotech sector are R&D companies, who in the nature of things work with new technology and in that sense engage in radical innovation. That may help to explain why approximately 10% of the companies in the various regions – the one exception being Kiel – engage only in radical innovation.

Where one region usually distinguishes itself from another is in the proportion of enterprises which work both with incremental and radical innovation. In Kiel, where many companies engage actively in innovation, the proportion is close to 80%. In Copenhagen, which comes second in the number of enterprises with both incremental and radical innovation, the figure is 50%. In the Swedish regions the level is slightly lower, while Helsinki is at the bottom of this particular league with only 25% of companies engaging in both incremental and radical innovation.

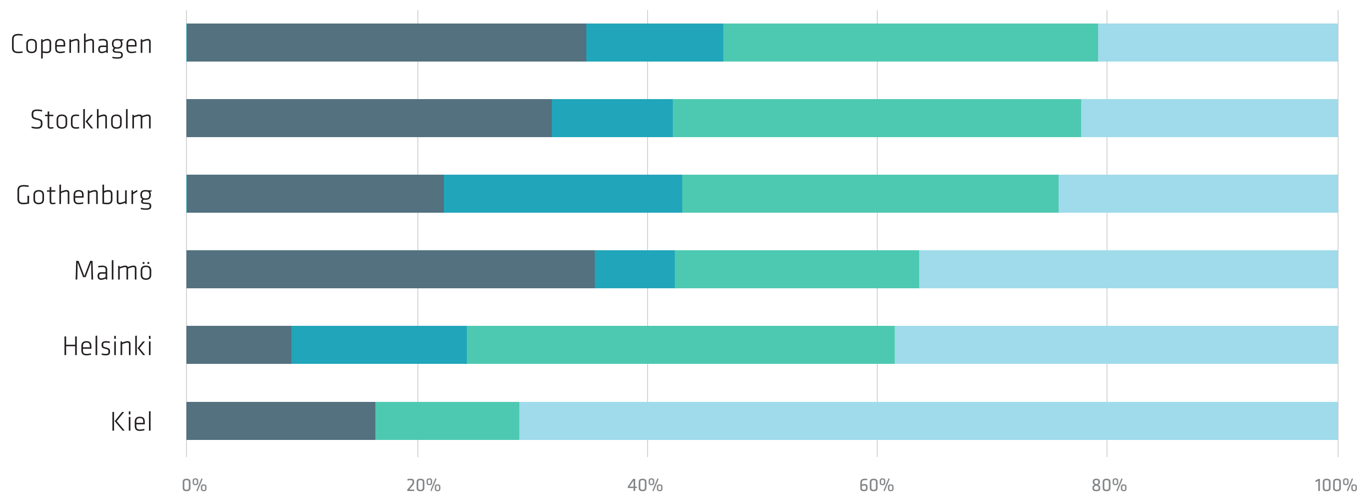
Measuring clusters' innovation only in terms of the proportion of innovation active enterprises is a very simple calculation. It says nothing about the extent of innovation within the individual company. As mentioned, those actively engaged in innovation were also asked about the extent of their incremental and radical innovation respectively.

Companies which responded that they worked with incremental innovation were also asked what proportion of their goods and services had been the subject of incremental innovation during the past two years.

In Copenhagen, Stockholm, Malmö and Gothenburg almost half of the companies replied that more than half of their products and services had been improved or developed. In Helsinki and Kiel the share was significantly lower, cf. fig. 3.3.

Fig. 3.3

What proportion of the company's products and services have been improved or developed in the past two years?



Note This question was put only to companies which had responded that they had worked with incremental innovation during the past two years.

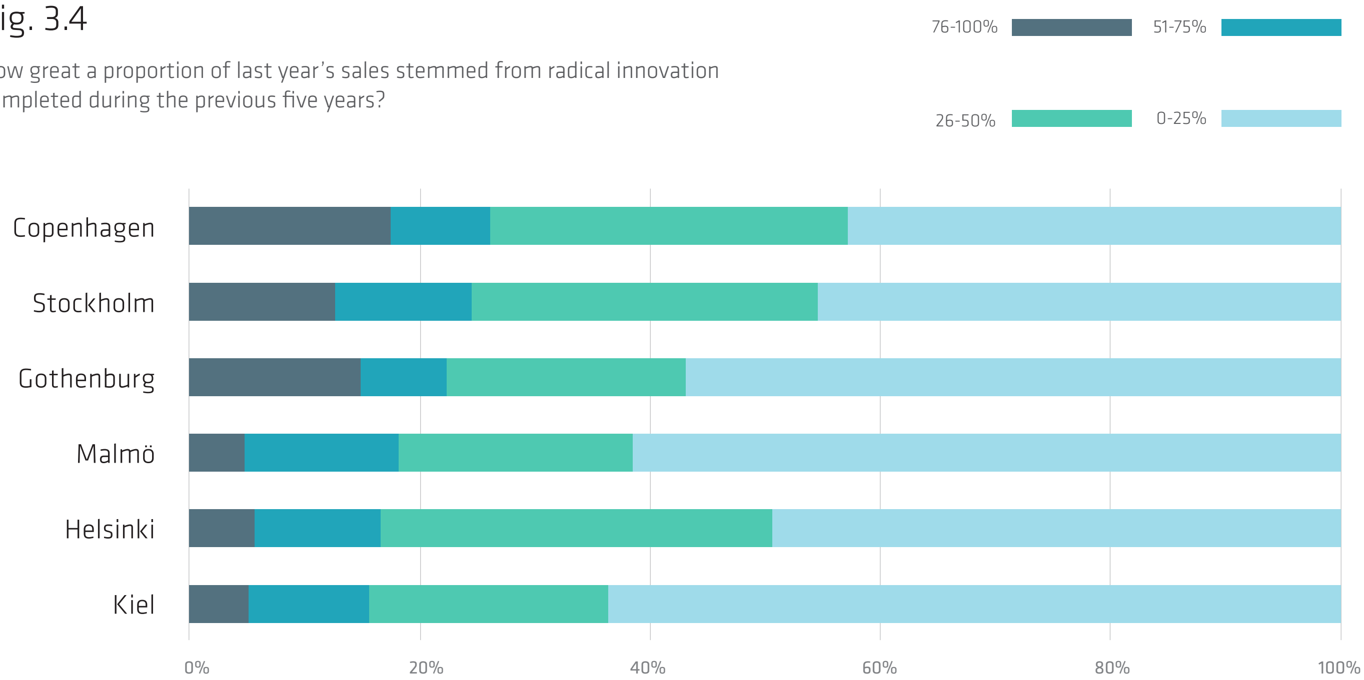
The picture changed when the question was altered from the simple one of whether companies worked with incremental innovation to asking how great a proportion of their business was affected by incremental innovation. The calculation of how great a percentage of companies were innovation active appears to overestimate Kiel's innovation activity. Measured in terms of how large a percentage of companies are innovation active, Kiel ranked no. 2 with 85% innovation active companies. In terms of how great a percentage of companies' products and services were continuously renewed, Kiel was ranked bottom.

Enterprises which responded that they worked with radical innovation were also asked what percentage of their sales stemmed from radical innovation completed within the past five year.

Life science clusters in Malmö, Stockholm and Copenhagen had a greater proportion of companies for whom radical innovation played an important role in sales, while the significance was less in Kiel, Gothenburg and Helsinki, cf. fig. 3.4.

Fig. 3.4

How great a proportion of last year's sales stemmed from radical innovation completed during the previous five years?



Note This question was put only to companies which had responded that they had worked with radical innovation during the past two years.

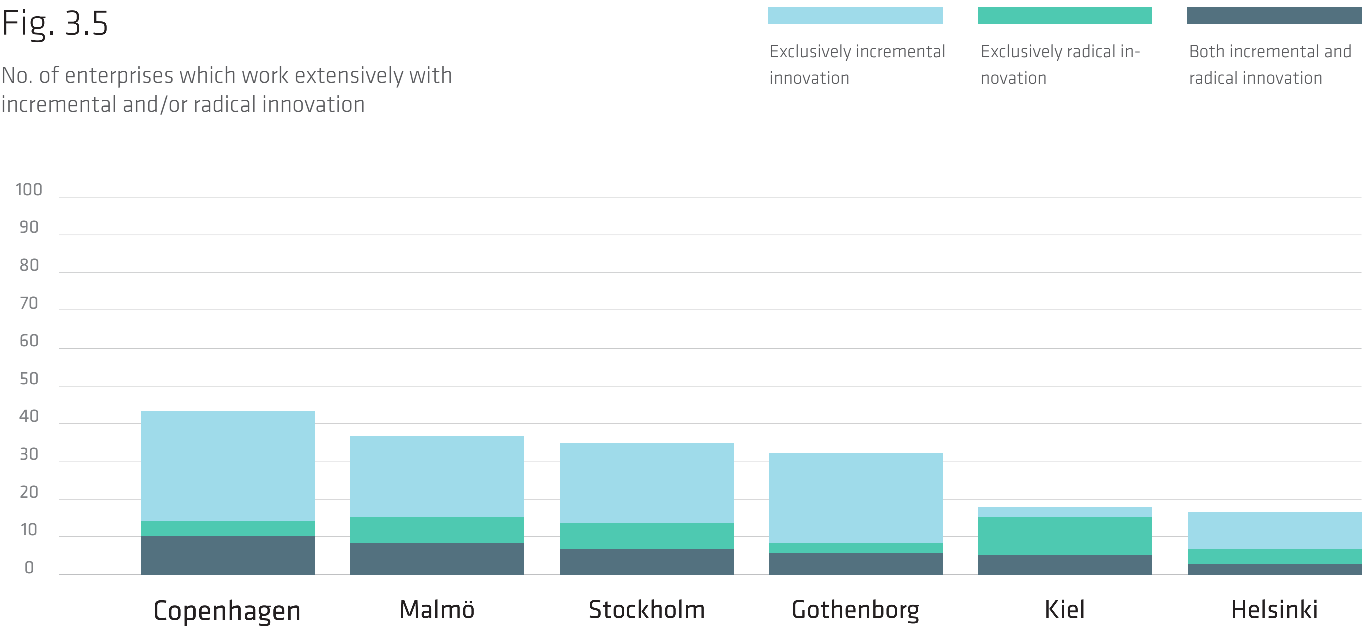
By progressing from simply asking whether companies work with radical innovation to asking how much radical innovation means for their sales, one gets a different impression of which regions are the most innovative. The calculation of how great a percentage of companies work with radical innovation again appears to overestimate Kiel's innovation activity – while at the same time underestimating Stockholm's innovation activity. Measured in terms of the percentage of enterprises which engage in radical innovation, Kiel ranks no. 2, while Stockholm ranks second from bottom as no. 5. But measured in terms of how much radical innovation means for sales, Stockholm ranks no. 2 and Kiel no. 4.

In an attempt to form an overall impression of innovation activity, the study identifies those companies whose incremental innovation accounts for more than half of their products and services and those companies whose radical innovation results account for more than half their sales.

By this measure, the regions appear to break down into two groups. Companies in Copenhagen, Stockholm and Malmö have more companies which work extensively with both incremental and radical innovation than life science companies in Gothenburg, Kiel and Helsinki, cf. fig. 3.5.

Fig. 3.5

No. of enterprises which work extensively with incremental and/or radical innovation



Note Incremental innovation is defined as significant for a company when it affects more than half the company's products and services. Radical innovation is defined as significant for a company when more than half of the company's sales can be attributed to radical innovation.

Analysis of the extent of incremental and radical innovation within companies has hitherto focused on the two forms of innovation separately. This has created a picture of Stockholm, Malmö and Copenhagen leading in innovation, with Gothenburg and Kiel hard on their heels, and Helsinki following on behind.

If special emphasis is placed on those companies which engage in both incremental and radical innovation, a clearer picture emerges of the most innovative clusters in BSR being found in Copenhagen, Stockholm and Malmö, see figure.

Involving users

In the global knowledge economy the ability to conduct and be successful with radical innovation becomes increasingly vital. The development of new platforms and concepts enables enterprises to offer the market something unique. But if innovations are quickly copied, profits are depressed by price based competition. Competition based primarily on price is one that companies in high cost countries such as Denmark, Sweden, Finland and Germany will lose.

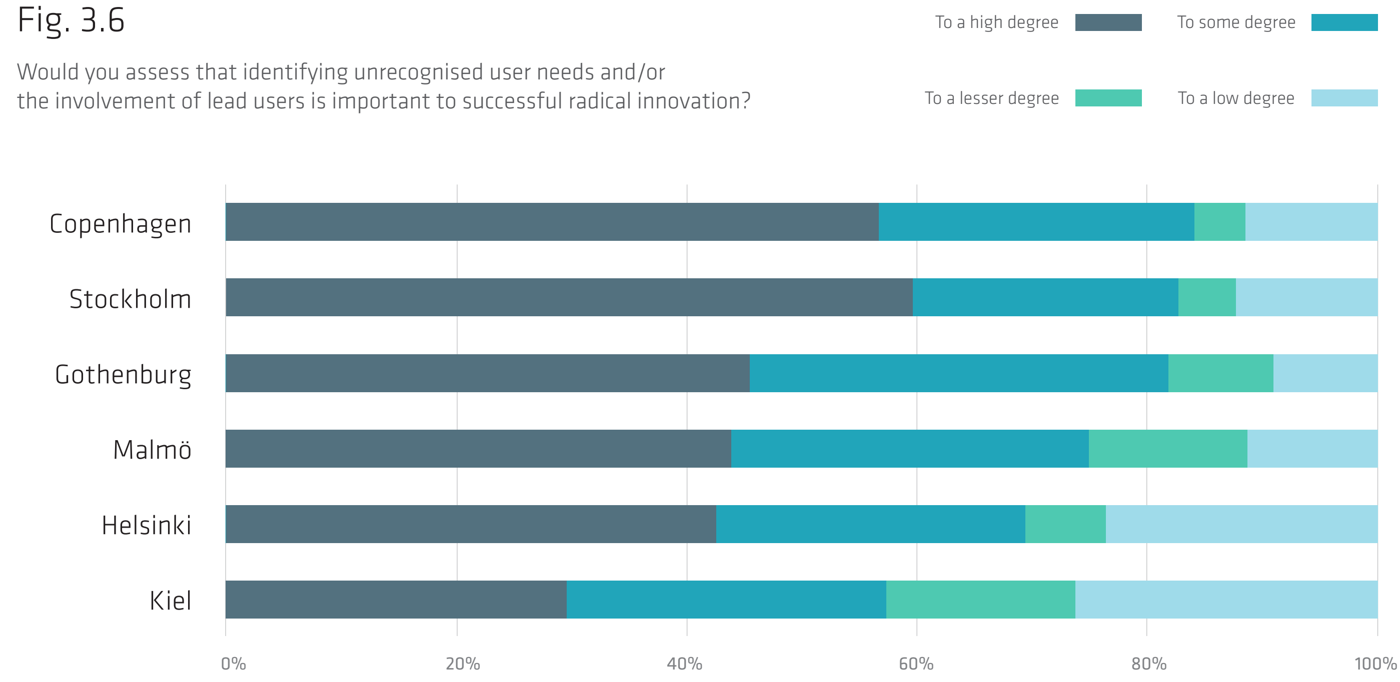
New technology and scientific discoveries have always been important to the innovation of life science companies, and that will continue to be the case in future – which is why investment in R&D is such a crucial element in the measurement of clusters' innovation capacity. New technology is no longer the only source of more radical innovation. New drivers are emerging. Co creation between companies and their customers and the inclusion of users in the innovation process are becoming increasingly important elements in the innovation process [18]

[18] FORA, New Nature of Innovation, 2009, www.newnatureofinnovation.org.

In the field of life sciences, too, teaming up with users will become a factor of growing importance to innovation. Enterprises in life science clusters in the Baltic Sea Region were asked to assess the importance of user driven innovation to their ability to introduce successful radical innovations. In Copenhagen, Stockholm and Malmö the response from more than half of the enterprises was that user driven innovation was very definitely important to successful radical innovation. In Gothenburg and Helsinki this assessment was shared by a little under half of the enterprises questioned, and in Kiel it was one third of enterprises, cf. fig. 3.6.

Fig. 3.6

Would you assess that identifying unrecognised user needs and/or the involvement of lead users is important to successful radical innovation?



Further analysis also shows that companies engaged in radical innovation typically assess user driven innovation as more important to successful radical innovation than companies which do not work with radical innovation. Three in four companies which engage in radical innovation say that user driven innovation to some extent or to a large extent is important for successful radical innovation. One in two companies which do not themselves work with radical innovation agrees with this assessment.

The more detailed analysis of innovation activity based on the extent of incremental and radical innovation and companies' assessment of user involvement confirms the picture of the six life science clusters dividing into two groupings – with Copenhagen, Stockholm and Malmö in the most innovative group and Gothenburg, Kiel and Helsinki in the second group, with only minor differences within the two groups.

Clusters' innovative capacity, employment and real wages

In the global knowledge economy, innovation capacity will be invaluable to the dynamics and market position of companies. Enterprises can increase their productivity through innovation (see next chapter). And with a strengthened position in global markets, innovation can at the same time provide fertile soil in which to boost employment and productivity.

It is likely that those life science clusters which today demonstrate the highest innovation capacity will prove in future to be the clusters with the highest growth rate in employment and productivity. Whether it also applied in the past is something that can be tested. However, there are both structural and data challenges in examining innovation capacity in the context of employment and productivity.

Employment is not an unambiguous measure of cluster performance. At first glance, many people in employment is a better situation than fewer, and rising employment is better than declining. But global competition imposes great demands on the ability of companies to adapt. A large cluster can be dominated by yesterday's winners who have not managed in time to adjust to changing market conditions. And reduced employment can be an expression of success if it is the result of outsourcing as part of a strategic effort to strengthen a company's position on the market.

Productivity may be viewed as a good performance measure because higher productivity will normally be better than lower productivity – but there are important data related problems in calculating and comparing productivity at the cluster level. Data is not readily available, and it is actually very complicated and resource intensive to construct good measures for productivity at the cluster level. However, real wages can be taken as an indicator of productivity, and it is significantly easier to gather data on real wages.

But comparisons of real wages across national boundaries are not without their difficulties. Corrections for differences in exchange rates cannot be done transparently; the same applies to corrections for differences in price levels[19]. There is also the added fact that short term changes in real wages can reflect the business cycle rather than real changes in company productivity.

In this survey, innovation was chosen as a measure of cluster performance. But – as already indicated – it is not easy to arrive at a reliable figure for innovation capacity. It can therefore be interesting to compare rankings according to innovation capacity with measurements for employment and productivity/real wages.

Employment can be measured in terms of both level and change and – in the case of cluster analysis – in terms of localisation quotient, which is a measure of how many persons are employed in a regional cluster compared to what could be expected in view of the size of the region. In other words, a total of three indicators[20].

[19] In comparisons between countries a correction is often made for differences between price levels in the respective countries by converting to purchasing power parities (PPPs). Ideally, such a conversion should be based on differences in clusters' input prices – but such figures are not available. Consumer price indices are used instead.

[20] Copenhagen, for example, had just over 22,000 people employed in life sciences in 2004. An increase of 5,500 since 2000. This number – 22,000 – is 3.6 times more than could have been expected on the basis of the size of the region. This means that in 2004 Copenhagen had a localisation quotient of 3.6. In 2000 the LQ was 2.5.

[21] The composite indicator is computed by taking a simple average of each of the three employment indicators, which have been normalised into index values representing their proportion to the maximum value, which is set to 100.

The three indicators for employment are combined to form one composite employment indicator[21]. It has been tested for validity, and the ranking of clusters is the same regardless of how the composite indicator is constructed – so the result is fairly robust, cf. appendix 6.

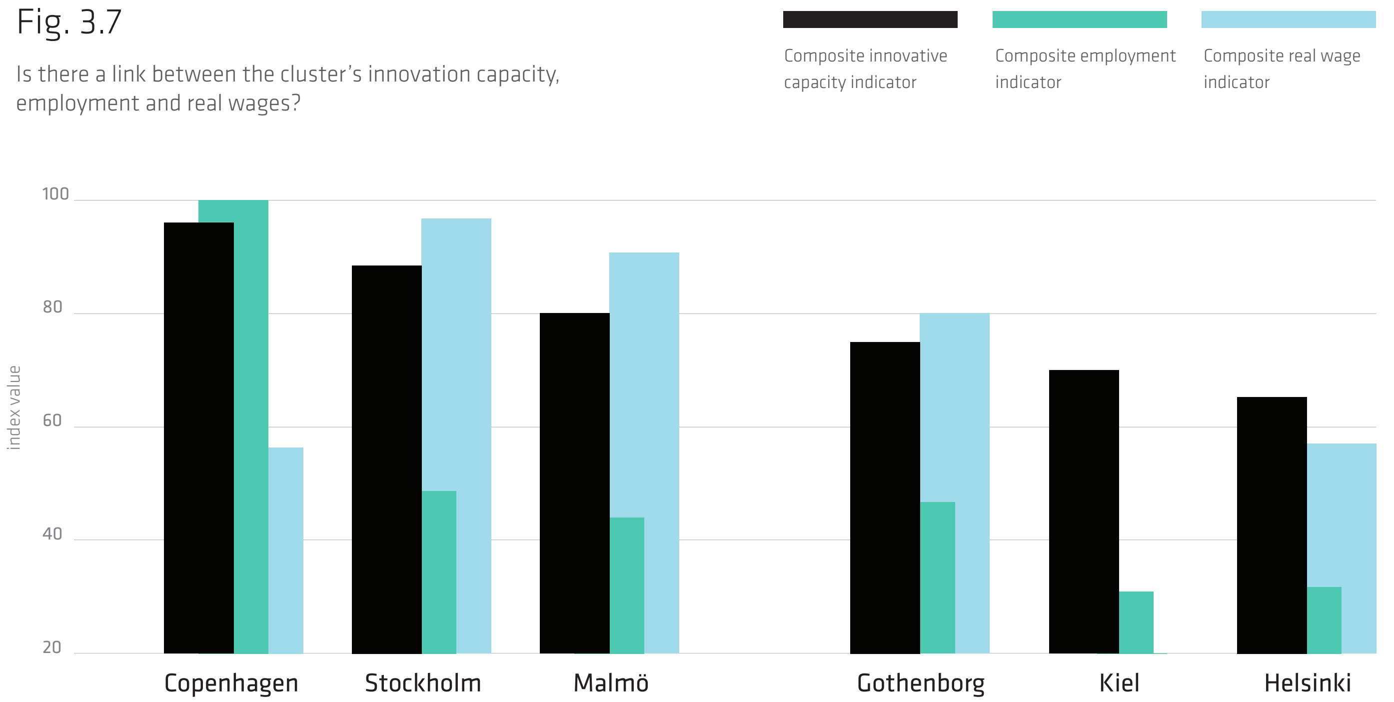
The composite employment indicator provides the same ranking as the composite innovative capacity indicator, i.e. with Copenhagen, Stockholm and Malmö in the best group and with Copenhagen significantly stronger in terms of employment.

Real wages have also been measured in terms of level and changes[22t]. The composite indicator for real wages does not return the same ranking as the innovation indicator; Copenhagen has a completely different result from the others. Copenhagen has both the lowest real wages and the lowest increase in real wages.

It has not been possible to obtain real wage statistics for Kiel, but in the case of the Swedish clusters and Helsinki there has been the expected respectable link between the indicator for real wage and the indicator for innovation, cf. fig. 3.7.

Fig. 3.7

Is there a link between the cluster's innovation capacity, employment and real wages?



Note In Copenhagen the average real wage in the life sciences sector was EUR 48,000 (PPP). Between 2000 and 2004, real wages increased nominally by 1.2% p.a. The very low rise in average salary indicates that much of the employment increase was in job functions in the low wage sector. The leading companies in Copenhagen are indeed responsible for much of the production in the region. A recent comparative study of life sciences in Sweden and Denmark appears to indicate that the volume of production is higher in Denmark than in Sweden, and that Swedish life science companies are more likely to outsource production to other countries than their Danish counterparts are. Particularly in the pharmaceutical industry (National and Regional Cluster Profiles – Companies in biotechnology, pharmaceuticals and medical technology in Sweden (VINNOVA, 2007) and Why is Danish life science thriving?) (VINNOVA, 2008).
The composite indicators are computed as a simple average of their underlying indicators. The underlying indicators' original values are in proportion to their maximum in order to enhance comparability across the indicators. Appendix 5 provides a more detailed account of the indexation method. The values of the underlying indicators are shown in table B6.1 and table B6.2 in appendix 6.

It is surprising and on the face of it inexplicable that the life sciences cluster in Copenhagen should have such low productivity/real wages compared to other clusters. Salary data was obtained from common European statistics in Eurostat: Structural Business Statistics (SBS). Eurostat is also the source of data for conversion of real wages to PPPs.

In 2004, the most recent available year with cluster data for employment and real wages at a regional level, real wages in Copenhagen were 35% lower than in Stockholm and 25% lower than in Malmö. This does not tally very well with companies' own views of remuneration levels in Denmark and Sweden respectively. At the same time, other data sources which calculate labour rates in a range of job functions do not seem to support this picture. They indicate a rather narrower difference in remuneration levels between Denmark and Sweden, cf. appendix 7.

In an attempt to evaluate why calculations based on SBS show such a low remuneration level in Copenhagen, a series of data checks were undertaken. The sensitivity of results to changes in the selected method of exchange rate correction was investigated – but without result. Irrespective which correction method was employed, the results were largely the same.

One possible explanation could be that the composition of the labour pool is quite different in Copenhagen from that in the Swedish regions. In Copenhagen the percentage of knowledge workers is lower than in Stockholm (see details above), presumably because the life science cluster in Copenhagen employs more people in the actual production of pharmaceuticals. And average remuneration for production workers is lower than for knowledge workers. This is most likely an important part of the explanation for the observed differences in the real wage level, but it cannot explain the entire difference in real wage levels, cf. appendix 7.

A more detailed examination of the rate of increase in labour costs in the life science cluster in Copenhagen produces quite surprising results. The average annual increase in real wages in the life science cluster in Copenhagen was 0.8% during the period 2000 2004 – whereas in Stockholm it was 2.5% and as high as 5.4% in Malmö. Tracing changes in real wages from year to year shows that movement is very erratic. In some years nominal real wages are almost static – there can actually be a decline – while in other years they increase very sharply. From 2000 to 2002 average real wages remained virtually unchanged in Sweden but during the period 2002 2004 they rose by almost 20%. The same pattern can be seen in Denmark. From 2005 to 2006 the statistics show an increase in real wages of no less than 13%. And in 2006 real wages in Sweden and Denmark were at the same level despite the fact that in 2004 Denmark appeared to have a real wage level that was markedly lower than in Sweden in the life science sector, cf. appendix 7. When regional cluster data in 2004, therefore, shows a real wage level in Copenhagen that is significantly lower than in Stockholm and Malmö, it would appear that the information should be treated with some degree of caution.

The significant fluctuation in wage statistics from year to year could indicate that the average figures are very much influenced by changes in the enterprises included in the sample. However, it has not yet been possible to find the explanation for the considerable fluctuations in the relative relationship between the life science clusters' real wage levels, cf. appendix 7.

In spite of the uncertainty attached to the real wage level and thus to the level of productivity in the life science cluster in Copenhagen, it was decided to apply the innovation indicator as a good expression of cluster performance. The view will therefore continue to be held that the life science clusters in Copenhagen, Stockholm and Malmö are the best performing clusters in the BSR, and that the clusters in Gothenburg, Kiel and Helsinki perform rather less well. The interesting question then arises of whether the difference in performance can be explained by differences in cluster specific framework conditions.

Why do some clusters perform better than others?

If it can be shown that the best performing clusters also enjoy the best framework conditions, it becomes possible to create a fact based foundation on which to build good cluster specific framework conditions.

For example, why is it that the life science cluster in Copenhagen has the highest innovation capacity of the six largest life science clusters in the Baltic Sea Region?

A number of enterprises in the Copenhagen area have achieved a position which has given them a global lead in their respective fields. Novo Nordisk, Lundbeck and Widex are examples of such companies, and Copenhagen also has a flourishing network of smaller, dynamic biotech enterprises and many companies in the meditech field. Has the dense concentration of life science enterprises in Copenhagen encouraged more intense rivalry in the Copenhagen life science cluster, and has an air of fertile teamwork between some companies and between companies and unique knowledge institutions led to successful innovation? It is questions of this nature that need answers if a fact based strategy is to be developed to improve the cluster specific framework conditions.

Of course, it is also important to the performance of life science clusters that general business conditions are good and that the horizontal framework conditions for innovation are good – the region's innovation capacity.

The general business conditions are good and roughly comparable in the four countries – Denmark, Finland, Germany and Sweden – discussed in this analysis. And there are few salient differences in their innovation capacity. Denmark and Finland record high figures, with Sweden and Germany not far behind[23].

The main hypothesis behind this survey is that general business conditions and differences in innovation capacity cannot entirely explain the difference in clusters' performance. The theory is that differences in cluster specific framework conditions also play a role in cluster performance. And this is the assumption that will be tested at regional level.

As the survey concerns only six regional life science clusters, and the difference in performance permits the identification of only two groups, statistical testing must be ruled out. The study has to confine itself to examining whether framework conditions in the group that performed best are better than the framework conditions available to the group whose performance is not as good.

[23] FORA, Nordic Innovation Monitor, 2009, www.foranet.dk.

Cluster specific framework conditions

Which cluster specific framework conditions are important to cluster performance?

In the global knowledge economy, enterprises compete more and more on the basis of innovation, and it has been illustrated that innovation appears to be a key parameter affecting enterprise performance. The choice was therefore made to focus on those cluster specific framework conditions that can be expected to affect companies' innovation.

It has been demonstrated over time that access to good human resources, high quality knowledge, and vigorous entrepreneurial activity is important to a region's innovation capacity.

But the fact that a region has good horizontal framework conditions for human resources, knowledge and entrepreneurial activity does not necessarily mean that all clusters in the region enjoy good cluster specific framework conditions.

A region can, for example, have well managed universities in terms of horizontal indicators such as number of graduates, their quality, and research scope and quality – but that does not mean that all clusters necessarily find that the graduates and knowledge they are looking for are of high quality at universities in the region. It was therefore decided to include the extent and quality of the region's supply of life science knowledge workers and know how as framework conditions.

A region can enjoy a good level of entrepreneurial activity – but that does not necessarily apply in all clusters. Consequently, it was decided to include cluster specific entrepreneurial activity as a framework condition.

Life science clusters are probably more dependent on public regulation than many other clusters. Many life science products require official approval, their use is often officially controlled, and many of their customers are public and public regulated institutions such as hospitals and medical practices. This being the case, it was decided that the quality of public regulation and demand in the life science sector should be included as one of the cluster specific framework conditions.

Finally, it was decided that co operation between cluster enterprises should be included as a separate framework condition, despite the fact that it is not possible through framework conditions planned by a public authority to influence co operation between enterprises – but the authorities can exert an indirect influence by supporting cluster organisations, etc. And it is a well known fact that there are many cluster organisations in Europe in particular[24]. However, there is very little fact based information on the importance of cluster initiatives to co operation and performance.

[24] Sölvell et al., Cluster Initiatives Greenbook, 2003.

This study is thus based on five policy areas which are deemed to have special significance for the framework conditions of life science clusters:

- Access to the appropriate human resources
- Access to the appropriate knowledge and extent of knowledge sharing
- Entrepreneurial activity
- Public regulation and demand
- Co operation between companies

Is there a link between innovation capacity and cluster specific framework conditions?

In the following pages the result will be reported for each of the policy areas. First, however, there is a general assessment and ranking of life science clusters' framework conditions – and an illustration of the extent to which the best performing clusters also have the best framework conditions.

The simplest way of obtaining a composite picture of cluster specific framework conditions is to take an average of all indicators. This gathers all information on the cluster specific framework conditions in a single indicator. But does it perform any useful purpose to gather results into a single indicator?

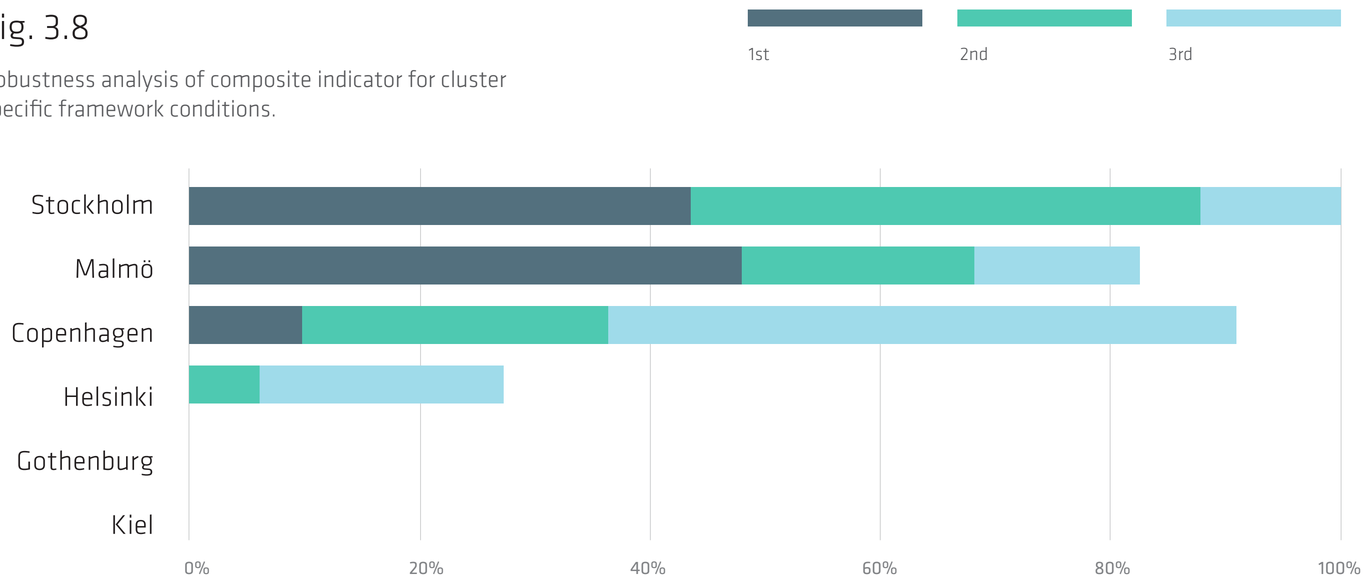
Not very likely – partly because we have no background on which to judge the importance of individual indicators. How important is access to knowledge within the region compared with entrepreneurial activity or co operation between companies?

As a first step – on the other hand – it is possible to conduct a robustness analysis, illustrating the extent to which cluster ranking depends on the weight with which a composite indicator is constructed.

The robustness analysis shows that the choice of weighting has no decisive effect on the overall conclusion concerning which regions have the best framework conditions for life science clusters. The composite indicator for cluster specific framework conditions provides a relatively robust ranking of the six regions. Almost irrespective of which set of weightings is applied in calculating the composite indicator for framework conditions, Copenhagen, Stockholm and Malmö will always be the regions with the best cluster specific framework conditions for life sciences, cf. fig. 3.8.

Fig. 3.8

Robustness analysis of composite indicator for cluster specific framework conditions.



Note The figure summarises the result of the robustness analysis, in which the composite indicator is computed 10,000 times, each time with a new and random weighting of the underlying indicators, and the regions are ranked from one to six. The figure shows how many times each region is ranked as number 1, 2 and 3 respectively.

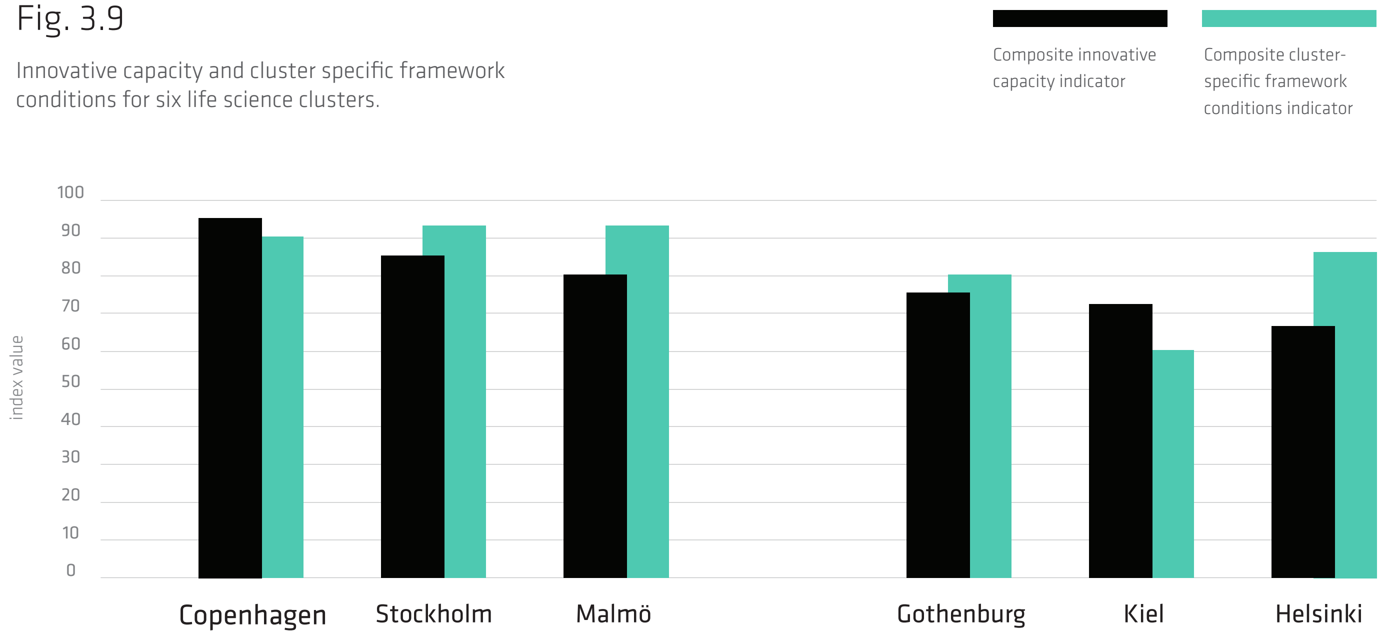
When very extreme weightings are applied, Helsinki can come in the top two on cluster specific framework conditions. This is because in some of the indicators Helsinki does fairly well (see below).

But even with these reservations the robustness analysis provides a fairly clear sign that the three best performing life science clusters in the BSR also have the best framework conditions.

If cluster innovation capacity is measured by a simple composite indicator, where all indicators have the same weighting, with a simple indicator for framework conditions in which all indicators also have the same weighting, it is possible to illustrate that the three regions that perform best also enjoy the best cluster specific framework conditions, cf. fig. 3.9.

Fig. 3.9

Innovative capacity and cluster specific framework conditions for six life science clusters.



Note The composite indicators are computed as a simple average of a series of underlying indicators. The underlying indicators' original values are in proportion to their maximum in order to enhance comparability across the indicators. Appendix 5 provides a more detailed account of the indexation method.

The illustrated link between the composite innovative capacity indicator and the composite indicator for framework conditions supports the theory that there is actually such a link between performance and cluster policy, and that the constructed model captures some of the correct framework conditions for innovation at cluster level.

The available data, however, does not permit the link to be statistically tested. There are too few clusters in the data source to establish clearly whether there is in fact a link, and – if so – how strong the link is. If it had been possible to include the leading clusters at a global level, a proper statistical analysis could have been performed. In the next chapter, statistical tests are conducted on the basis of enterprise data.

If simple composite indicators are used to provide an early assessment of the performance and framework conditions of individual clusters, we see that the life science clusters in Copenhagen and Kiel perform well in relation to their framework conditions, while clusters in Stockholm, Malmö, Gothenburg and especially Helsinki have a lower innovation capacity than their framework conditions suggest should be the case.

Composite indicators, of course, are far too weak a basis on which to make decisions but it is an indication that something is to be gained from a more detailed comparison of cluster specific framework conditions.

Human resources

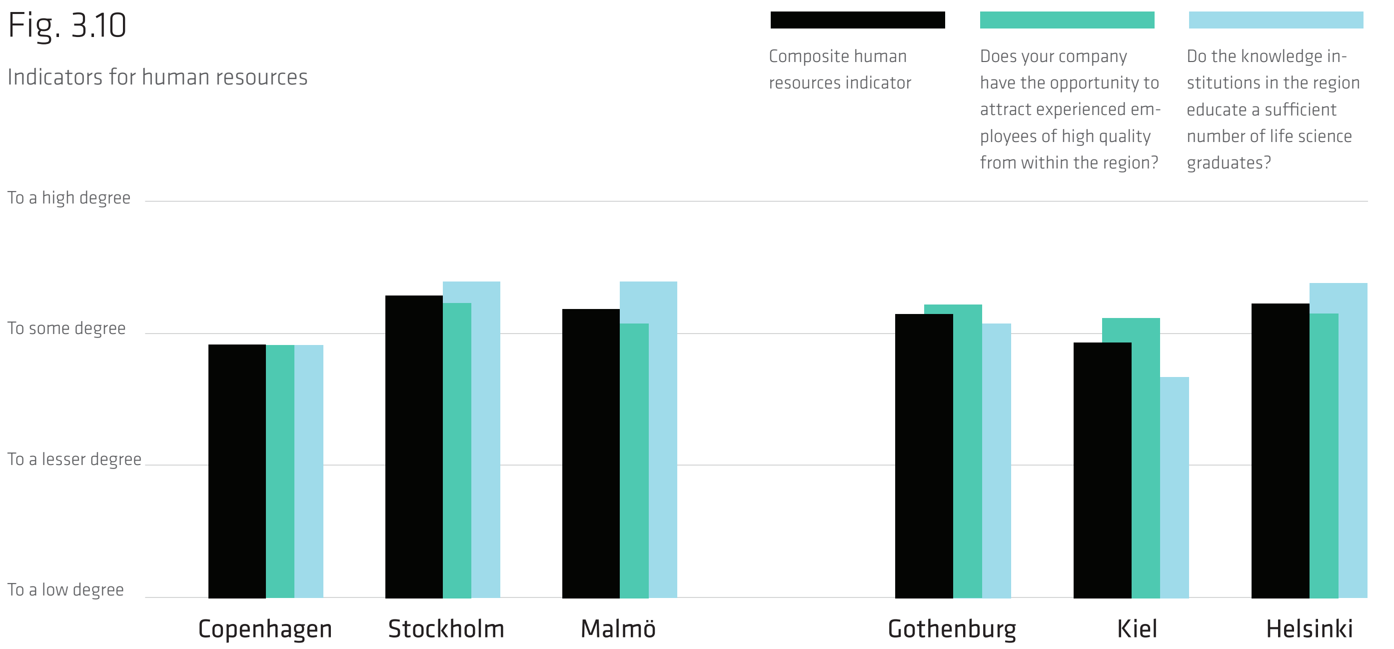
Knowledge workers and researchers have an important part to play in companies' ability to compete on innovation and thus in wealth creation. It is therefore essential that clusters have the opportunity to attract knowledge workers. In this connection it is essential that universities turn out an adequate supply of graduates and post graduates with the skills and knowledge that life science enterprises are looking for. And that graduates have good qualifications comparable with their international fellows. But it is also important that companies can attract more experienced employees with specialist knowledge in their respective fields, both from their own region and from elsewhere in the world.

The survey asked two questions about human resources. First, enterprises were asked: "Do knowledge institutions in the region educate an adequate number of graduates in the life sciences with the right qualifications to meet companies' needs?". The second question was: "Is your company able to attract experienced employees of high quality?" Companies were asked to give their assessment from "To a low degree" to "To a high degree" on a scale of 1-4.

The two questions probably do not provide sufficient information to arrive at any final conclusion about the cluster specific framework conditions as they apply to human resources but they do capture some of the important aspects of human resources. The general picture emerging from companies' responses is that they are relatively uniform across the regions. Enterprises typically respond that to some degree they have access to an adequate supply of graduates with the right qualifications and that to some degree they are able to attract the experienced and specialised employees they need, cf. fig. 3.10.

Fig. 3.10

Indicators for human resources



Note The composite indicator is calculated as a simple average of the two underlying indicators – also shown in the figure. Appendix 5 provides a more detailed account of the indexation method.

Copenhagen, however, appears to have a lower level than the other regions. The picture scarcely seems to tally with the fact that Copenhagen has the highest innovation capacity and most employees. But at the same time it may be providing part of the explanation.

The life science cluster in Copenhagen has experienced a steep rise in employment. From 2000 to 2004 the number of persons in employment rose by 5,500. That can have caused a shortage of labour for many life science enterprises in Copenhagen, with the result that Copenhagen companies report that they can only to some degree attract the necessary workforce. It may also be possible that the production of life science graduates from Copenhagen universities is at a relatively high level. That would require register data to determine but the situation illustrates one of the weaknesses of survey data.

The general picture – that enterprises only to some degree have access to qualified labour – is an indication that life science clusters in the Baltic Sea Region are unable to exploit their potential to the full. It could therefore be interesting to examine the theory in more detail based on sound register data and comparisons with the educational capacity of some of the most successful life science clusters in the world.

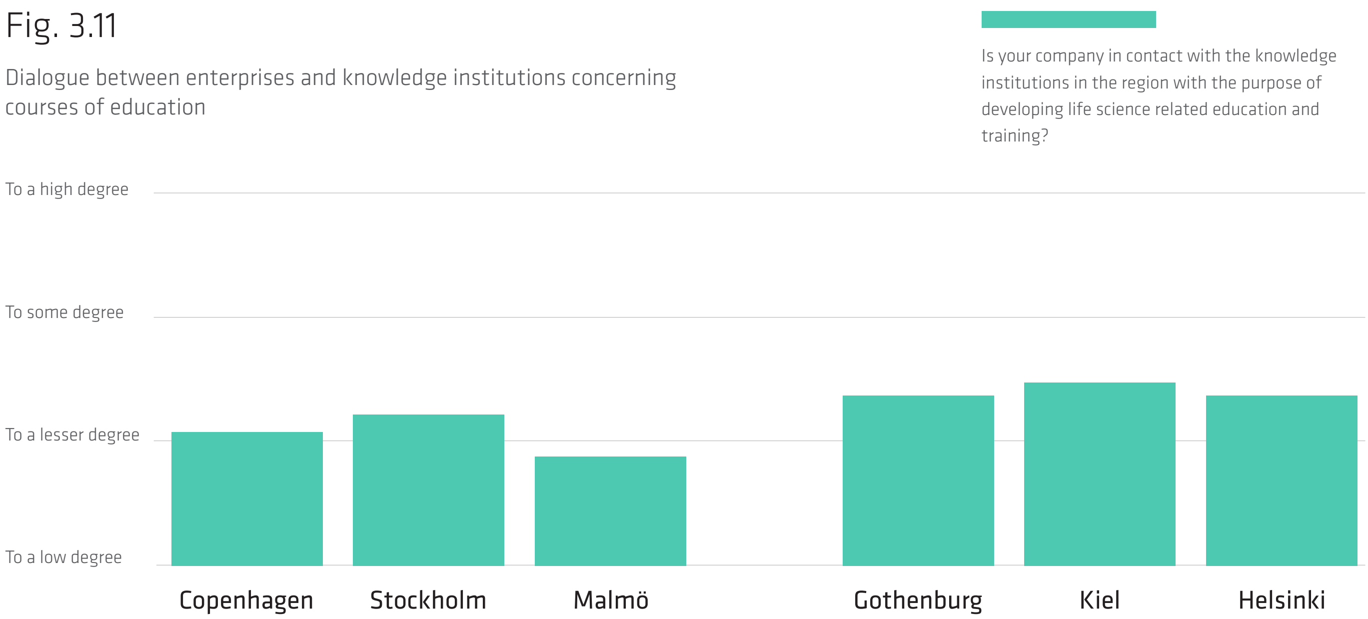
Co operation between enterprises and universities on courses of education

It is important that universities and other institutes of higher education produce graduates with the right qualifications. An important tool for ensuring that educational establishments are aware of companies' needs is establishing dialogue and co operation between the parties. When companies and educational institutions enter into a dialogue and discuss new courses of education, it raises the quality of the graduates who later join the companies. Planning internships and involving companies in project work can be of great importance in developing relevant, high quality educational programmes.

Enterprises are asked whether they are "in contact with educational institutions in the region with a view to developing life science courses and post graduate courses". The result should give rise to anxiety. There is very little contact, and that response applies to all regions, cf. fig. 3.11.

Fig. 3.11

Dialogue between enterprises and knowledge institutions concerning courses of education



In all regions there is a need for closer relations between enterprises and educational institutions, and it could inspire such a relationship if an international benchmark analysis showed that close relations are in fact common in the best performing clusters – which is probably the case.

Access to a qualified workforce is important but it is also important that management and organisation are geared to innovation. There is a need for flat organisations in which staff can work in teams and see their creativity and responsibility being utilised to the full. That requires management with a global approach, strong strategic skills, and focus on innovation management. This aspect of human resources has not been examined here but it is an area which can turn out to be of great importance to companies' capacity for using knowledge workers to boost their own innovation capability.

Knowledge building and knowledge sharing

A key innovation driver is access to knowledge. And that is particularly true in life sciences, which for many years have been noted for intense competition to secure knowledge and new technology. Although global knowledge sharing has become more common and in future will be essential in the race to innovate, there are indications that access to local knowledge of an international standard will continue to be important.

Regions which house knowledge institutions of an international class will have a strong pull on companies which increasingly source their knowledge globally. There are studies showing that proximity between enterprises and knowledge institutions is an important driver for innovation and cluster formation[25].

[25] Economist Intelligence Unit, Fertile Ground: Cultivating a talent for innovation, 2009.

Enterprises were asked whether "knowledge institutions in the region research adequately into aspects of life science which are relevant to the company" and whether "the research environment in the life science field in the region is on a par with the leading research environments in the world". In order to give a true answer to that question, enterprises must have a pretty sound knowledge of the best research environments.

Companies were also asked to assess whether "other life science enterprises had established themselves in the region in order to gain access to the region's life science knowledge". If it is the case, it will be an indication that the region offers a high degree of knowledge building and has achieved a critical mass of talent and expertise in one or more areas of commercial interest to life science enterprises. It cannot be ruled out that this indicator is a better expression of the framework conditions for knowledge building in the regions than direct assessments of the extent and quality of the research of knowledge institutions.

Considering the response to all three questions under one heading, there would seem to be an indication that the extent and quality of knowledge and research are given a relatively low evaluation, as was the case with access to a qualified workforce. All questions receive responses of either "To some degree" or "To a lesser degree". There is an indication that enterprises assess access to knowledge a little more positively in the three regions with the best performing clusters – but there is not a dramatic difference, cf. fig. 3.12.

Fig. 3.12

Indicators for knowledge building

Note The composite indicator is calculated as a simple average of the three underlying indicators – also shown in the figure. Appendix 5 provides a more detailed account of the indexation method.

Helsinki, however, departs from the normal pattern: the composite indicator for knowledge building in Helsinki is on a par with the clusters in Copenhagen, Stockholm and Malmö.

The difference between the two groups of regions is more remarkable when one considers the indicator for whether life science enterprises outside the region set up business in the region in order to gain access to the region's life science knowledge. If this indicator is allotted greater weight in calculating the composite indicator for knowledge building, the difference between regions also becomes more pronounced – but again Helsinki is the exception.

The general picture – of enterprises only to some degree or a lesser degree having access to knowledge – should raise a few eyebrows and cause observers to consider whether research is adequately tailored to the needs of companies. Not that corporate needs should be the only factor determining the direction in which research should be moving but all Nordic countries emphasise the desirability of planning research to take account of companies' needs. This would not appear to be happening in the case of research relevant to life science enterprises. This is another thesis that could be qualified by reference to an international benchmark of the framework conditions for life science clusters.

Entrepreneurship

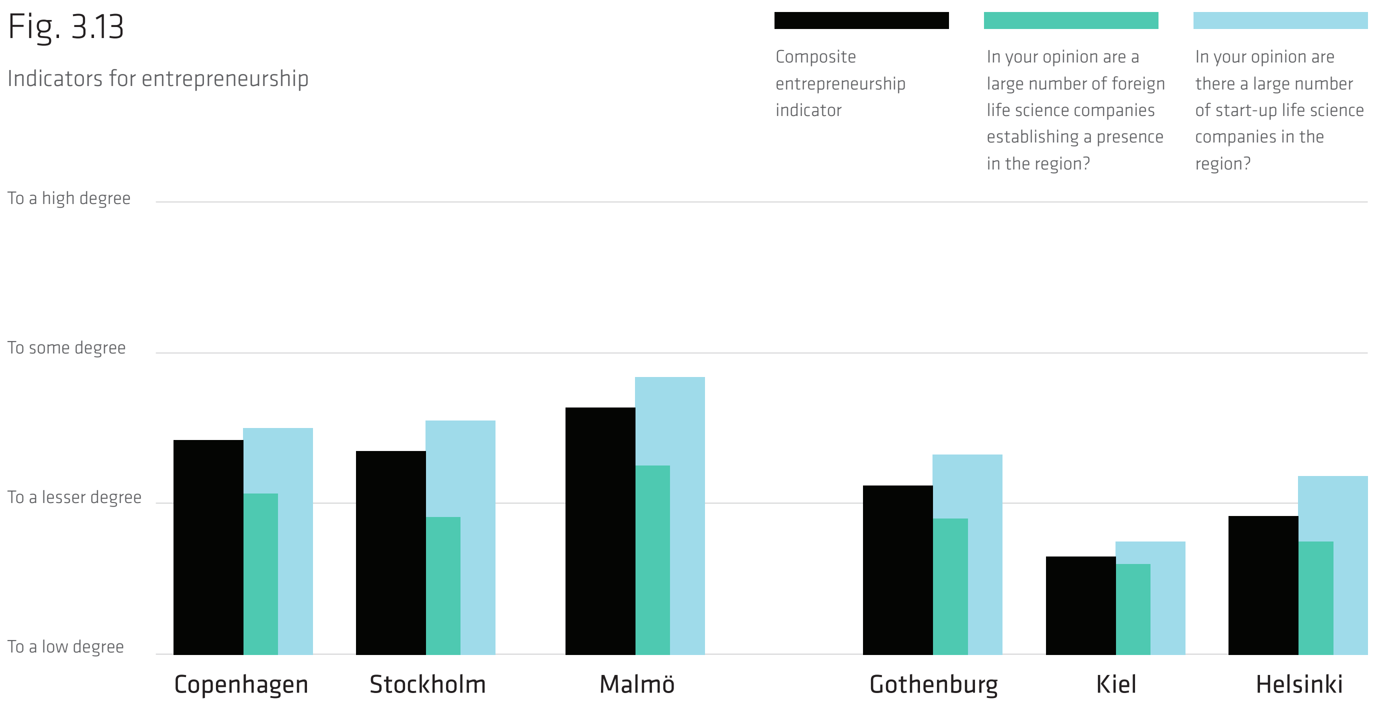
It is important to clusters' innovation capacity and overall performance that there is a steady flow of new enterprises. Radical innovation projects are risky and therefore cannot always be undertaken by existing companies. It is therefore vital that setting up new companies is a smooth process, and that the region can offer entrepreneurs the services of a well managed infrastructure. This applies to the physical infrastructure with research parks and laboratories – but also to the knowledge infrastructure with specialised consultants and access to venture capital.

In order to be able to assess whether the cluster specific framework conditions for entrepreneurs are favourable, it is important to know the extent of entrepreneurial activity. Companies interviewed during the survey were asked to assess whether "many new life science enterprises have been set up in the region" and whether "many foreign life science companies have set up business in the region".

Identifying the scope of entrepreneurship shows that the three leading regions in the index of innovation capacity are also the most active in terms of entrepreneurship. But entrepreneurship lives a quiet existence, it would seem. Even in the leading regions, the view of enterprises is that new businesses are started only to a lesser degree in the life sciences sector, cf. fig. 3.13.

Fig. 3.13

Indicators for entrepreneurship



Note The composite indicator is calculated as a simple average of the two underlying indicators – also shown in the figure. Appendix 5 provides a more detailed account of the indexation method.

In terms of entrepreneurship Helsinki ranks lower than the best regions. A number of studies into innovation and entrepreneurship have shown that entrepreneurship plays an important role in the innovation capacity of regions, and that is likely also to be the case with clusters. That may in part explain why Helsinki does less well in innovation capacity than the framework conditions for human resources and access to knowledge indicate.

The fact that enterprises in all clusters take a relatively negative view of entrepreneurial activity is also something that should give rise to anxiety. And call for more searching analyses and international benchmarking to uncover the reasons and provide inspiration for improving framework conditions for entrepreneurship.

Regulation and public demand

As a commercial enterprise, the life sciences are subject to considerable regulation and sell a great number of their products and services to public sector customers. Inevitably, therefore, regulation and public demand affect the innovative capacity of life science clusters.

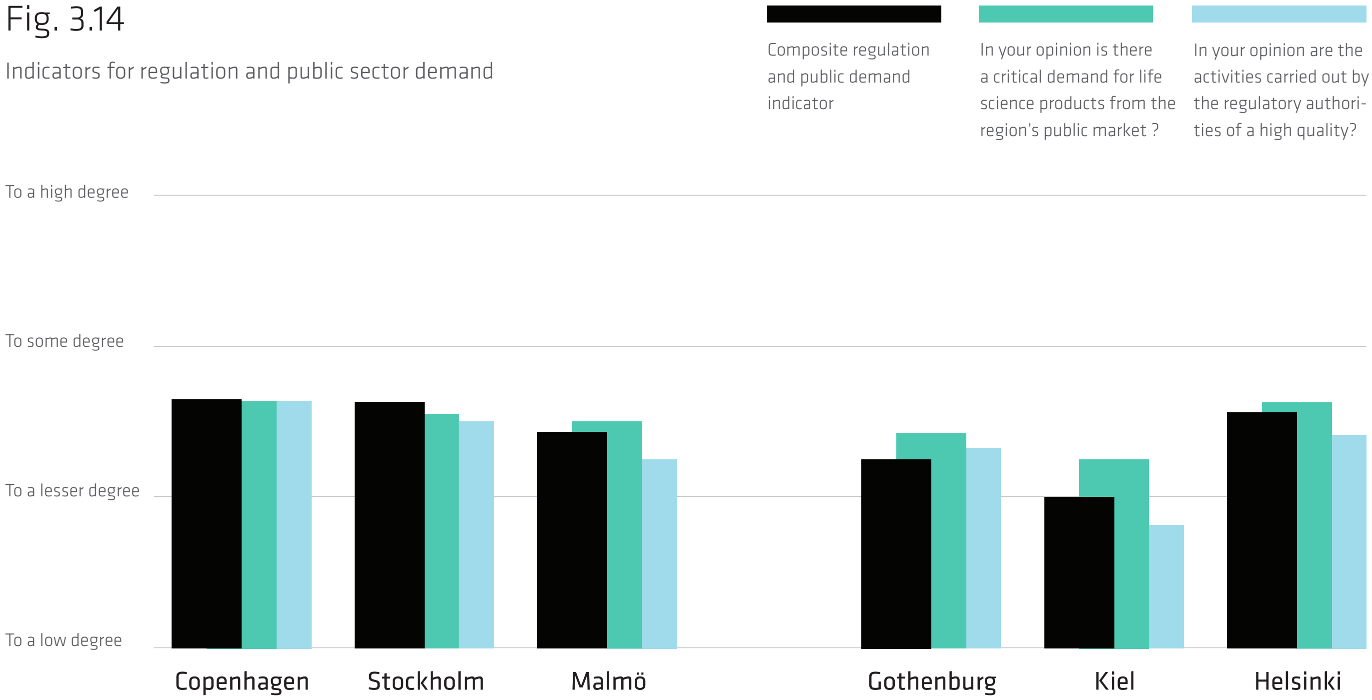
High quality regulation and high standards can act as a driver of innovation. The same applies to public purse demand; critical but intelligent public demand can stimulate innovation.

As part of the survey, enterprises were asked to assess whether “the activities of regulating authorities are of high quality” in 11 specific areas, including approval of clinical testing and approval of new pharmaceutical products, cf. appendix 8. They were then asked to judge whether “the public market in the region exercises a critical demand for life science products”, thereby acting as a lead market.

The survey reveals that enterprises generally are critical of the quality of official regulation and of public sector demand. Enterprises for the most part responded that regulation “to a lesser degree” was of high quality. The same response was given in assessing public demand. At the same time, the survey showed that companies in the three regions that lead in innovation capacity usually assess the quality of official regulation and public purse demand more positively than companies do in the remaining three regions – although again Helsinki is an exception to the rule, cf. fig. 3.14.

Fig. 3.14

Indicators for regulation and public sector demand



Note The composite indikator is calculated as a simple average of the two underlying indicators – also shown in the figure. Appendix 5 provides a more detailed account of the indexation method.

Collaboration between cluster companies

Competition and rivalry among the member companies of a cluster are important drivers in fostering the cluster's innovative capacity and performance. But enterprises also benefit from collaboration. The degree of co operation in a cluster determines the extent to which companies can reap the benefit of having a large concentration of related players and skills in the region.

This study defines the degree of collaboration between companies in two stages. First, companies are asked whether they regard themselves as being part of a cluster. This gives an indication of whether enterprises are at all aware of there being a concentration of skills in their region that they can benefit from.

They are then asked of the extent to which they take part in specific collaborative efforts. An effort is made to identify co operation between companies in tackling shared challenges such as attracting employees, improving the efficiency of corporate operations, and cluster branding. Such areas can be important to companies, although not directly associated with their innovation and business development. The extent of specific efforts to collaborate on innovation and business development is examined separately.

Do companies regard themselves as part of a cluster?

Although an enterprise may be located within a cluster, it is by no means certain that it is aware of the fact or attaches importance to it. If the enterprise is to harness any benefit from being located with other companies, it probably requires a certain degree of co operation – which must start with the realisation of being part of a cluster. The study shows that enterprises are more likely to regard themselves as part of a cluster in the leading innovation clusters in Copenhagen, Stockholm, Malmö and Helsinki than in Gothenburg or Kiel, cf. fig. 3.15.

Fig. 3.15

Do companies regard themselves as part of a cluster?

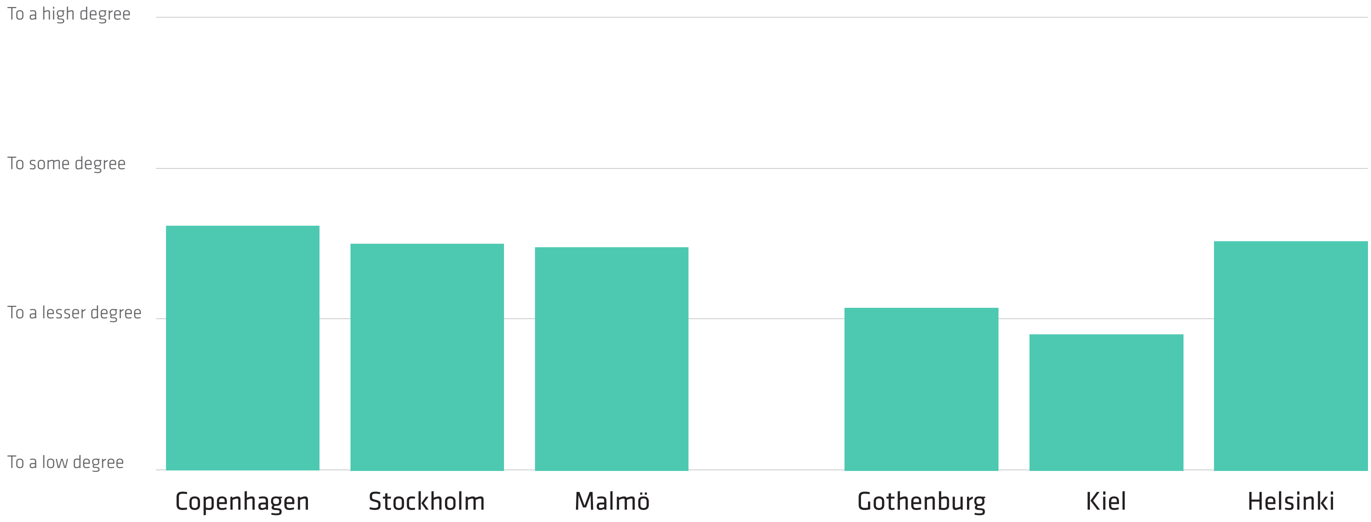
Consists of the following questions :

Do you find, that there is a concentration of life science companies in the region?

Does the companies perceive themselves as part of a community with other life science companies in the region?

Is the company in direct competition with other life science companies in the region?

Composite cluster perception indicator



Note The composite indicator is computed as a simple average of the three underlying indicators. Appendix 5 provides a more detailed account of the indexation method.

The leading innovation clusters appear to have achieved a greater degree of critical mass than the other regions. Again, Helsinki stands out in that it achieves the same level of cluster awareness as the leading innovation clusters. Although the life sciences cluster in Helsinki is not large in terms of the size of its workforce and does not generate a high innovation capacity, its member companies harbour the same sense of being part of a cluster as companies in Copenhagen, Stockholm and Malmö. This may be attributed to the fact that since 1993 Finland – as part of its national innovation strategy – has worked intensively with cluster development.

Do companies work together on shared challenges?

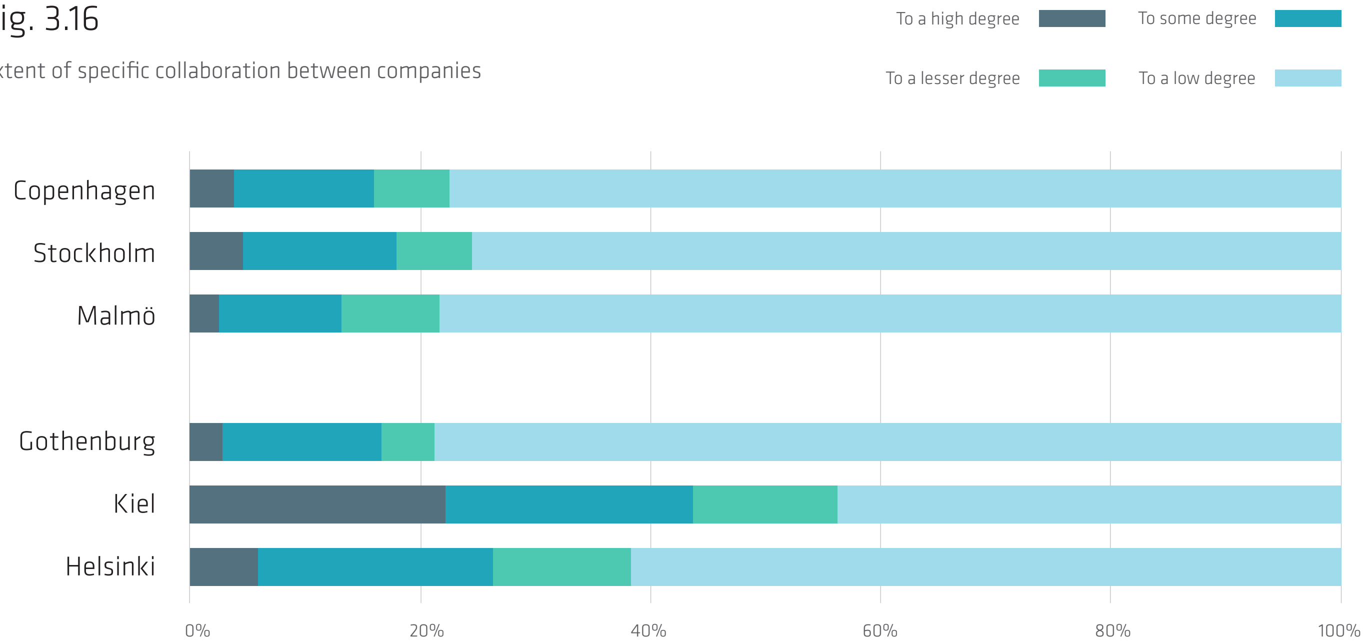
During the survey, enterprises were asked to what extent they collaborated with other life science companies in the region on initiatives to attract foreign workers, develop an encouraging environment for entrepreneurs, gain access to new markets, or improve the efficiency of company operations. Companies were questioned on 10 specific areas. Areas such as cluster initiatives and cluster organisations, which Medicon Valley Alliance in the Øresund Region has frequently focused upon[26].

[26] Sölvell et al., Cluster Initiatives Greenbook, 2003.

Responses indicate that there is very little specific co operation. For the most part, enterprises say that they are only to a small extent involved in specific initiatives to collaborate with other life science companies in the region, cf. fig. 3.16.

Fig. 3.16

Extent of specific collaboration between companies



Has your company, in co operation with other life science companies in the region, taken part in:

- A Purchasing
- B Trade fairs and branding activities
- C Efforts to attract workers – including knowledge workers and foreign workers
- D Development of an entrepreneurial environment
- E Efforts to access new markets
- F Development of the company's operations, including initiatives vis à vis suppliers, new logistics options, and new production methods.

Note Answers to questions A to F have been computed to produce a simple average.

The degree of co operation over shared problems is typically lower in those regions that lead in innovation than in regions with a lower innovation capacity. In Copenhagen, Stockholm and Malmö nearly 80% of enterprises responded that they had only to a very limited degree specific co operation with other companies to tackle common problems. Only a small number of enterprises responded that they enjoy a high degree of collaboration with other life science enterprises in their region to increase the efficiency of their operations and the framework conditions for innovation. The same picture is evident in Gothenburg, while it differs in Kiel – and to some extent Helsinki. In Kiel almost half the enterprises interviewed responded that they had some or a high degree of co operation with other enterprises in their region aimed at solving shared problems.

However, that does not alter the overall impression that there is a very low degree of specific collaboration among enterprises.

Do companies collaborate on innovation and research?

As global competition based on innovation has increased, so too has the need for global knowledge sharing. More and more enterprises set up global innovation alliances. At the same time, there are signs that local co operation on research and innovation plays a growing part in companies' innovation. A survey shows that it is widely believed among enterprises that both local and global co operation will prove to be of growing importance to innovation in the coming years[27].

[27] Economist Intelligence Unit, Fertile Ground: Cultivating a talent for innovation, 2009.

There are grounds for supposing that the latest global trends towards co operation in innovation also apply to the life sciences – perhaps even to a greater extent than in many other clusters because life science enterprises depend to a large extent on knowledge which is specialised and difficult to access, see box 3.1.

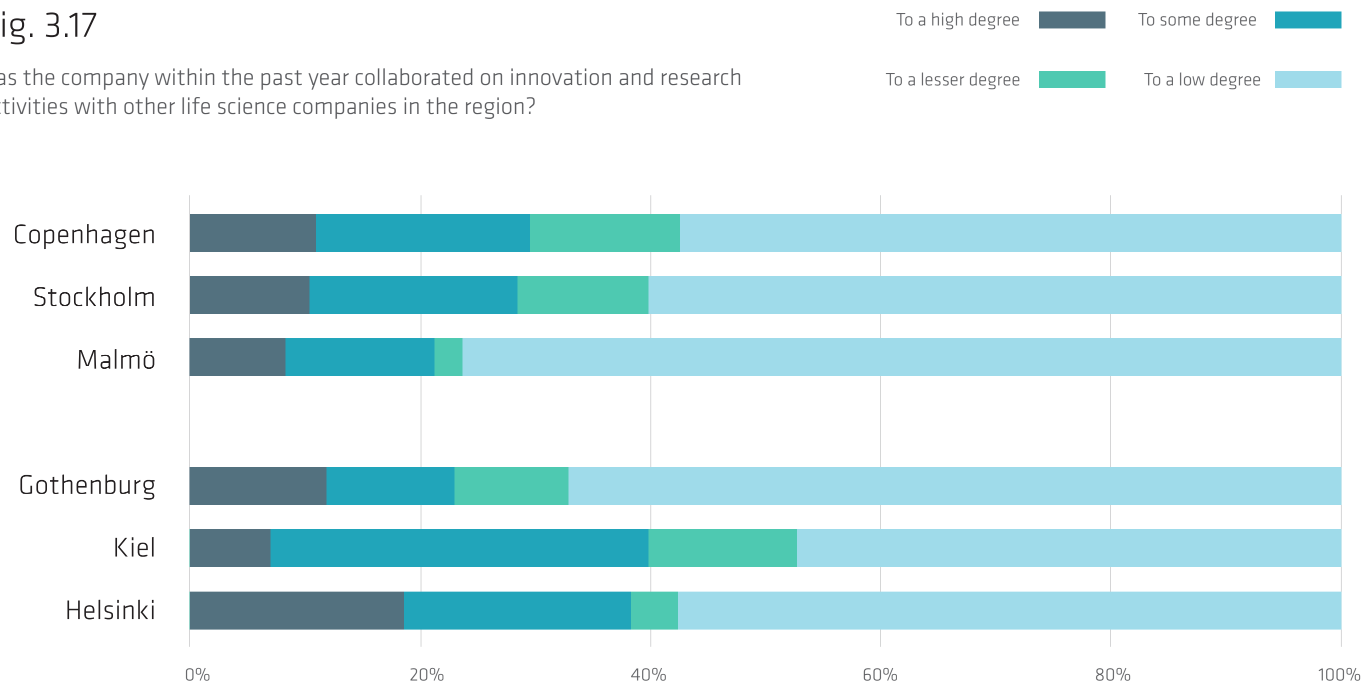
Box 3.1 Eli Lilly sets up InnoCentive

Back in 1998 it was obvious to pharmaceutical manufacturer Eli Lilly that in some instances innovation was being hampered by a lack of specialised knowledge which the company was unable to build up and maintain on its own. Faced with the growing challenge of developing new pharmaceutical products, the company launched InnoCentive in 2001, an online market place for enterprises and specialists within which the "seeker" companies can formulate problems they themselves cannot solve – and the "solver" specialists (who may be employed in competing enterprises) can develop and sell solutions.

In the survey, enterprises are asked to what degree within the past year they have "collaborated on innovation and research activities with other life science companies in the region". More than half the enterprises and as many as three out of four reported only a low degree of collaboration with other enterprises on innovation and research in each region. There are far fewer companies for whom innovation and research occupy a more central position. In most regions, one in seven enterprises responds that it collaborates to a high degree with other companies in matters of innovation and research, cf. fig. 3.17.

Fig. 3.17

Has the company within the past year collaborated on innovation and research activities with other life science companies in the region?



Any global co operation in which enterprises may have engaged is not dealt with in this survey. That is a shortcoming which should be rectified in future surveys of this nature. The analysis in the next chapter based on data for individual enterprises shows that those companies which co operate on research and innovation assess the cluster

specific framework conditions better than enterprises which do not co operate. In addition, the analysis shows that companies which co operate on research and innovation are more innovative and are more productive than companies which do not co operate.

It is a clear indication that co operation on innovation is important to companies' innovation and thus to the innovative capacity, productivity and employment of the clusters to which they belong.

The very limited degree of co operation on innovation that occurs in the leading life science clusters in the BSR and is shown by this survey is therefore worrying. It could be interesting to know why so few enterprises engage in research and innovation co operation. The position could perhaps be examined in an international benchmark analysis which could possibly also show whether co operation on research and innovation receives low priority from cluster organisations in the BSR or whether it is given low priority by the authorities who could make resources available to encourage the formation of networks.

In summary

Analysis of the largest life science clusters in the Baltic Sea Region shows that the best performing clusters – Copenhagen, Stockholm and Malmö – also enjoy the best cluster specific framework conditions. But as the material is sparse, it has not been possible to draw more reliable conclusions on the importance of the cluster specific framework conditions. That would require further benchmark analyses – and preferably analyses from several countries.

The link between cluster specific framework conditions and company performance in innovation and productivity is supported by the results of the statistical analysis of company data in the next chapter. Admittedly, it has not been possible to demonstrate a significant statistical link between productivity and framework conditions – presumably because enterprises in the BSR share a fairly uniform assessment of the cluster specific framework conditions, and the spread of responses is therefore so narrow that it limits the options for statistical testing. For this reason, too, it could be interesting to have a wider analysis, introducing more marked differences.

The statistical analysis shows, however, that those enterprises which collaborate on research and innovation adopt a more positive view of the framework conditions and enjoy higher productivity than enterprises which do not collaborate.

The other main result of the survey is that enterprises in life science clusters in the BSR have a relatively negative assessment of the cluster specific framework conditions. Unfortunately, the analysis cannot show us the extent of the problem. That would require a basis for comparison.

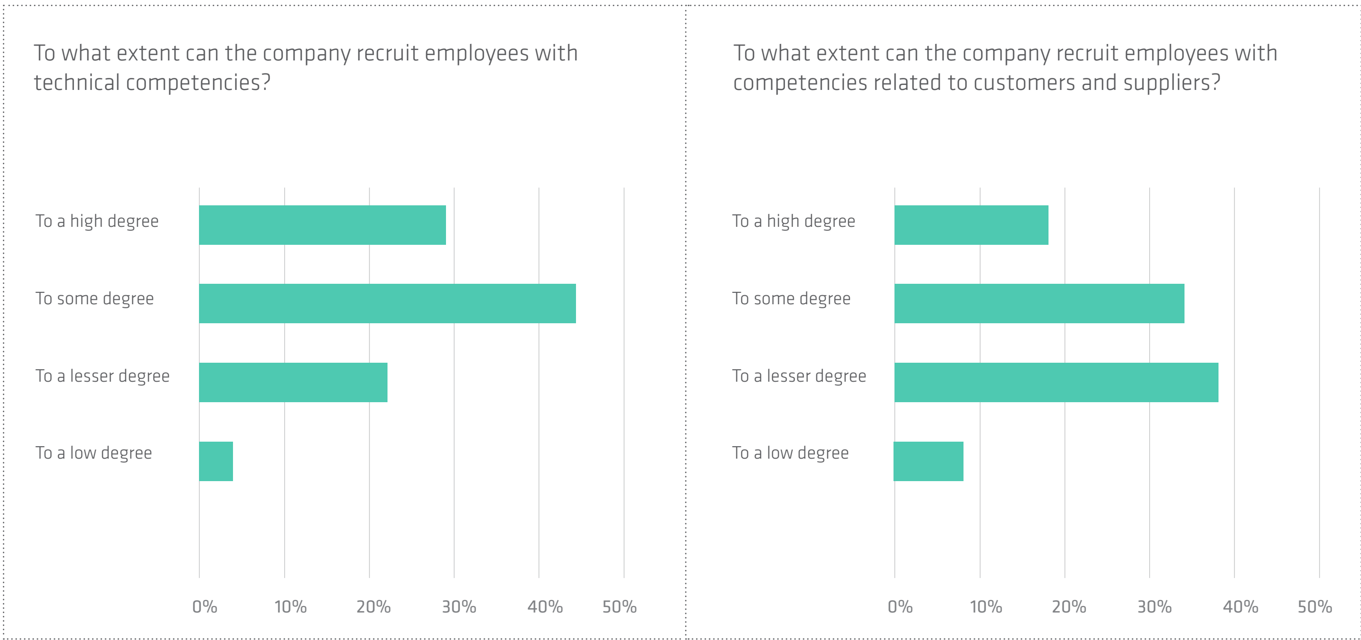
The discussion of the individual policy areas touches upon how a broader benchmark analysis could provide a basis for a more qualified assessment and a more fact based foundation for thoughts on how to improve cluster specific framework conditions.
It is, however, possible to compare the result of the Copenhagen life science cluster with similar results from other Danish cluster analyses. In a survey of the Danish electronics cluster, companies were asked to evaluate employee skills in terms of technological qualifications, co operation with other skill groups, and the skills required to work with user involvement in the innovation process.

The survey covered the skill sets of newly trained employees, of new employees arriving from other companies, and of existing employees.

Companies in the Danish electronics cluster looked very positively upon their access to human resources with solid skills[28]. That was particularly the case with technological skills but only to some degree with the skills necessary for user driven innovation, cf. fig. 3.18.

[28] FORA, Brugerdreven innovation i elektronikbranchen, 2005, www.foranet.dk.

Fig. 3.18



Any desire to compare the Copenhagen life science cluster with the Danish electronics cluster must be treated with caution – partly because the analytical methods differ. Survey questions were not exactly the same but the comparison leaves the broad impression that the Danish electronics cluster looks positively upon its options for accessing relevant human resources while companies in the Copenhagen life science cluster adopt a rather negative view. That shows that the cluster specific framework conditions for innovation can differ significantly within the same region.

Chapter IV

Test at the company level

Difference between analyses at cluster and company levels

When data is used at cluster and regional levels, it is investigated whether the typical life science enterprise in a particular cluster is more successful than the typical life science enterprise in another cluster. Or whether the typical enterprise perceives the cluster specific framework conditions in its own cluster as being better than the conditions offered to the typical enterprise in another cluster.

These are average considerations, the intention being to rank clusters according to their performance and framework conditions, to test for links, and to find a basis and inspiration for fact based cluster policy.

The drawback with average surveys, of course, is that a large volume of data and many clusters and regions are required in order to do statistical testing.

To some extent, the problem can be overcome by basing analysis on enterprise data, and – as will be seen below – enterprise data can be used to test interesting hypotheses on the importance of cluster formation.

Enterprise data will be used below to investigate whether the most innovative life science enterprises in the BSR are also the most productive. It will also be investigated whether the most productive enterprises also take the most positive view of the framework conditions and whether the most productive enterprises tend to co operate more than less productive enterprises.

More than 600 enterprises in the six largest life science clusters in the BSR took part in the survey of innovation and framework conditions, and at the same time the survey had access to accounting data relating to the financial results of the same enterprises.

Do the most innovative companies produce the best financial results?

An attempt has been made to answer the question of a link between innovation and financial results by comparing the productivity of enterprises with survey data relating to the extent of enterprise innovation.

In company accounts enterprises report their overall financial result – but the accounts provide no direct information on any financial profit the enterprise may have made from innovation. But it is in fact possible – by making certain assumptions – to compute the financial result that enterprises have obtained from innovation: the so called multi factor productivity, cf. box 4.1.

Box 4.1 Calculating companies' multi factor productivity

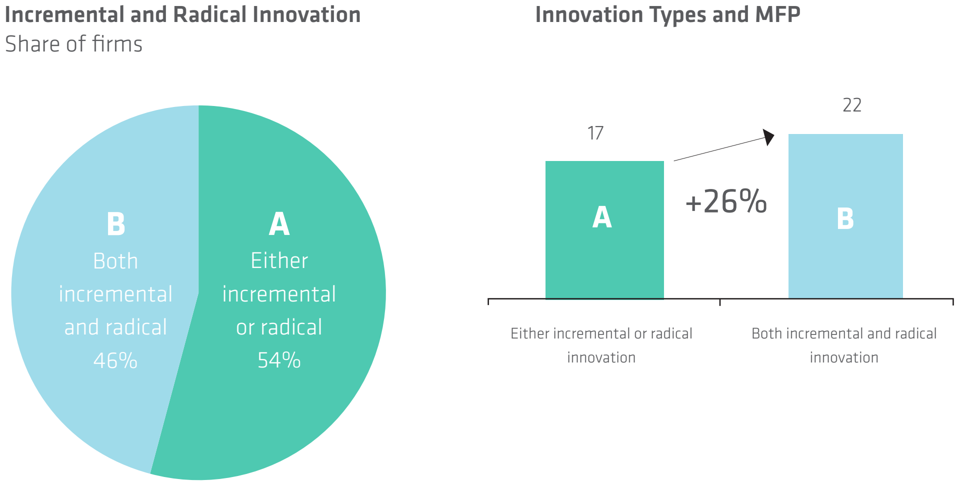
Expressed in simple terms, companies arrive at a financial result by using labour and capital. Two enterprises using the same amount of labour and capital do not necessarily achieve the same financial result. The most innovative enterprise achieves the best result and the highest productivity. The portion of productivity lying outside the investment of capital and labour is called multi factor productivity (MFP), and it is assumed that the main contribution to MFP comes from innovation.

Multi factor productivity is not something you can read directly in a company's accounts. It has to be estimated. With accounting data obtained from enterprises it is possible to estimate their multi factor productivity by means of a Cobb Douglas production function, cf. appendix 9. The calculation assumes that enterprises have the same average return from their labour and capital, and that any return beyond that (MFP) can be attributed to innovation.

When company responses on the extent of innovation are compared with multi factor productivity, a clear link emerges – 46% of enterprises are engaged in both incremental and radical innovation, and these enterprises have on average 26% higher multi factor productivity than other enterprises, cf. fig. 4.1.

Fig. 4.1

Innovative companies have a higher productivity level (MFP)



Source BSR Life Science Survey and Copenhagen Economics Performance Estimations

The analysis of enterprise data thus supports the analysis of cluster data in the previous chapter, where the assumption was made that the most innovative enterprises also enjoyed the best financial results.

Link between performance and framework conditions

An investigation was made into whether the most innovative enterprises also have the best perception of cluster specific framework conditions. The investigation examined the framework conditions as a whole and each of the five identified policy areas individually: human resources, new knowledge, entrepreneurial activity, regulation and public demand, and co operation among enterprises.

The result shows a positive and statistically significant link, apart from the link between innovation and regulation, but although the link is statistically significant, it is very weak, cf. table 4.1.

Table 4.1 Estimation of link between performance and framework conditions

Model	Sign	Significance	R^2
a) Innovation = α Overall framework conditions +ε	Positive	Yes	0.017
b) Innovation = α HR +ε	Positive	Yes	0.019
c) Innovation = α Entrepreneurship + ε	Positive	Yes	0.011
d) Innovation = α Knowledge + ε	Positive	Yes	0.011
e) Innovation = α Regulation + ε	Negative	No	0.001
f) Innovation = α HR + β Knowledge + δ Entrepreneurship + θ Regulation + ε	HR: Positive Knowledge: Positive Entrepreneurship: Positive Regulation: Negative	HR: Yes Knowledge: No Entrepreneurship : Yes Regulation: No	0.037

Investigating enterprise data therefore cannot verify the hypothesis of a key link between performance and cluster specific framework conditions. But conversely the hypothesis cannot be disproved because of a very small variation in companies' perception of cluster specific framework conditions.

Certainly within each cluster there is a clear variation in companies' assessments of the framework conditions but between clusters the assessment of the framework conditions is fairly uniform – as the previous chapter showed. The conclusion here was that on average figures for framework conditions no clear ranking of the six regions was discernible – only a division into two groups, and even between these two groups the difference in perception of the framework conditions was small. It is therefore hardly surprising that the same result is obtained on the basis of enterprise data.

There is no way of telling whether the small variation in responses is an indication that the cluster specific framework conditions are in fact fairly uniform in the six life science clusters in the BSR or is due to weaknesses in the survey data. Appendix 9 discusses this problem in more detail. As emphasised in the previous chapter, it would have strengthened the survey if some of the indicators for cluster specific framework conditions had been based on register data.

The survey would also have benefited from having data from countries which are more mutually different than is the case with the Nordic countries and northern Germany.

On the available information we simply have to accept that the theory of a direct link between performance and cluster specific framework conditions can neither be confirmed nor disproved on the basis of the enterprise data collected in the survey.

As stated, there is a clear variation in data within each of the six clusters. That is true of both data on innovation and survey data for companies' assessment of framework conditions – which makes it possible to test interesting hypotheses on the importance of cluster formation. The results of this are presented below.

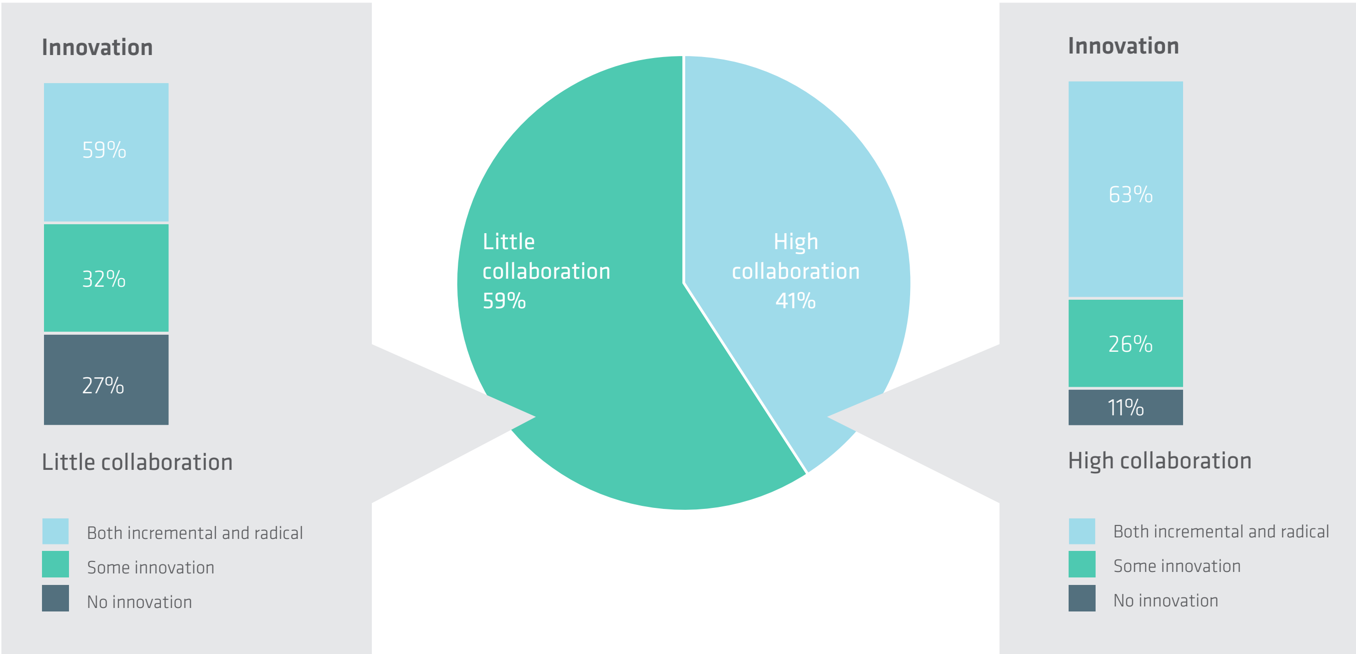
Link between performance and co operation

The project investigated whether the most innovative enterprises are those that collaborate most. And they are. In terms of research and innovation, 16% of enterprises said that they have a high degree of co operation and 25% responded that they have some degree of co operation. Thus a total of 41% of enterprises can be said to collaborate in the fields of research and innovation. Of those enterprises that collaborate, 63% are engaged in both incremental and radical innovation while this applies to only 41% of enterprises which do not collaborate, cf. fig. 4.2.

Fig. 4.2

Firms that innovate also collaborate more

Collaboration
Has your company collaborated on innovation and research activities with other life science companies in the region during the past few years?



Note Little collaboration is defined as collaboration to a low or a lesser degree. High collaboration is defined as collaboration to some or to a high degree.

Data clearly shows that the most innovative enterprises are more likely to co operate on innovation and research with other members of the cluster than enterprises which are less innovative. This is also confirmed by a detailed analysis of companies' collaboration (see below). Although it is not possible from the figures alone to determine the causal relationship, only the relationship between innovation and collaboration, it would be natural to suppose that collaboration led to innovation – not the other way around. Why should innovative and successful enterprises enter into co operation with other enterprises, if it did not lead to greater innovation and increased return on investment?

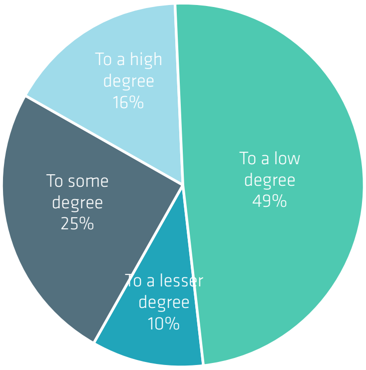
Of course, this does not mean that individual companies cannot practise innovation successfully without collaborating with other enterprises. Cluster based collaboration is not essential to innovation but enterprise data does show that it will usually improve innovation – across the many types of life science enterprises and regions covered by the survey.

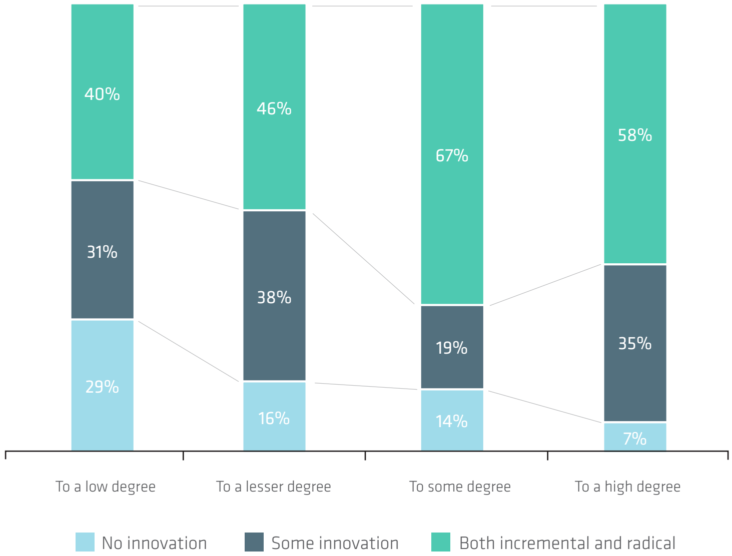
Of the 16% of enterprises in the survey which co operate to a high degree on innovation, 58% engage actively in both incremental and radical innovation. Of the 25% of enterprises which co operate to some degree on innovation, 67% engage actively in both incremental and radical innovation. Of those enterprises which to a lesser or low degree collaborate on innovation, 46% and 40% respectively are actively engaged in both incremental and radical innovation, cf. fig. 4.3.

Fig. 4.3

Detailed account of link between innovation and collaboration

Collaboration and Innovation
Has your company collaborated on innovation and research activities with other life science companies in the region during the past few years?





Enterprise data gives a clear indication that there is a close link between collaboration on research and innovation and the extent of innovation. Innovative enterprises appear to a greater degree than other enterprises to draw upon resources available within the cluster through specific forms of collaboration on innovation and development.

Companies which collaborate express a more positive assessment of the framework conditions

As noted earlier, at the cluster level no crucial link was observed between cluster performance and cluster specific framework conditions. An investigation based on enterprise data was conducted to discover whether companies which collaborate with each other take a more positive view of framework conditions than companies which do not collaborate.

Companies were asked about collaboration in a number of fields but with regard to areas of relevance to cluster specific framework conditions they were asked:

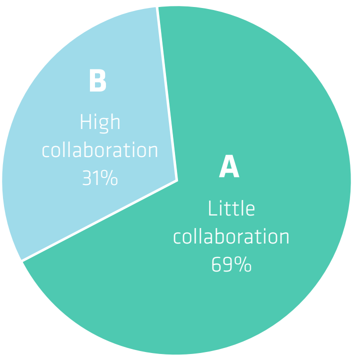
- Has the company within the past year collaborated on innovation and research activities with other life science companies in the region?
- Has the company in collaboration with other life science companies in the region participated in efforts to attract workers, including knowledge and foreign workers?
- Has the company, in co operation with other life science companies in the region, helped with the development of the entrepreneurial environment?

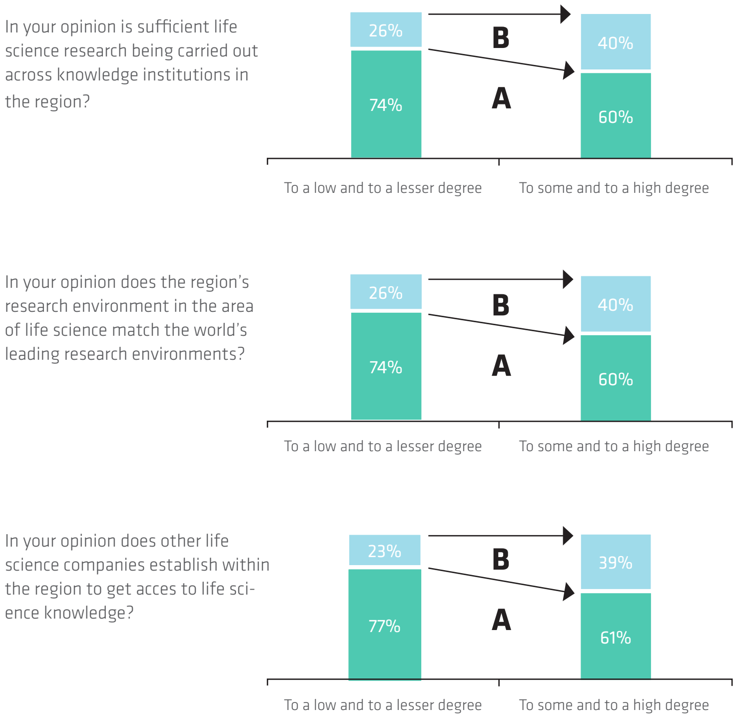
Enterprises which to some degree or to a high degree collaborate on research and innovation have a more favourable perception of the cluster specific framework conditions for knowledge building than other enterprises. Forty percent of enterprises which to some or to a high degree collaborate on research and innovation respond that a large volume of relevant high quality research is conducted at the region's knowledge institutions; this assessment is shared by 26% of enterprises which to a lesser or low degree collaborate on research and innovation. Thirty nine percent of those enterprises that collaborate hold the view that foreign companies set up business in their region in order to access unique knowledge, while 23% of enterprises which collaborate only to a lesser or low degree share that view, cf. fig. 4.4.

Fig. 4.4

Link between collaboration on research and innovation and the framework conditions for new knowledge

Collaboration
Has your company collaborated on innovation and research activities with other life science companies in the region during the past few years?





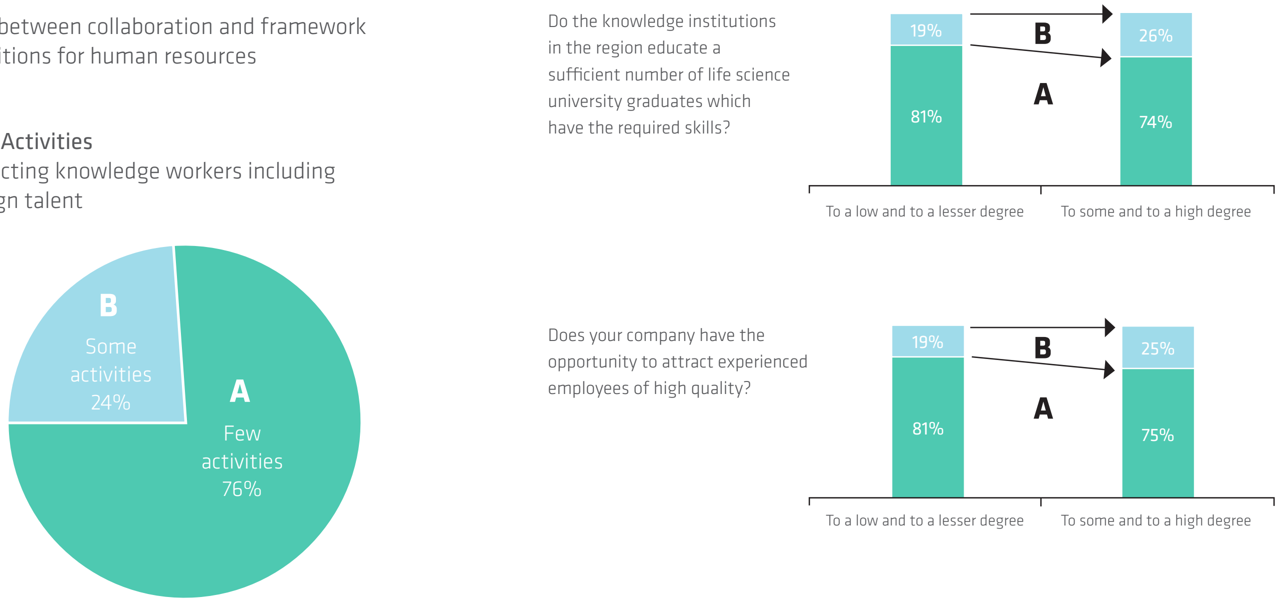
Note The columns show the distribution according to the extent that companies collaborate. Every column is stacked according to their assessment of the given indicator for cluster-specific framework conditions for new knowledge. Little collaboration is defined as collaboration to a low or a lesser degree. High collaboration is defined as collaboration to some or to a high degree.

Enterprises which collaborate on attracting knowledge workers to their region have a more positive perception of the cluster specific framework conditions for human resources – although the difference is less pronounced. One in four enterprises which collaborate on attracting workers consider the output of graduates in the region to be adequate and the conditions for attracting workers with specialists knowledge good. Among enterprises which only to a lesser or low degree collaborate on attracting workers, one in five share the same perception, cf. 4.5.

Fig. 4.5

Link between collaboration and framework conditions for human resources

Joint Activities
Attracting knowledge workers including foreign talent



Note The columns show the distribution according to the extent that companies have joint activities. Every column is stacked according to their assessment of the given indicator for cluster-specific framework conditions for human resources. Few activities are defined as activities to a low degree. Some activities are defined as activities to a lesser, some or a high degree.

A test was also conducted to discover whether enterprises which collaborate on developing the entrepreneurial environment have a more positive perception of entrepreneurial activity – but this was not the case.

In Summary

It is not an easy task interpreting the results with a view to establishing whether a link exists between collaboration and the perception of cluster specific framework conditions.

There is within each cluster a marked difference in companies' perception of the framework conditions. Some enterprises consider the framework conditions very weak, while others find the same framework conditions very good. That may be, of course, because companies actually do have a completely different perception of the same conditions. But it may also be because companies are different, and the significance of framework conditions is assessed differently.

Some enterprises may perhaps be unable – or able only with difficulty – to find the right workers and the relevant knowledge within the cluster, while other enterprises – perhaps in an entirely different segment of the life sciences – find it easier to procure good workers and relevant, high quality knowledge within the same cluster.

It is tempting to interpret the results as showing that enterprises which have a positive perception of the framework conditions are also the enterprises that get most out of collaboration.

If that is the case, one could say that the survey shows that for some enterprises both collaboration and the framework conditions for human resources and knowledge building are important to their financial result.

Chapter V

Developing a fact-based cluster policy

The aim of this study has been to test a model for fact based cluster policy by showing a direct link between cluster specific framework conditions and companies' economic performance. The model has been tested on data for the six largest life science clusters in the Baltic Sea Region (BSR), and analyses were conducted at cluster and regional level and at enterprise level.

The assessment is that analyses illustrate a link between cluster specific framework conditions and companies' innovation and productivity level.

Based on cluster and regional data, the six clusters can be divided into two groups, and the best performing group enjoys rather better framework conditions than the group performing less well. Lack of data prevents statistical testing at cluster level.

Based on enterprise data, a statistical significance can be shown between innovation and productivity, and there is evidence that companies which collaborate with other companies are more innovative and have a more positive perception of the framework conditions than non collaborating companies. If the framework conditions are improved, enterprises will collaborate more and become more innovative. Whether the direct correlation between framework conditions and performance is close cannot be demonstrated or disproved on the basis of enterprise data.

The model used to test the link between performance and cluster specific framework conditions cannot be used directly to define a fact based cluster policy – but the model can be used to focus and prioritise those processes that lead to a fact based cluster policy.

Clearly, there is more than one way to conduct an evidence based cluster policy. In the following, a procedure will be presented based upon international benchmarking, with examples drawn from the life science cluster in Greater Copenhagen.

In examining the principles of a fact based cluster policy, three key questions arise:

- How successful is the Greater Copenhagen life science cluster compared with leading life science clusters elsewhere in the world?
- In which life science clusters do we find the prime competitors of Greater Copenhagen life science enterprises?
- How do the framework conditions available to competitors compare with the framework conditions available to the Greater Copenhagen life science cluster?

How successful is the Greater Copenhagen life science cluster compared with leading life science clusters elsewhere in the world?

Identifying the world's leading life science clusters is obviously a challenging task. The first step is to determine the parameters on which to select the world's leading clusters, the second is to establish comparative data.

The European Cluster Observatory has data only for employment and only for EU and EFTA countries and Turkey, and it is not possible to obtain more detailed data for subclusters. The European Cluster Observatory can be seen as a starting point in generating good cluster data but in its existing form it does not lend itself as a basis for fact based cluster policy. As a minimum requirement there should be access to data on employment and real wages, and there should be data from non EU countries.

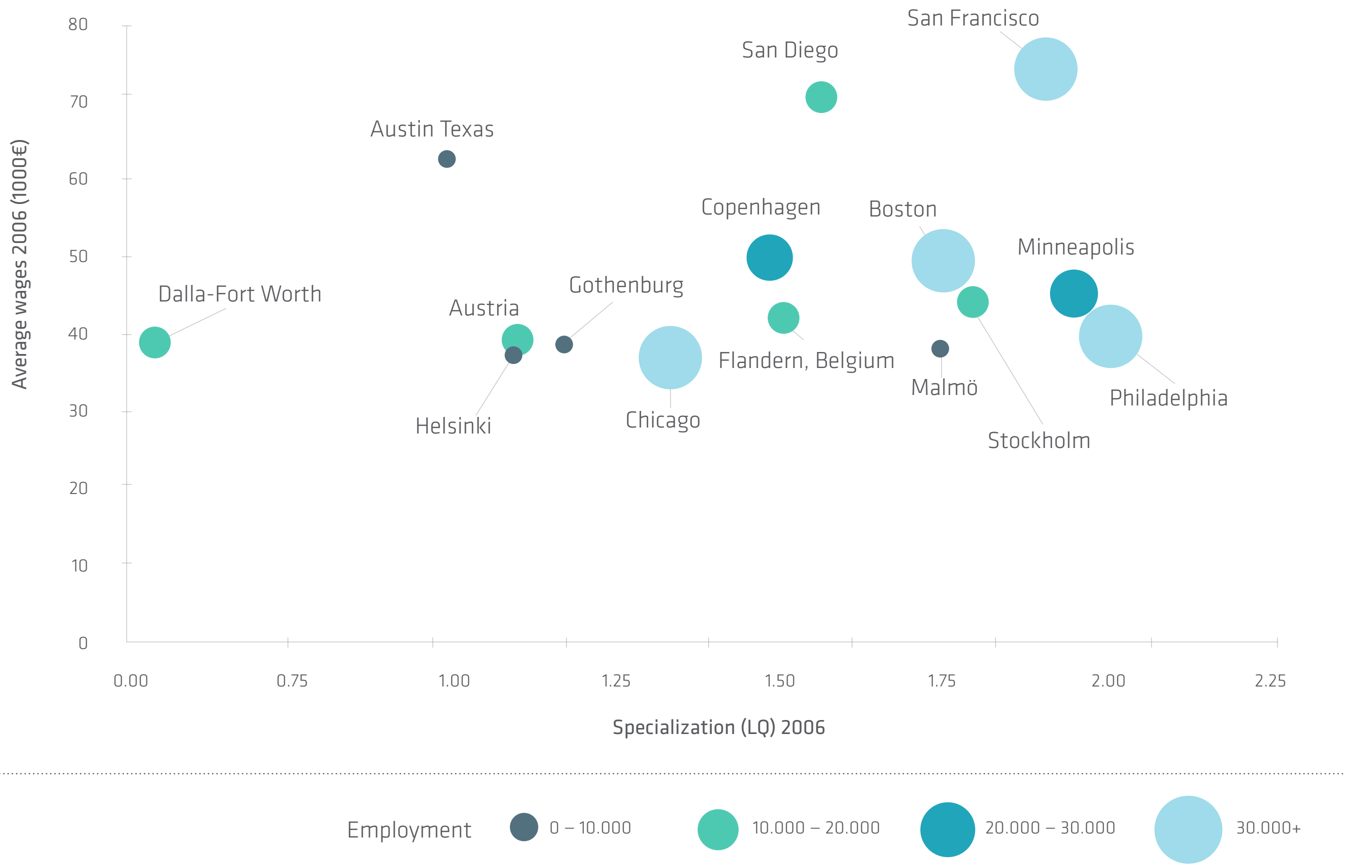
For the purposes of this study it was possible to access the database Monitor Global Cluster Mapping Dataset[29]. This is not fully processed data material, presenting a picture of the world's leading life science clusters; it is purely a comparison of selected life science clusters in the United States and the five main Nordic life science clusters. It is therefore only an illustration of the benchmark idea.

[29] See www.compete.monitor.com

The leading American life science clusters are significantly larger than their Nordic counterparts, cf. fig. 5.1.

Fig. 5.1

Employment and average remuneration in selected life science clusters in the United States and Europe



Note The reference region for calculating specialisation (LQ) is industrialised countries. Swedish data for average salaries is for 2005. The American regions are defined in accordance with the US Census Bureau's record of economic regions. Due to a lack of remuneration data for the biopharmaceutical cluster in Austin, Philadelphia, Boston and San Francisco, average salaries for the life sciences in these regions have been calculated only on the basis of the medico cluster. On account of a lack of remuneration data for the medico cluster in Dallas, average salary for the life sciences in Dallas were calculated only on the basis of the biopharmaceutical cluster.

Source Monitor Global Cluster Mapping Dataset, 2009

For reasons of data availability, the figures for real wages are not fully comparable, cf. note accompanying the table. The following should therefore be considered more as an illustration of a mindset than as an undisputed comparison of clusters' productivity level.

In terms of real wage statistics, the two most productive life science clusters in the US appear to be the two clusters in California – San Francisco and San Diego – but the relatively small life science cluster in Austin, Texas, would also seem to have high productivity/real wages.

The life science clusters in San Diego and Austin have arisen over the past 20 years and have specialised in biotechnology. The San Francisco cluster, too, has a significant sub cluster devoted to biotechnology.

Average real wages in the three clusters are 30 50% higher than average real wages in American life science clusters generally.

Broadly speaking, real wage levels in Nordic life science clusters are on a par with the American average.

If one were to identify the leading life science clusters in the United States on the basis of the information summarised in fig. 5.1, they are likely to be: San Francisco, Boston, Philadelphia and San Diego.

The Greater Copenhagen life science cluster is rather smaller than their influential American cousins – but if it is combined with the adjacent life science cluster in Malmö-Lund, it may be argued that there is a Nordic life science cluster which can measure itself with leading US life science clusters. Real wage levels in the Copenhagen life science cluster are on a par with average levels in the US but are 50% below the leading life science cluster in San Francisco.

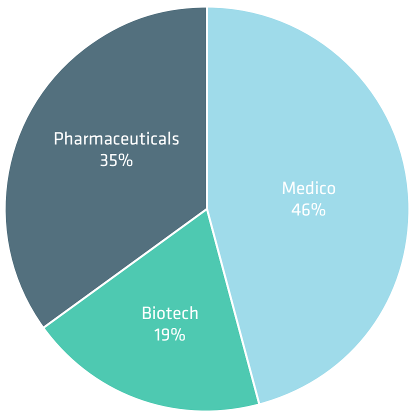
Who should the Greater Copenhagen life science cluster compare with?

Every business cluster, of course, is interested in comparing itself with the best – but if it is to be politically relevant, it should also compare itself with the clusters in which its direct competitors are located.

The Greater Copenhagen life science cluster is known for having a critical mass in all three subclusters: manufacture of pharmaceuticals, biotechnology and medical devices, cf. fig. 5.2.

Fig. 5.2

Employment percentages in terms of subclusters in the life sciences in Greater Copenhagen



Note The breakdown into subclusters is based on the survey under review. The survey did not embrace all companies in the clusters and is therefore subject to a degree of uncertainty. The life science cluster in Copenhagen employs 22,000 people but the figure is based on responses from companies employing a total of 16,500 people.

When conducting international benchmarks in the area of biotech Greater Copenhagen is among the leading locations in Europe. In terms of employment and the number of products in the pipeline Greater Copenhagen is at the top of the ranking[30]. However, a recent study comparing the Danish biotech cluster against those of Cambridge (UK), Boston and Stockholm/Uppsala points to a range of challenges to the continued development of the cluster; challenges that have to be solved for the cluster to retain a prominent spot in an international perspective.[31]

Generally speaking, it is natural to compare the Copenhagen life science cluster with clusters which are also strongly positioned in all three fields – pharmaceuticals, biotech and medical devices – whereas other clusters which, for example, specialise heavily in biotechnology or medical devices should choose other peers.

Furthermore, the Greater Copenhagen life science cluster has specialised in fairly specific medical devices and is only to a small extent represented in non prescription drugs and cosmetic products, which virtually dominate some life science clusters, cf. chapter 2. Some of the world's biggest clusters engage in large scale production of non prescription drugs and cosmetics, which would not be a relevant basis for comparison for the Greater Copenhagen life science cluster.

In order to select relevant peers it is necessary to supplement an analysis of subclusters with a study of the direct competitors of the enterprises concerned. In which clusters does one find the companies with which the Greater Copenhagen life science enterprises primarily compete? Enterprises are naturally well aware of their immediate competitors; it would therefore be necessary to involve enterprises in identifying relevant peers for the purpose of a cluster comparison.

[30] See e.g. Ernest & Young, Biotech in Denmark, 2008 and Critical I, Biotechnology in Europe: 2006 Comparative study, 2006.

[31] IRIS Group, Vejen til en stærk biotekklynge i Hovedstadsregionen – en analyse af rammebetingelser i internationalt førende biotekregioner, 2009.

How are the framework conditions in peer clusters?

Data on cluster specific framework conditions is not readily available. Register data exists which can be carefully processed to produce useful information on cluster specific framework conditions, e.g. statistics on production of graduates in the life sciences and the region's investment in life science knowledge. But it is probably necessary to collect data via surveys to obtain a full picture of cluster specific framework conditions.

Constructing cluster specific data from available but horizontal register data is resource intensive. And it is resource intensive collecting data from surveys. And if data is to be collected from a number of foreign based peers, the work will require even more resources.

If data has already been collected to describe one's own cluster's framework conditions, and a picture has been formed of the areas in which framework conditions appear to be strong/weak, it can perhaps provide a basis for prioritising policy areas in which it could be specially interesting to know the framework conditions available within the clusters of peers.

Peer Reviews

Identifying peer clusters which are enjoying success and housing many competing enterprises – and defining framework conditions in peer clusters – can provide an evidence based footing on which to build a strategic cluster policy. Where should framework conditions be improved in order to be on a par with the framework conditions of one's best competitors?

[32] Danish entrepreneurial policy for the past several years has been based in part on international benchmarks and comprehensive peer reviews, cf. Entrepreneurship Index, 2005 – 2008, www.ebst.dk/ebst2/ebst2opd.xsql?emne=ivaerksaetter&produkt=ebst2&tekst_id=0&show=7&num=0&str=

It is possible that comparisons can reveal that very little investment is made in specific areas of knowledge. It may be that a lack of entrepreneurial activity impedes rivalry and dynamism or it may be that collaboration on research and innovation is less pronounced than in the best clusters. It may also be a factor that public regulation and public sector demand play a smaller role in cluster innovation than they do in the best clusters.

But identifying weaknesses in the cluster specific framework conditions does not explain whether and where framework conditions should be improved. It is by no means certain that an effort should be made at all cost and in all areas to create the best possible framework conditions. It may make sense to prioritise, and only in certain selected areas to create unique, world class framework conditions. Peer comparison cannot answer that – although peer comparison can help create a fact based foundation for prioritising.

Nor does identifying weaknesses in cluster specific framework conditions explain what should be done to improve the framework conditions.

It may be possible to conduct a peer review, a very detailed investigation of what brought about a particularly favourable set of framework conditions in specific clusters. Not in order unquestioningly to copy the cluster policies of the best clusters because it is not certain that what was correct and wise policy in one region would also work in other regions. But experience shows that healthy inspiration can be drawn from peer reviews and that good experience from other countries can help to expand the political horizon[32].

Selecting peers also makes it possible to draw up quantitative goals for a cluster's development – and provides a measure against which to determine whether the policy is working and the goals have been achieved.

Appendices

Appendix 1

Definition of life science clusters and regions in the BSR

The life science cluster is comprised of two sub-clusters; pharmaceuticals and medical device, which is defined in further detail below. The two sub-clusters are defined based on industry statistics (NACE rev. 1.1).

Pharmaceuticals cover the following industries:

- Manufacture of basic pharmaceutical products (24.41)
- Manufacture of pharmaceutical preparations (24.42)

Medical devices cover the following industries:

- Manufacturing of medical and surgical equipment and orthopaedic appliences (33.10)
- Manufacture of invalid carriages (35.43)

The BSR is divided into 31 regions. The regions are divided based on Eurostat's classification of region used to carry out regional statistics. The regions are at NUTS II-level, which implies that the region has a population in the range from 800 000 to 3 million. The NUTS II regions Stockholm and Östra Mellansverige have been merged into one for the purpose of this study since life science in Stockholm and Uppsala is perceived as being one integrated life science cluster. The two NUTS II regions on either side of Øresund, The Capital Region of Denmark and South Sweden are increasingly working as one integrated cluster with a joint cluster organization (Medicon Valley Alliance) and an increasingly integrated labour market. However, it has been our assessment that the framework conditions in Sweden and Denmark, respectively, are still quite different and that they each should be analyzed separately. However, the five Danish NUTSII-regions are merged into two regions, which are more suitable for describing life science in Denmark, cf. Table B1.1.

Table B1.1 ATable B1.1: Region names and relevant NUTS II regions.

Region's name in Danish	Region's name in English	Official Region Name, Eurostat NUTSII	Eurostat, NUTSII code
København	Copenhagen	Hovedstaden + Sjælland	DK01 + DK02
Stockholm	Stockholm	Stockholm + Östra Mellansverige	SE11 + SE12
Malmø	Malmö	Sydsverige	SE22
Gøteborg	Gothenburg	Västsverige	SE23
Kiel	Kiel	Schleswig-Holstein	DEF0
Helsingfors	Helsinki	Etelä-Suomi	FI18
Oslo	Oslo	Oslo og Akershus	NO01
Rostock	Rostock	Mecklenburg-Vorpommern	DE80
Vestfinland	West Finland	Länsi-Suomi	FI19
Vestdanmark	West Denmark	Syddanmark + Midtjylland + Nordjylland	DK03 + DK04 + DK05
Hamborg	Hamburg	Hamburg	DE60
Estland	Estonia	Eesti	EE00
Østfinland	East Finland	Itä-Suomi	FI13
Nordfinland	North Finland	Pohjois-Suomi	FI1A
Åland	Åland	Åland	FI20
Island	Iceland	Island	IS
Litauen	Lithuania	Lietuva	LT00
Letland	Latvia	Latvija	LV00
Hedmark og Oppland	Hedmark and Oppland	Hedmark og Oppland	NO02
Sydøst Norge	South-East Norway	Sør-Østlandet	NO03
Agder og Rogaland	Agder and Rogaland	Agder og Rogaland	NO04
Vestnorge	West Norway	Vestlandet	NO05
Trøndelag	Troendelag	Trøndelag	NO06
Nordnorge	North Norway	Nord-Norge	NO07
Szczecin	Szczecin	Zachodniopomorskie	PL42
Olsztyn	Olsztyn	Warminsko-Mazurskie	PL62
Gdansk	Gdansk	Pomorskie	PL63
Småland med øer	Smaaland and Islands	Småland med öarna	SE21
Midtsverige	Central Sweden	Norra Mellansverige	SE31
Midt Norrland	Middle Norrland	Mellersta Norrland	SE32
Øvre Norrland	Upper Northland	Övre Norrland	SE33

Appendix 2

Designing and carrying out the survey study

This study probably marks the first attempt of systematically collecting data on cluster-specific framework conditions across several regions that may be used for benchmarking purposes. We have created a solid platform for assessing regional framework conditions; however, it has not been possible to carry out data collection as originally planned. Below we highlight some of the methodological experiences that we have learned from carrying out the survey.

Design

The purpose of the survey is to map the innovation capacity and cluster-specific framework conditions of life science clusters. This will make it possible to test for a positive correlation between cluster innovative capacity and cluster-specific framework conditions. A positive correlation will confirm that the method used in the study covers significant framework conditions conducive to a strong performance and therefore can be used as a fact-based platform for further developing these framework conditions.

To obtain the largest possible variation in innovation capacity and cluster-specific framework conditions the survey has been organized to cover life science companies in all 31 BSR regions.

To gain the best possible coverage of cluster-specific framework conditions companies, knowledge institutions and experts have been asked to assess framework conditions. The survey questions are presented in a comparable manner to each of the groups to allow for weighing together the replies and thus gain a single measure of each region's cluster specific life science framework conditions.

Questionnaire

The questionnaire comprises 83 main questions and 80 sub-questions for covering 5 innovation drivers: human resources, entrepreneurship, new knowledge, regulation and public demand and cluster collaboration. Companies were asked to rate the questions on a scale from "to a low degree" to "to a high degree", cf. questionnaire in appendix 8.

In developing the questionnaire emphasis was placed on a particular question technique, where the manner in which questions are asked remains identical – to the extent it is possible- throughout the questionnaire to allow respondents to assess and answer a question in the easiest possible manner. The core purpose of applying this technique is to lower the time spent on filling in the questionnaire.

Companies have been approached in one of two ways; via an electronic survey or via phone interviews. Experts and knowledge institutions have only been contacted via the electronic survey (see below).

Identification of companies, knowledge institutions and experts

There is no publicly available list of all life science companies, knowledge institutions and experts in the BSR. Hence, it has been necessary to use a number of sources and methods for identifying relevant companies, knowledge institutions and experts.

To identify BSR companies the following sources were used:

- The Amadeus database[33]
- The ScanBalt database[34]
- The Danish Association of Biotechnology Industries
- Medicoindustrien, Denmark
- The Danish Association of the Pharmaceutical Industry
- Copenhagen Capacity, Denmark
- VINNOVA, Sweden
- Ministry of Employment and the Economy, Finland
- Various information from the internet

Experts and knowledge institutions were identified using a snowball -approach, where experts and knowledge institutions themselves were asked to identify additional experts and knowledge institutions. The initial list of experts and knowledge institutions used to launch the snowball were put together using input from national contact points within the BSR InnoNet (WP 4 members), a number of industry organizations and the ScanBalt-database, which in addition to companies contains information on life science knowledge institutions in the BSR.

Using these sources a total of 3442 companies, 660 knowledge institutions and 169 experts were identified, cf. Table B2.1.

Table B2.1 Number of identified companies, knowledge institutions and experts in the BSR

	Companies	Knowledge Institutions	Experts
Sweden	1100	239	73
Denmark	625	56	23
Finland	553	139	20
North Germany	526	62	4
Norway	210	48	24
Estonia	127	15	4
Lithuania	127	12	13
Latvia	64	63	4
Iceland	61	17	4
North Poland	29	18	0
Total	3422	669	169

33 www.bvdep.com/en/amadeus.html

34 www.scanbalt.org

Distributing the questionnaire

In order to obtain an accurate mapping of cluster innovation capacity and cluster-specific framework conditions all of the identified companies, knowledge institutions and experts have received an electronic questionnaire.

After sending out the electronic survey and after one reminder we had received 199 replies from companies, 73 from knowledge institutions and 32 from experts. A number of countries and regions returned only a handful of questionnaires –in some cases none, cf. Table B2.2. This was far lower than expected and far from sufficient to test the analytical model. To carry out a robust analysis a high response rate is necessary.

Table B2.2 Number of replies and response rate for the electronic questionnaire

	Number of replies			Response rate		
	Companies	Knowledge institutions	Experts	Companies	Knowledge institutions	Experts
Sweden	64	31	22	6	13	17
Denmark	75	21	4	12	38	30
Finland	28	14	3	5	10	15
North Germany	4	3	0	1	5	0
Norway	17	3	3	8	6	13
Estonia	1	0	0	1	0	0
Lithuania	2	0	0	2	0	0
Latvia	2	0	0	3	0	0
Iceland	6	1	0	10	6	0
North Poland	0	0	0	0	0	0
Total	199	73	32	6	11	19

There could be several explanations to the low response rate. Life science employment is limited in some regions. With only a limited number of employees in a region's life science cluster a questionnaire on cluster-specific framework conditions may appear less relevant. Electronic questionnaires are not as effective as phone-based surveys. It may also be the case that the questionnaire simply has been too extensive. Shorter questionnaires often will carry a higher response rate compared to longer questionnaires.

To address the low response rates the questionnaire was limited to 52 questions carried out among companies via phone interviews in the 12 largest regions measured in terms of employment and the number of companies, cf. Table B2.3.

Table B2.3 The 12 regions selected for phone interviews

	Region	Share of life science employment in the BSR	Number of identified companies
1	Copenhagen	19%	438
2	Stockholm	13%	474
3	Kiel	11%	249
4	Helsinki	9%	338
5	Gothenburg	5%	147
6	Malmö	5%	219
7	Oslo	5%	108
8	West Denmark	4%	154
9	Hamburg	3%	155
10	Eastern Mid Sweden	3%	160
11	Rostock	2%	137
12	West Finland	1%	134
13	Lithuania	3%	121
14	Estonia	1%	121
15	Latvia	3%	64
16	Smaaland and Islands	1%	40
17	Upper Northland	1%	38
18	North Finland	0%	38
19	East Finland	1%	37
20	Central Sweden	0%	30
21	West Norway	0%	28
22	Middle Northland	0%	25
23	South-East Norway	1%	19
24	Troendelag	0%	16
25	Gdansk	2%	12
26	Szczecin	2%	11
27	Agder and Rogaland	1%	9
28	North Norway	0%	9
29	Hedmark and Oppland	0%	8
30	Olsztyn	1%	6

Phone interviews has increased the number of completed interviews among companies to 855, corresponding to a 31 percent response rate.[35] When distributing replies across the 12 regions we find that Gothenburg has the highest response rate and Kiel the lowest, cf. Table B2.4.

[35] We have identified 2757 companies in the 12 selected regions. Contact information was collected for 2052 of those corresponding to a response rate of 42 percent among companies that it has been possible to contact.

Table B2.4 Response rates in the 12 regions

Region	Number of replies	Response rate
Copenhagen	144	31%
Stockholm	231	34%
Kiel	46	19%
Helsinki	95	30%
Malmo	64	37%
Gothenburg	67	43%
Oslo	50	42%
West Denmark	37	22%
Hamburg	30	20%
Rostock	33	24%
West Finland	58	35%
Total	855	31%

Appendix 3 Representativity analysis

The survey study does not cover the entire population of companies in the regions. Hence, it is important to test the representativity of replies to assess if the applied data may be biased. It is possible to compare the distribution among the biopharmaceutical sub-cluster and the medico cluster in the collected sample and in the entire population. The comparison indicates that the distribution among biopharma and medico is almost identical in the sample and in the population, cf. Table B3.1.[36]

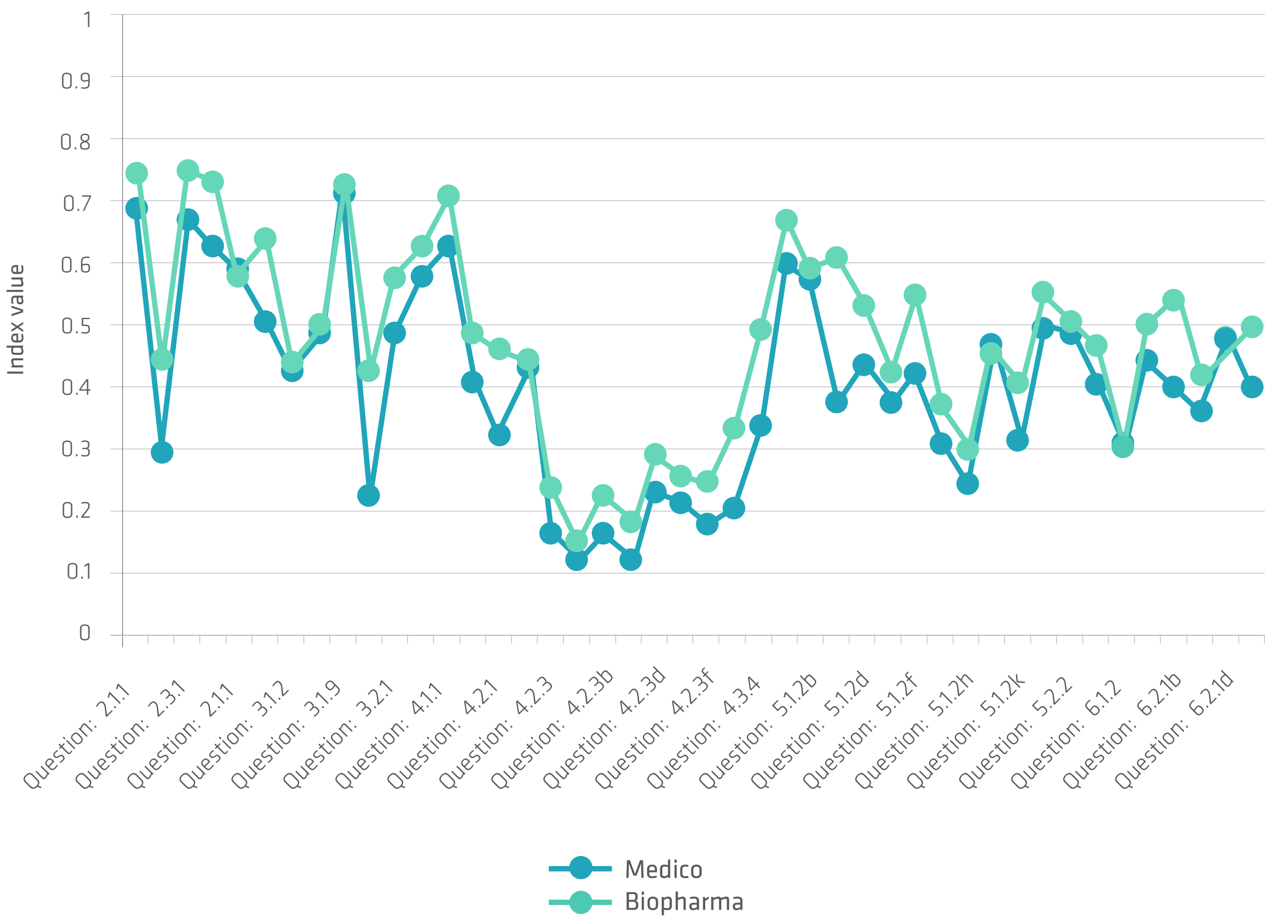
Table B3.1 Regional distribution of Biopharma and Medico companies in the survey sample and the population.

	Sample		Population	
	Biopharma	Medico	Biopharma	Medico
Copenhagen	57%	43%	75%	25%
Stockholm	57%	43%	79%	21%
Kiel	64%	36%	37%	63%
Helsinki	51%	49%	46%	54%
Malmo	40%	60%	53%	47%
Gothenburg	29%	71%	55%	45%
Oslo	77%	23%	76%	24%
West Denmark	34%	66%	20%	80%
Hamburg	70%	30%	64%	36%
Rostock	75%	25%	23%	77%
West Finland	64%	36%	45%	55%

However, there is a significant discrepancy among the two distributions for Rostock, Kiel and Gothenburg. These discrepancies may impact the study. If companies in the two sub-clusters give different replies it may cause the biased sample in Rostock, Gothenburg and Kiel to give us the wrong outcome. A comparison of replies from the biopharmaceutical cluster and the medico cluster shows that the replies are typically similar; however, biopharma offers a more positive assessment for the majority of questions asked, cf. Figure B3.1.

[36] The distribution for the entire population among bio pharma and medico is calculated using employment data from the BSR database; the distribution in the sample is based on the number of companies. This leads to some uncertainty the overall account, which altogether should be given due attention.

Fig. B3.1 Average reply in biopharma and medico



One of the questions shows a significant discrepancy between biopharma and medico; companies in the biopharmaceutical clusters dedicates a larger share of their turnover to R&D compared to other companies in the medico cluster[37].

The overall impression from this simple analysis is that the collected data is representative for the entire population. It has not been possible to test data representativity on other parameters.

[37] See question 3.1.10 in the questionnaire.

Appendix 4

Benchmarking innovation capacity and cluster specific framework conditions in five smaller life science clusters in the BSR

Fig. B4.1

The innovation capacity of life science clusters

Fig. B4.2

No. of enterprises which conduct incremental and/or radical innovation

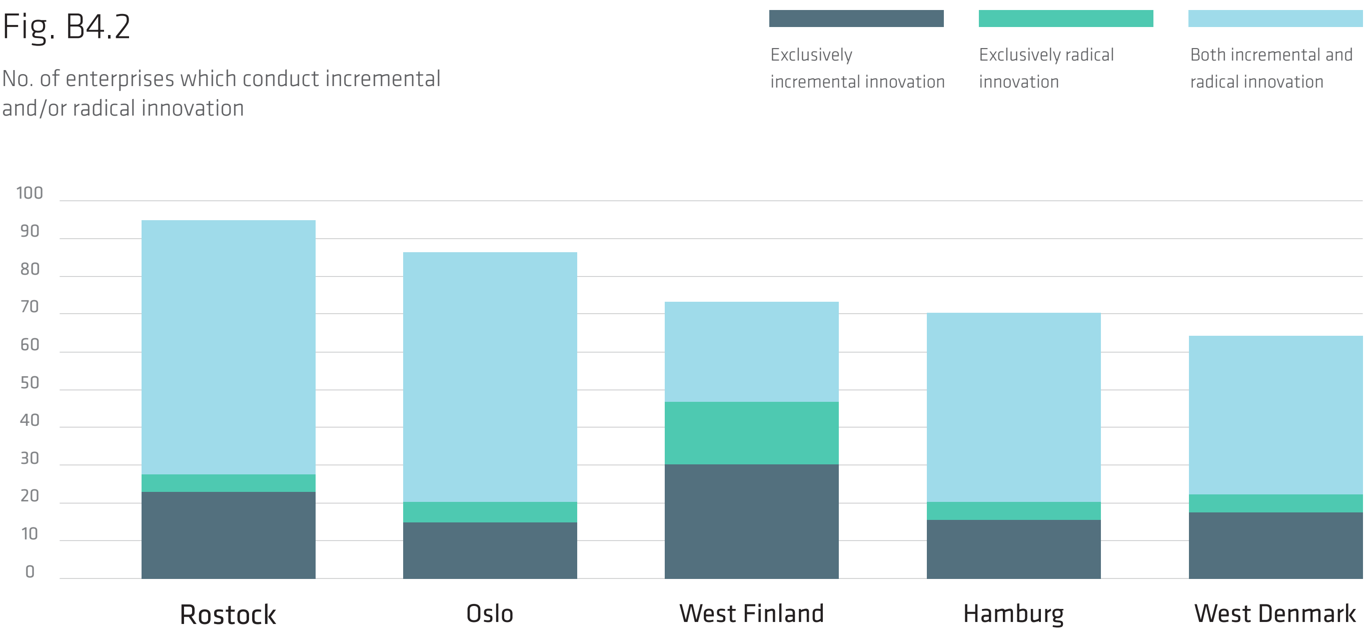


Fig. B4.3

What proportion of the company's products and services have been improved or developed in the past two years?

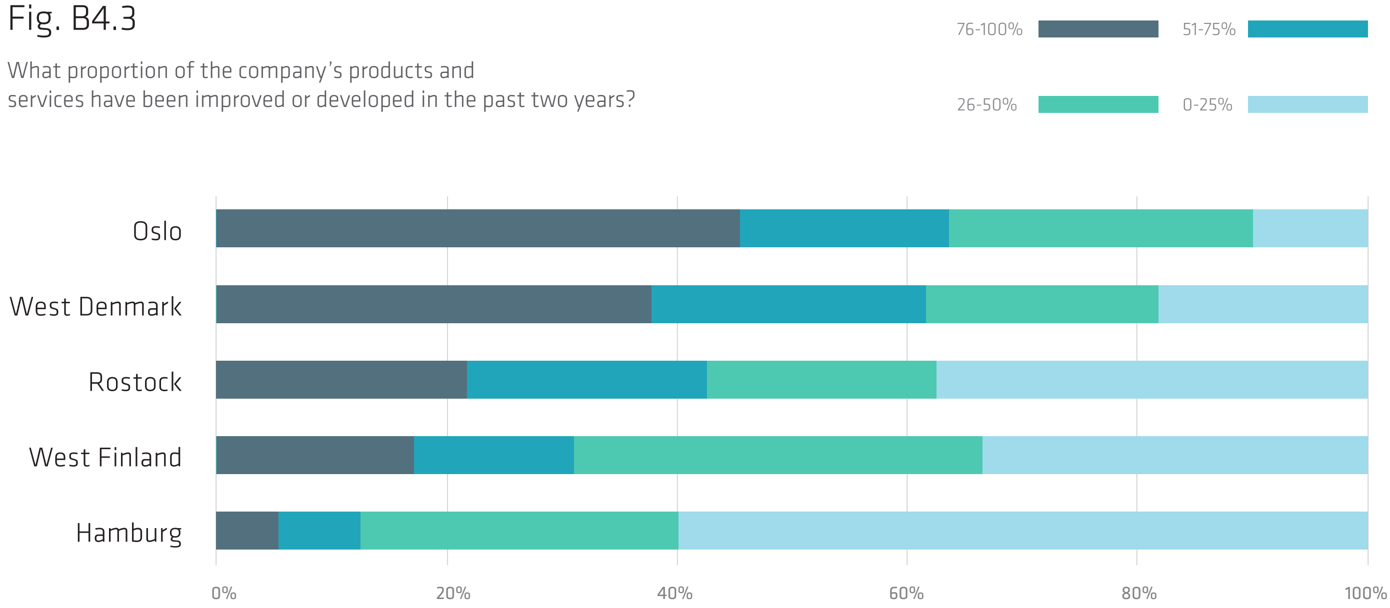


Fig. B4.4

How great a proportion of last year's sales stemmed from radical innovation completed during the previous five years?

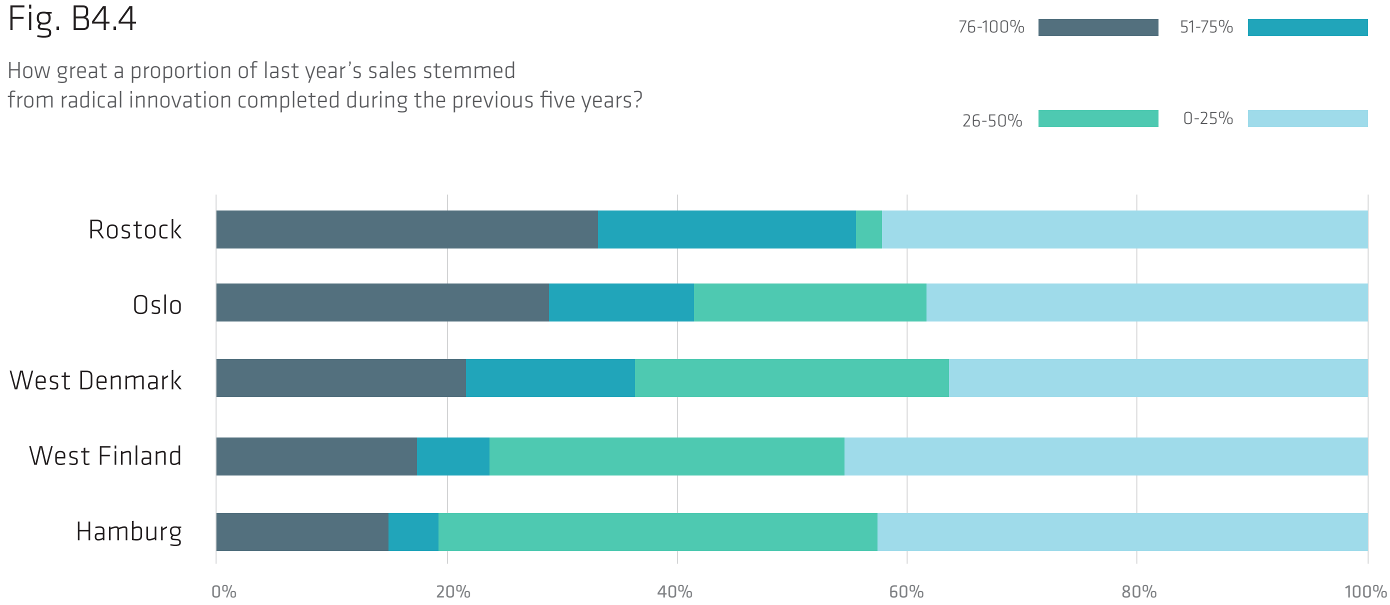


Fig. B4.5

No. of enterprises which work extensively with incremental and/or radical innovation

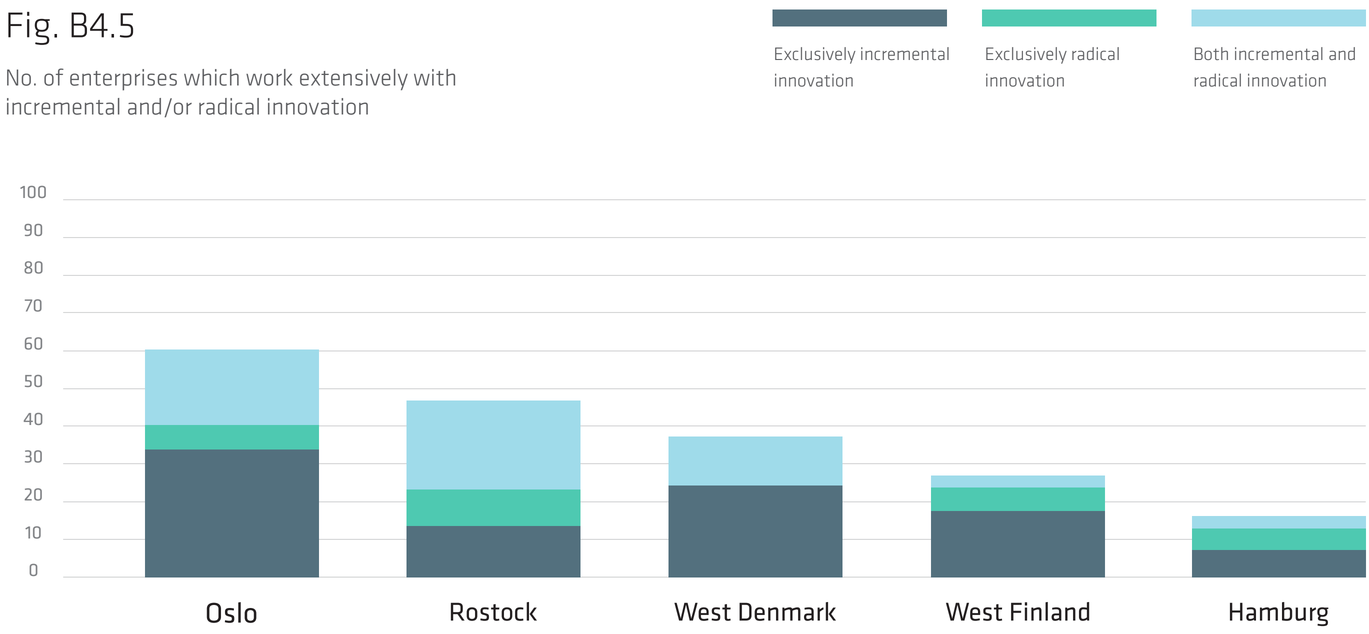


Fig. B4.6

Would you assess that identifying unrecognised user needs and/or the involvement of lead users is important to successful radical innovation?

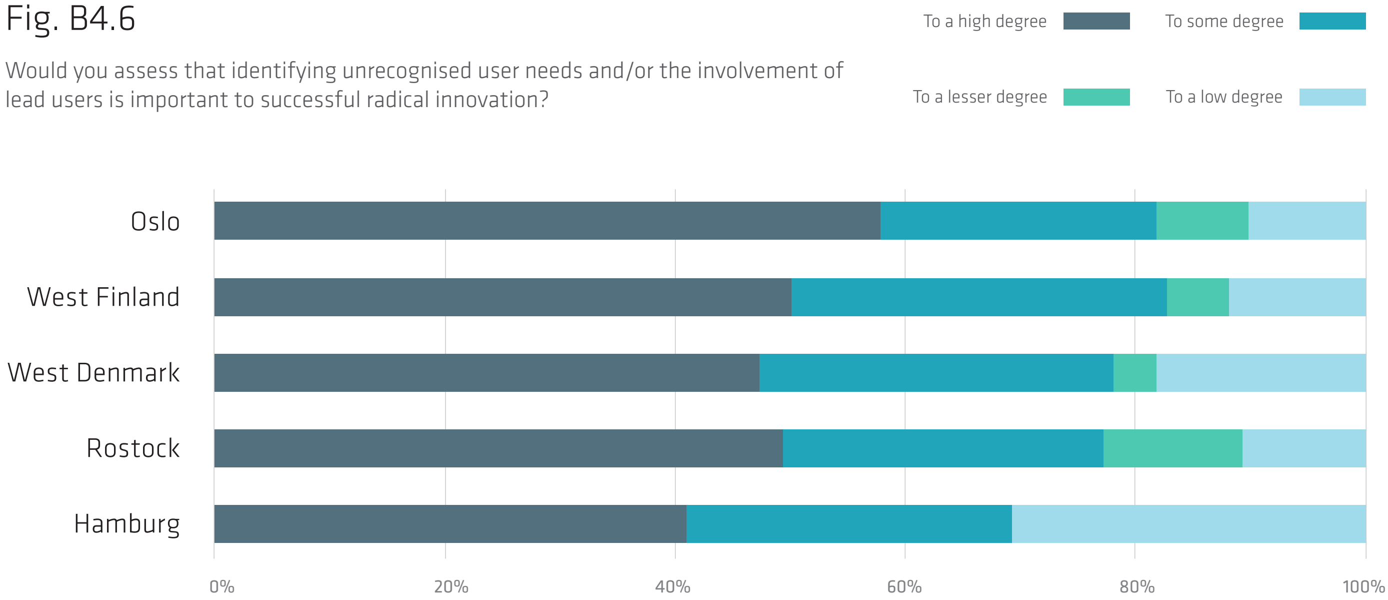
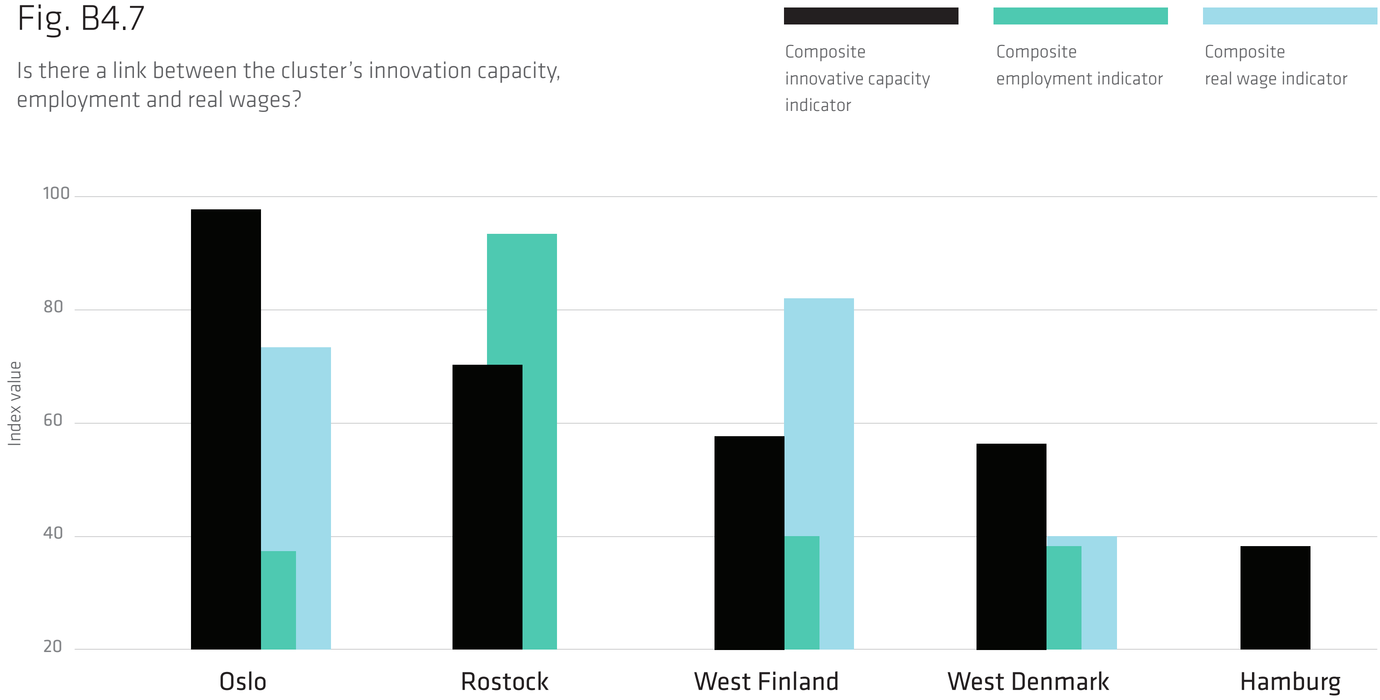


Fig. B4.7

Is there a link between the cluster's innovation capacity, employment and real wages?



Note Hamburg has the index value -61 on the composite employment indicator, which is not included in the figure. It has not been possible to collect data on real wage levels in Rostock and Hamburg. Hence, there are missing values for the composite real wage indicator for those regions.

Fig. B4.8

Robustness analysis of composite indicator for cluster specific framework conditions.

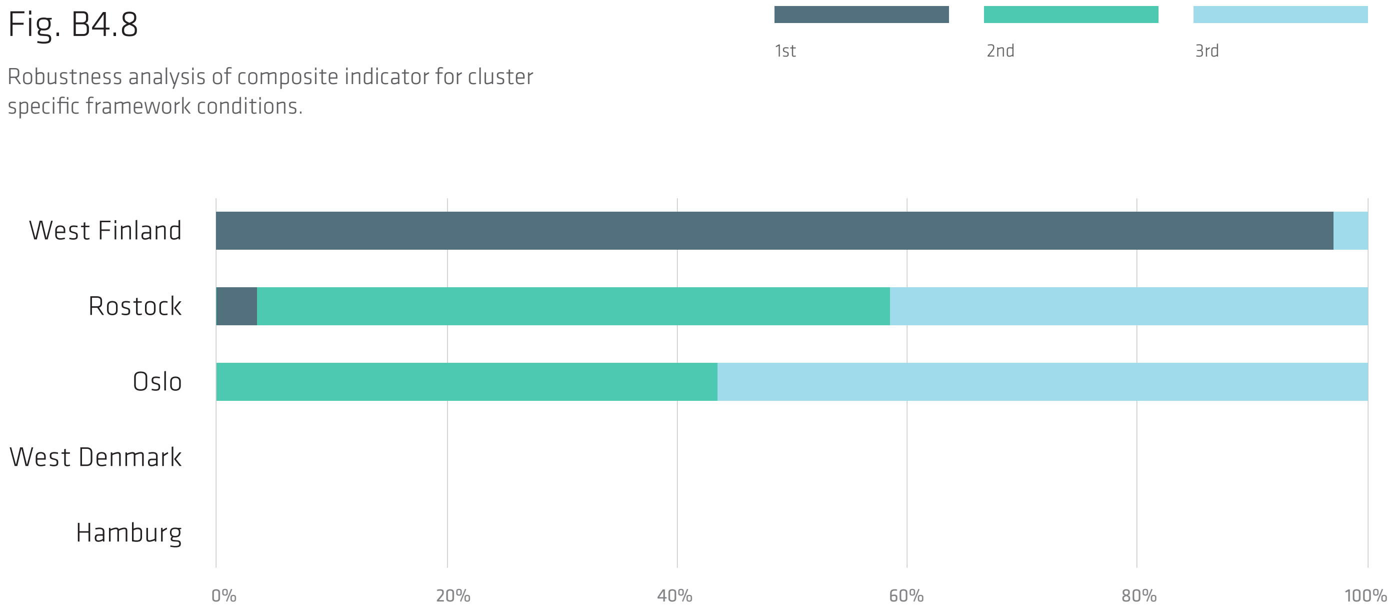


Fig. B4.9

Innovation capacity and cluster specific framework conditions for six life science clusters.

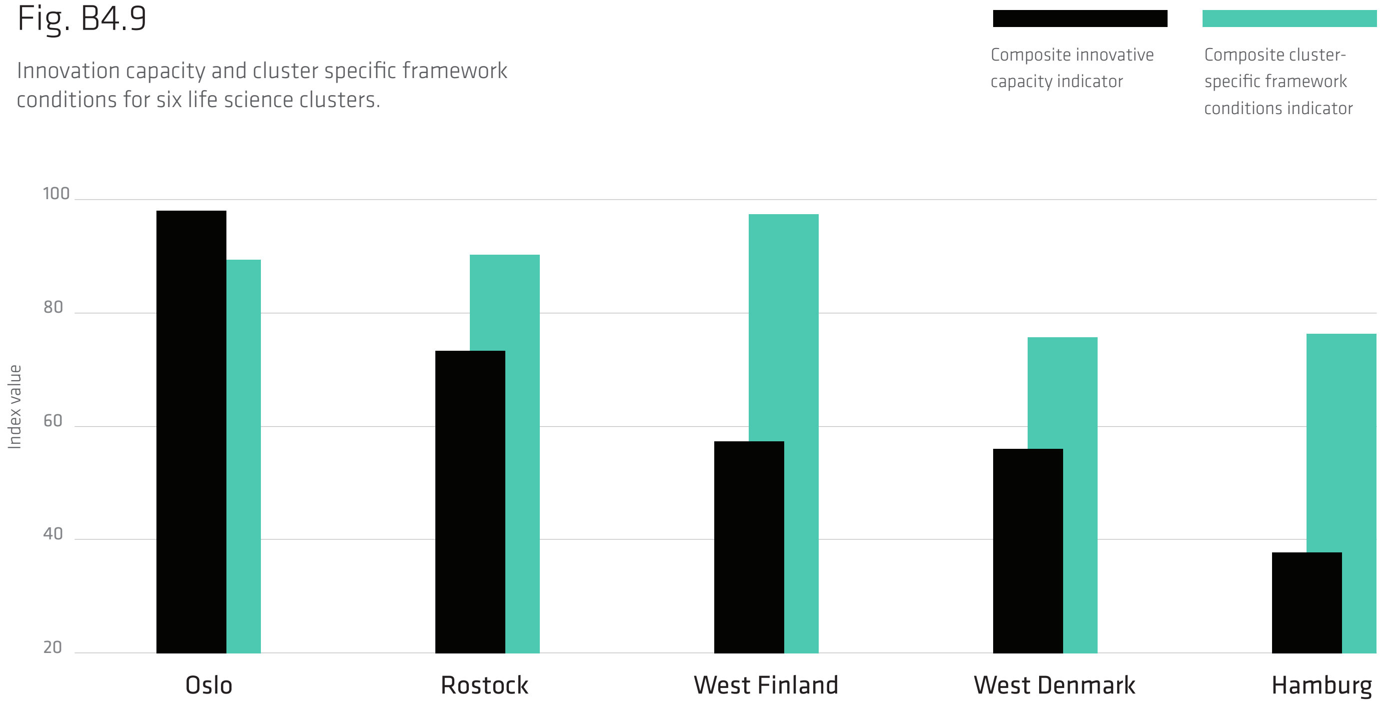


Fig. B4.10

Composite indicator for Human Resources

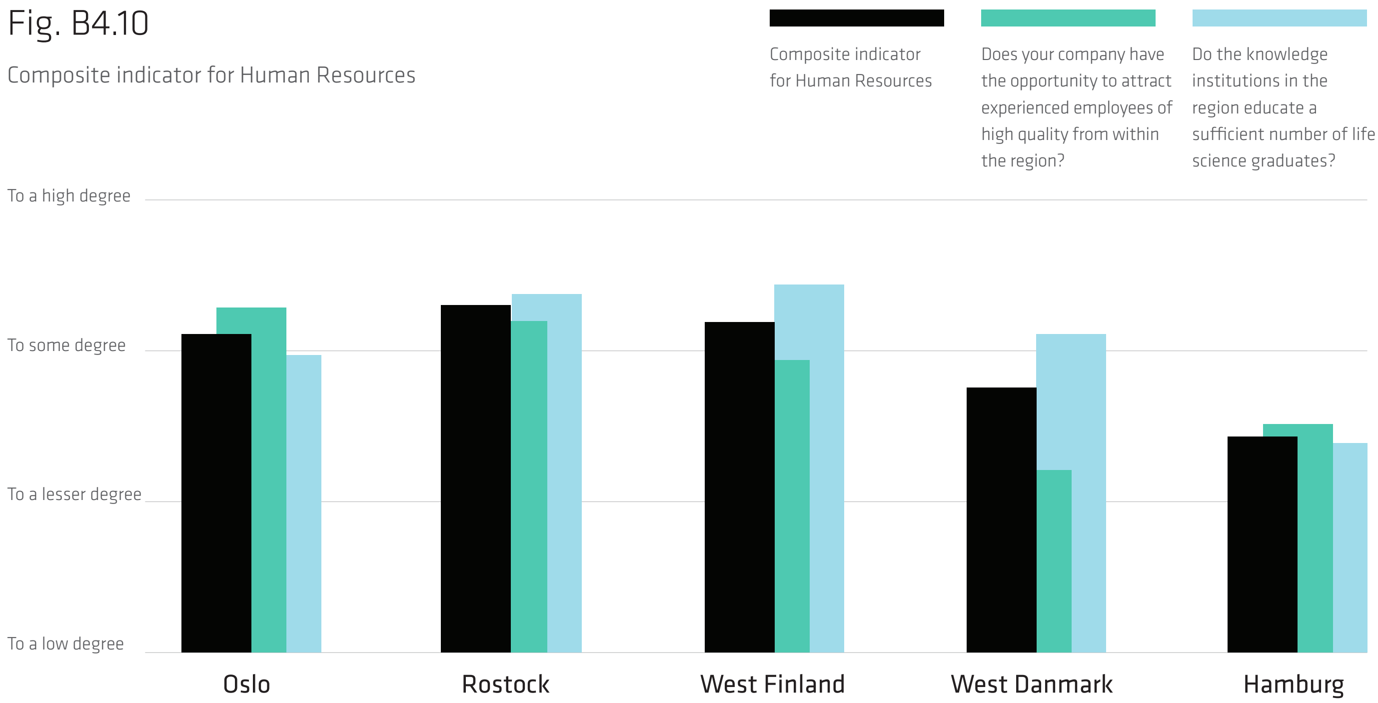


Fig. B4.11

Dialogue between enterprises and knowledge institutions concerning courses of education

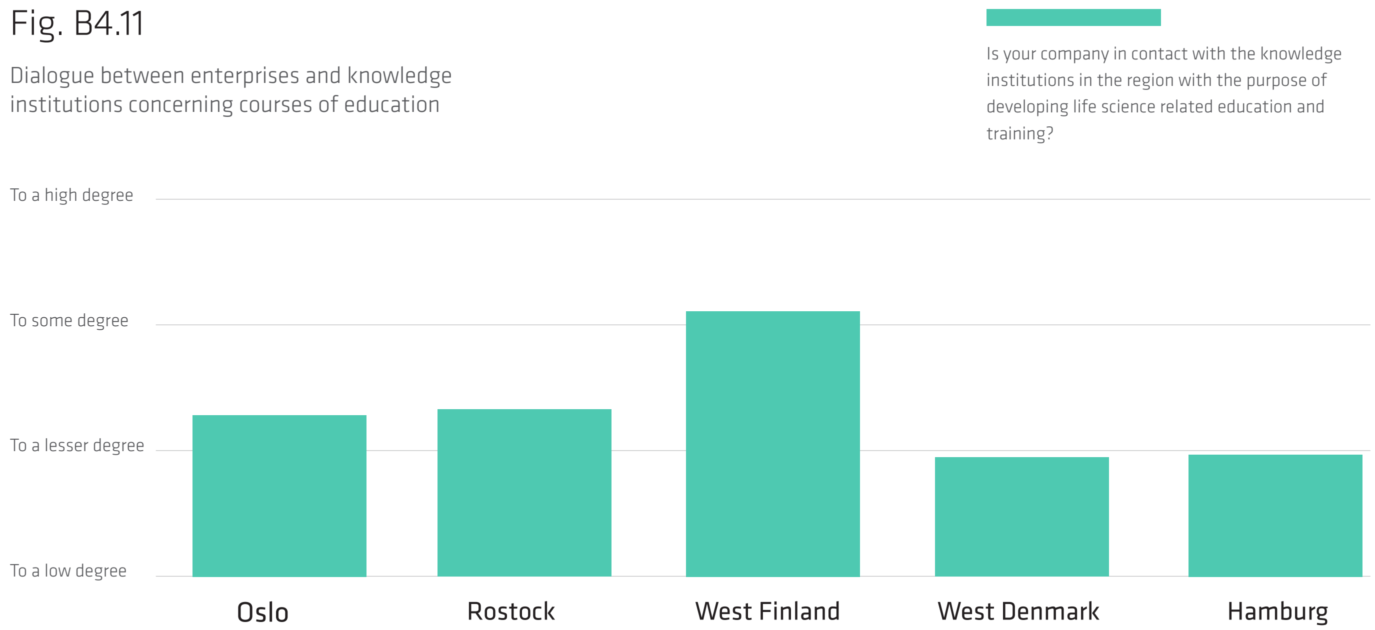


Fig. B4.12

Indicators for knowledge building

Fig. B4.13

Indicators for entrepreneurship

- Composite entrepreneurship indicator
- In your opinion are a large number of foreign life science companies establishing a presence in the region?
- In your opinion are there a large number of start-up life science companies in the region?

Fig. B4.14

Indicators for regulation and public sector demand

- Composite regulation and public demand indicator
- In your opinion is there a critical demand for life science products from the region's public market ?
- In your opinion are the activities carried out by the regulatory authorities of a high quality?

Fig. B4.15

Do companies regard themselves as part of a cluster?

Consists of the following questions

Do you find that there is a concentration of life science companies in the region?

Does the companies perceive themselves as a part of a community with other life science companies in the region?

Is the company in direct competition with other life science companies in the region?

Fig. B4.16

Extent of specific collaboration between companies

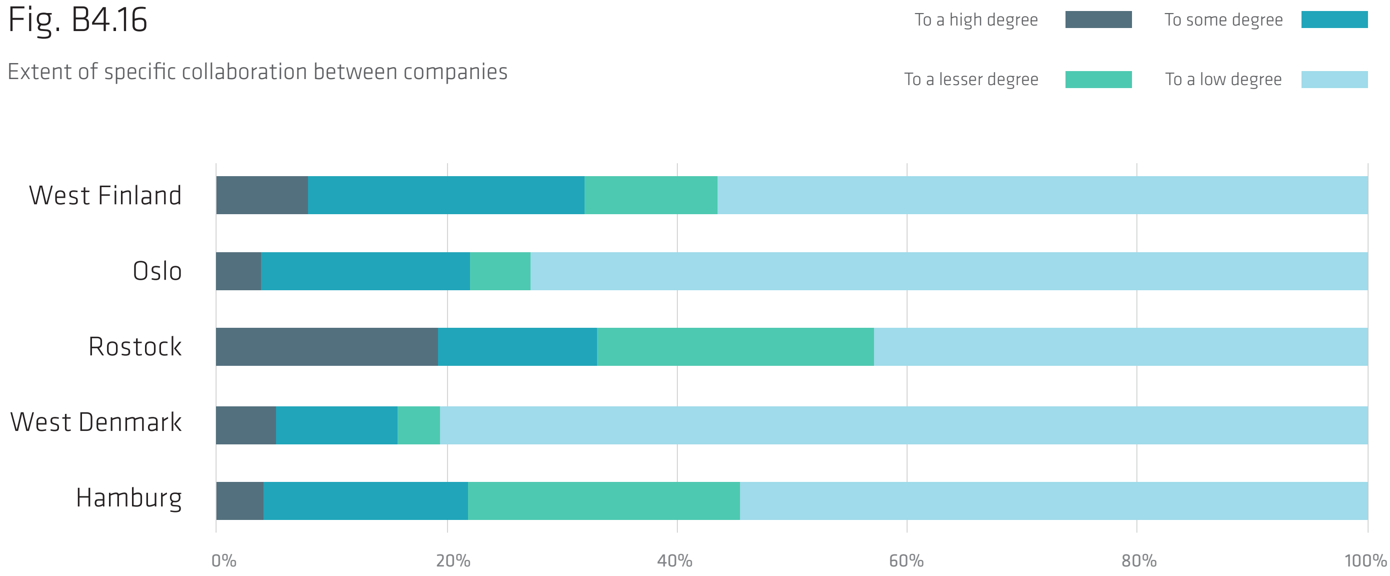
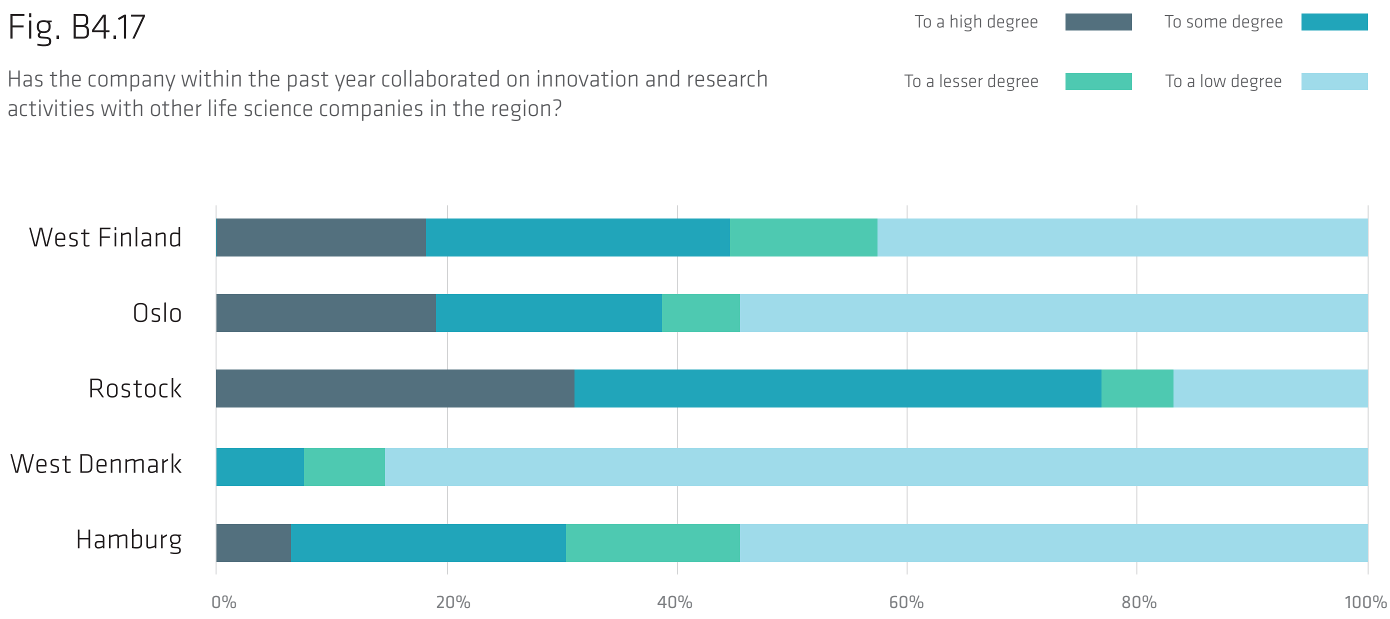


Fig. B4.17

Has the company within the past year collaborated on innovation and research activities with other life science companies in the region?



Appendix 5 Applied methods and calculations

The following methods and calculations have been applied in calculating indicators and composite indicators and carrying out robustness analyses.

The companies have replied to a number of questions related to innovation and cluster specific framework conditions. Companies have replied using the following categories: “To a high degree”, “to some degree”, “to a lesser degree”, “to a low degree”. The replies have then been converted into a numeric scale to allow for calculating a regional average, cf. Table B5.1.

Table B5.1 From ordinal to numeric scale

Ordinal scale	Numeric scale
To a high degree	0
To some degree	0.33
To a lesser degree	0.67
To a low degree	1

The companies' replies are converted into a regional average by taking a simple average from the companies' replies in each region. The purpose of this exercise is to make it possible to rank the regions and carry out benchmarking.

Composite indicators are comprised of several indicators. As indicators use the same scale the composite indicator can be calculated as a simple average for each indicator. In some cases the indicators do not use the same scale. This is the case for the composite employment indicator. In this case the indicators' values have been normalized to gain a better comparability of the indicators' scales before the composite indicator is calculated. The normalization is carried out by relating each indicator's value to its own maximum value.

Calculating composite indicators raises the question of which weights to assign each of the underlying indicators. Ideally the weighing of each indicator should reflect the indicator's relative impact on the phenomenon it is supposed to express, for example the quality of the regions' entrepreneurship framework conditions. However, we do not know which weight to assign to each indicator. It is possible, though, to carry out a robustness analysis of the composite indicator. On that basis it is possible to assess if the ranking of regions using the composite indicator is robust to – or heavily dependent on – the chosen weighing.

The robustness analysis is based on 10,000 calculations of the composite indicator. For each calculation a random weight is chosen for each indicator. For each calculation the regions are ranked and it is calculated the number of times each region is ranked as first, second and third, respectively.

If regions gain the same ranking regardless of the weights applied for the underlying indicators the ranking is considered robust and the composite indicator is calculated as a simple average of the indicators' values.

Appendix 6

Raw data and robustness analysis for employment and real wage indicators

Table B6.1 Raw data for the composite employment indicator

	Employment 2004	Change in employment, 2000-2004	Specialization quotient, 2004	Change in specialization quotient, 2000-2004
Copenhagen	22.184	5.519	3,6	1,1
Stockholm	16.890	-816	1,9	0,0
Malmö	5.871	102	1,9	0,1
Gothenburg	5.400	1.217	1,0	0,2
Helsinki	14.695	-3.183	2,3	-0,4
Helsingfors	7.054	-752	1,0	-0,1

Note Data is from the BSR cluster database, which is based on numbers form national employment statistics in accordance with Eurostat's Structural Business Statistics. Employment include both full-time and part-time employees as well as self-employed.

Table B6.2 Raw data for composite real wage indicator

	Average real-wages in Euro (PPP) per employee, 2000	Average real-wages in Euro (PPP) per employee, 2004	Average annual growth, 2000-2004
Copenhagen	47.000	48.500	0,8%
Stockholm	58.600	64.800	2,6%
Malmö	48.300	59.500	5,4%
Gothenburg	49.700	59.400	4,6%
Helsinki	34.900	41.200	4,2%

Note Data is from the BSR cluster database, which is based on numbers from national statistics in accordance with Eurostat's Structural Business Statistics. Average real-wages are calculated using personnel costs including salaries, pensions and social security costs divided by the number of full-time employees. In 2004 social security costs amounted to 6% of personnel costs in Denmark, 33% in Sweden and 18% in Finland.

Fig. B6.1

Robustness of the composite employment indicator

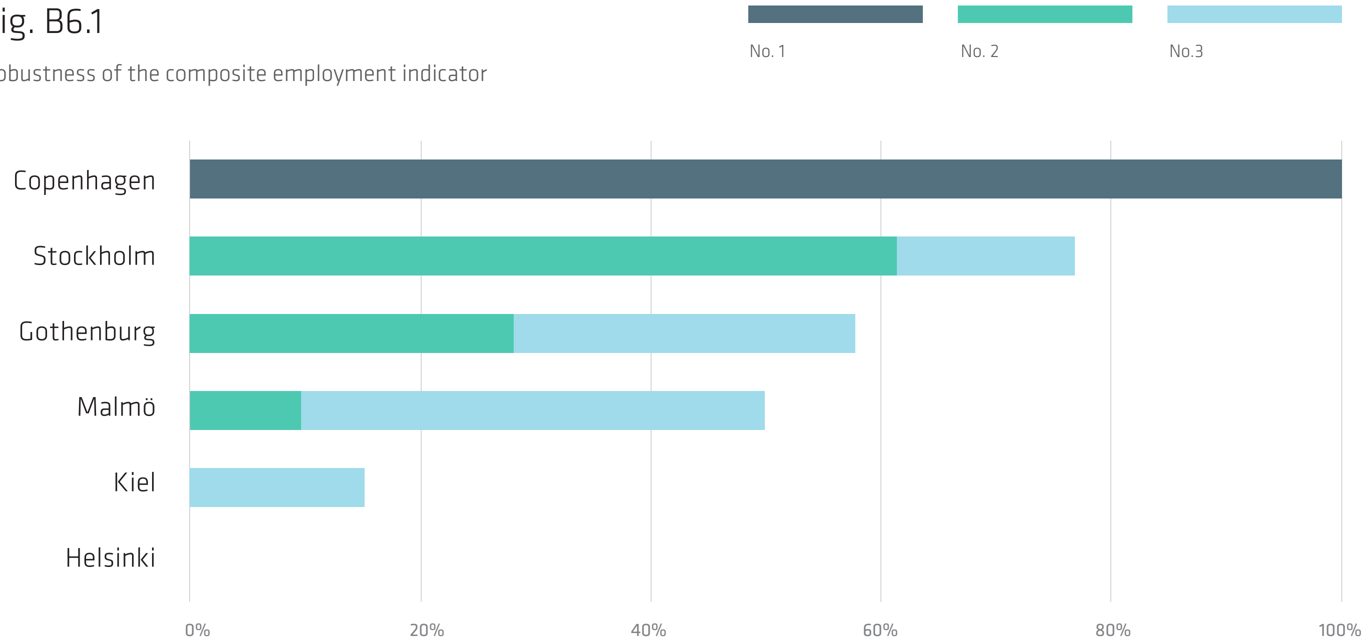
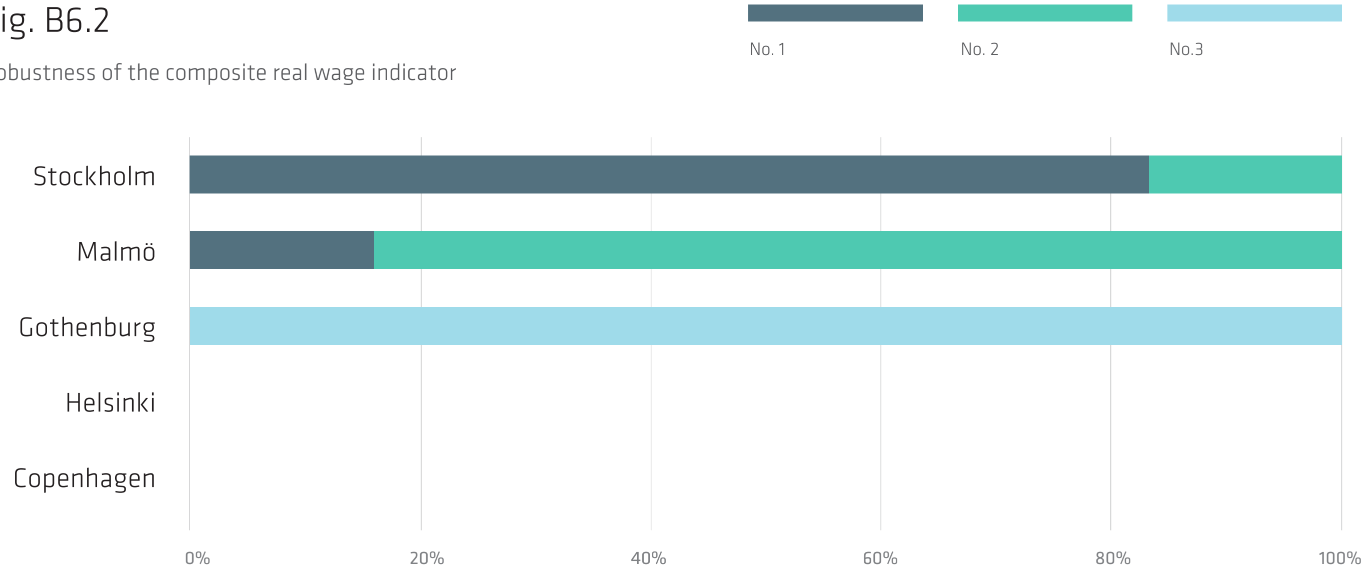


Fig. B6.2

Robustness of the composite real wage indicator



Appendix 7

Comparing real-wage levels within life sciences in Denmark and Sweden

In the BSR InnoNet project FORA measures cluster performance. The first analyses point to a significant gap in real-wage levels in life science clusters when comparing Copenhagen and Stockholm. In 2004 the average real wage in Copenhagen was approximately 61 000 Euro compared to more than 72.000 Euro in Stockholm/Uppsala. When PPP adjusting the numbers the gap is even more pronounced, cf. appendix 6. This appendix analyses the underlying reasons for this gap in real wage levels. The reasons behind the gap could be:

- A generally higher real-wage level in Stockholm vis-à-vis Copenhagen in comparable job functions
- A higher share of knowledge workers in Stockholm
- That the Danish real-wage level is misrepresented in available statistics
- That prices and exchange rates are significantly different when comparing Sweden and Denmark
- That the gap in real-wage levels were remarkably high in 2004

Real-wage levels across job functions

In collaboration with the investment agency Copenhagen Capacity it has been possible to assess salaries in Copenhagen and Stockholm across 15 different job functions[38]. The comparison points to a limited gap in overall personnel costs in various job functions when comparing Copenhagen and Stockholm with the exception of high-level employees i.e. the top management. Here, salaries are significantly higher in Stockholm. However, the top management constitutes a very limited share of the total number of employees in life science in the two clusters. Therefore, the difference fails to contribute to explaining the gap in real-wage levels across the two regions.

[38] The account of salaries across 15 job functions has been drawn from another database. The BSR Cluster database cannot be split into job functions.

On this basis it is not possible to conclude that the gap between Copenhagen and Stockholm can be accredited to a generally higher real-wage level in Stockholm's life science cluster.

The share of knowledge workers

One should expect the overall personnel costs of knowledge workers to be markedly higher compared to blue collar workers. In order find a proxy for the share of employees with a degree in higher education we have used output from the survey, where companies among other things were asked to report the share of employees with a degree from higher education. When comparing Copenhagen and Stockholm the share of companies where more than 50 percent of the employees had a degree from higher education was markedly higher in Stockholm; here, 81 percent of the companies reported a 50+ percent share. In Copenhagen the share was 37 percent (cf. Table B7.1).

Table B7.1 Share of companies' employees with a higher education degree:

	0-25 pct.	26-50 pct.	51-75 pct.	76-100 pct.	Do not know
Copenhagen	6	57	26	11	0
Stockholm	4	14	71	10	2

Note The shares are calculated on the basis of 375 responses from life science companies in Copenhagen and Stockholm.

When summing up the companies' replies at a regional level the account shows that 52 percent of the employees in Stockholm have a higher education degree compared to 40 percent in Copenhagen.

The salaries for employees with or without a higher education degree cannot be deducted from the available data. But if we assume that employees with a higher education degree on average retain salaries that are between 50 and 100 percent higher compared to employees with no long-term education it is possible to calculate the share of the real-wage gap that is explained by differences in educational background[39].

The calculation shows that if Copenhagen had the educational composition found in Stockholm, where 52 percent of the employees had a higher education degree, the overall real-wage level would be between €3000 and €5000 higher[40]. This corresponds to between 30 to 50 percent of the difference in real-wage levels when comparing Copenhagen and Stockholm. Since the calculations are founded on a number of assumptions it should of course be treated with some caution.

Overall, this could indicate that differences in educational composition across the two regions constitute a significant part of the explanation as to why real-wage levels are lower in Copenhagen. However, calculations also show that this is hardly the main explanation behind the difference.

Real-wage levels in the clusters' largest companies

In order to assess if part of the difference in real-wage levels can be attributed to errors or statistical differneces we have scrutinized annual accounts from two Danish companies: Novo Nordisk and Lundbeck. The two companies employ 72 percent of all biopharmaceutical sub-cluster employees in Copenhagen. Similarly, AstraZeneca employs a significant portion of employees in the biopharmaceutical sub-cluster in Stockholm/Sweden. Hence, a run-down of the company's account will make it possible to evaluate the Swedish statistics. However, it has not been possible to collect information on AstraZeneca's Swedish activities[41]. In the following section we will therefore only assess the Danish statistics.

Novo Nordisk and Lundbeck had 11,000 full-time employees in 2004. The average salary including pension schemes was 494.000 DKK in Novo Nordisk and 491.000 DKK in Lundbeck (cf. Table B7.2).

[39] If knowledge workers are assumed to retain a salary that is 50 percent higher the total average salary is calculated to be 51 000 euro for employees without a higher education degree and 76000 euro for employees with a degree from higher education. If knowledge workers are assumed to retain a salary which is 100 percent higher the total average salary is calculated to be 44 000 euro for employees without a higher education degree and 87 000 euro for employees with a degree from higher education.

[40] All other things being equal.

[41] AstraZeneca is a Swedish/UK company with 65,000 employees world-wide of which roughly 20 percent are employed in Sweden.

Table B7.2 Number of full-time employees and personnel costs (DKK) in Novo Nordisk and Lundbeck

	Novo Nordisk		Lundbeck	
	2000	2004	2000	2004
Full-time employees	6025	9643	1525	1985
Total average personnel cost	484.000	520.000	409.000	491.000
Average salary including pension	460.000	494.000	409.000	491.000
Average salary excluding pension	431.000	446.000	373.000	439.000

Note Total personnel costs at Novo Nordisk include 1) salary, 2) costs related to stock-based compensation, 3) pension, 4) other social security costs 5) other personnel costs. Total personnel costs at Lundbeck include 1) salaries and remunerations, 2) contributions to pension schemes and 3) other social security expenses. Average salary including pension is the sum of 1), 3) and 4) for Novo Nordisk and 1) to 3) for Lundbeck. The average salary excluding pension consists of 1) for both companies.
Source: Annual reports, 2000 and 2004.

Average salary including pension provides the best comparison platform against available Danish statistics, which form the backbone of the BSR cluster database. The average salary in Copenhagen's biopharmaceutical sub-cluster is calculated in the BSR cluster database at 478,000 DKK in 2004, which is 3% lower than the average salary at Novo Nordisk and 2.5% lower than the average salary at Lundbeck. If Novo Nordisk and Lundbeck are salary leaders in the cluster there is a strong link between company accounts and the statistical material.

The average annual salary growth is 1.8 percent for Novo Nordisk and 4.5 percent for Lundbeck. In the BSR database the corresponding figure is -0.2 pct. for the biopharmaceutical sub-cluster and 1.5 percent for the entire life science cluster in Copenhagen. Salary trends in Copenhagen's biopharmaceutical sub-cluster are much lower than indicated in the annual accounts for the largest companies in the cluster. Thus, available statistics seems to underestimate salary trends in the clusters.

Price levels and exchange rates

International comparisons of real-wage levels are difficult and should always be treated with some caution. In order to compare salaries they must be converted into a common currency. The most frequently used method is to convert salaries into purchasing power parities (PPP), which accounts for both differences in exchange rates and price levels across countries. This allows for accounting for differences in relative living expenses and inflation rates across countries. This is particularly relevant when comparing GDP at regional and national levels.

Price levels are measured using consumer prices indexes. This is applicable when comparing living standards across countries. However, when the starting point is to measure differences in productivity a product price index would be more suitable. The consumer price index may divert significantly from the product price index in the selected cluster. However, a product price index is currently not available[42].

[42] Eurostat is currently carrying out a project for constructing an industry price index called EU KLEMS. See www.euklems.net.

One way to address this flaw in calculating purchasing power parities is to exclusively use the exchange rate and thus not account for different price levels when calculating a common currency. However, exchange rates show much more variation compared to price levels. This implies that exchange rate fluctuations will have a significant impact when comparing cluster salaries.

There are some challenges associated with calculating purchasing power parities and simple Euro conversions. Therefore, both methods have been used for the purpose of this study. The purpose of comparing salaries has first and foremost been to rank the selected clusters. Therefore it is important to know if the applied method will impact the ranking of regions. This is not the case. Regions are ranked the same regardless of method applied (cf. Table B7.3).

Table B7.3 Converting salary levels into common currency

	Euro			Purchasing power parities (PPP)		
	Personnel costs in € per employee, 2000	Personnel costs in € per employee, 2004	Average annual growth, 2000-2004	Personnel costs in € (PPP) per employee, 2000	Personnel costs in € (PPP) per employee, 2004	Average annual growth, 2000-2004
Copenhagen	57.500	61.000	1,5%	47.000	48.500	0,8%
Stockholm	69.000	72.500	1,2%	58.500	65.000	2,6%
Malmö	57.000	66.500	4,0%	48.500	59.500	5,4%
Gothenburg	58.500	66.500	3,2%	49.500	59.500	4,6%
Helsinki	38.000	45.000	4,4%	35.000	41.000	4,2%

The real-wage gap between Stockholm and Copenhagen is €11,000, and salaries in Stockholm are 18 percent higher compared to Copenhagen. When converting to PPP the gap is €16,500 and salaries are 34 percent higher in Stockholm. This implies that employees in Stockholm are better paid vis-à-vis their living expenses compared to Copenhagen employees.

Differences in real-wage levels in 2004

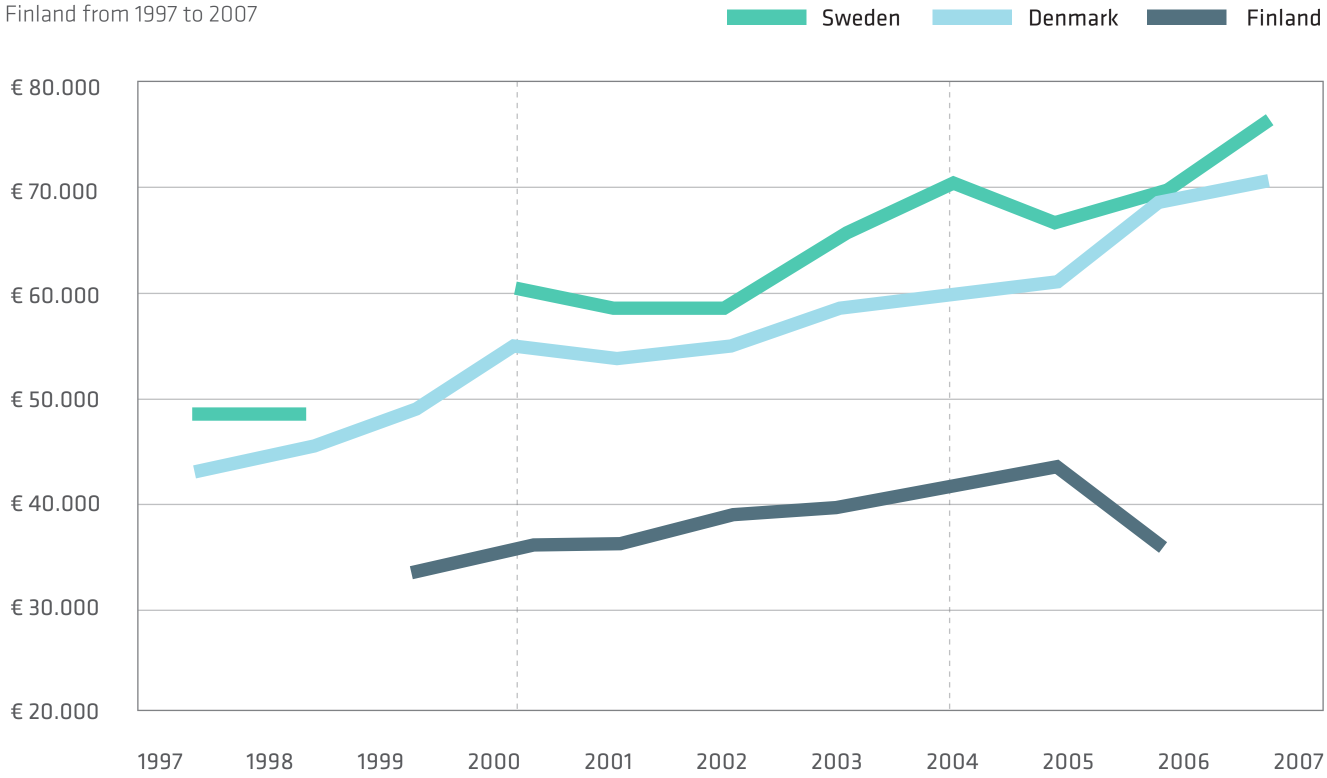
Trends in real-wage levels reflect the improvements in productivity over time. Real wage trends also reflect inflation and business cycles. If inflation rates in Denmark and Sweden are not similar and if business cycles do not evolve simultaneously it may impact the real wage indicator used for the purpose of the analysis.

By observing real wage trends over several years it is possible to gain an insight into the trends and size of annual fluctuations in real wages. Since regional data is not publicly available and has to be commissioned at each country's national statistical office it has not been possible to collect regional data for several years. Data is available at a country level, which makes it possible to compare Denmark, Sweden and Finland over a ten-year period.

When comparing real wage levels, the numbers show that over the entire ten-year period Sweden is the leading country, followed closely by Denmark. Finland lags some-what behind (cf. Figure B7.1).

Fig. B7.1

Labor costs per employee in life science in Sweden, Denmark and Finland from 1997 to 2007



Note Calculated on the basis of the following business sectors: Manufacture of basic pharmaceutical products (24.41), Manufacture of pharmaceutical preparations (24.42) and Manufacture of medical and surgical equipment and orthopaedic appliances (33.10).
Kilde Structural Business Statistics, Eurostat.

When observing changes in labour costs (real wages) year over year it shows a very steady trend. Some years, costs remain stable, even declining in some years, while showing significant growth in other years. From 2000 to 2002 Sweden experienced a small drop in real wages; from 2002 to 2004 it grew by nearly 20 percent. Denmark shows a similar pattern, but in different years. From 2005 to 2006 there was a 13 percent growth in real wages. Over a ten-year period however the general impression is that real wage developments show similar trends. When looking exclusively at the last five-year period the figure points a stronger salary trend in the Danish life science cluster. If this trend continues Denmark will surpass Sweden.

In 2006 Denmark and Sweden has similar real-wage levels despite the fact that in 2004 Denmark appeared to have much lower real-wage levels. In 2004 the gap between Denmark and Sweden appeared to be heavily influenced by annual short-term fluctuation in real wage levels.

When comparing real-wage levels and real-wage trends within the life science over a ten-year period the real-wage level is higher in Sweden. However, when using the regional data in the BSR Cluster database in 2000 and 2004 differences in real-wage levels and real-wage trends appear to be overestimated.

In summary

Comparing real-wage levels and trends in Denmark and Sweden shows that the real-wage level – measured in terms of labour costs are higher in Sweden. On the other hand there is a strong indication that the difference is smaller than indicated by the composite real wage indicator shown in Chapter 3. From 2000 to 2004 Sweden's trend in real wages was of historic proportion. In 2004 the gap between Denmark and Sweden were higher than in any other year over a ten-year period. At the same time the real-wage gap between comparable job functions was limited. The main conclusion to the real-wage gap appears to be related to differences in educational composition where Sweden has a higher share of employees with a degree from higher education. However, it has not been possible to draw a solid conclusion based on available data.

Appendix 8 Questionnaire

Introduction

This survey is part of an international analysis of comparing the performance and business conditions for life science companies in the Baltic Sea region with the most important life science clusters in the world. The purpose of the analysis is to find ways to improve the framework conditions of life science clusters in the region.

A cluster is a group of companies and affiliated institutions within a particular field, localised in the same geographic area and interconnected by (a number of) common complementary characteristics.

Therefore, all companies working in areas with relation to the life science field are invited to take part of the survey.

The project is financed by the Danish Enterprise and Construction Authority and the Baltic Sea Region Innovation Network, BSR-INNOnet which is part of EU's INNOnet program. The INNOnet program is a new innovation policy initiative under the EU that intends to become the future focal point of innovation policy analysis and development throughout Europe.

The survey is conducted by FORA, the Danish Ministry of Economics and Business Affairs' unit for research and development, in collaboration with Medicoindustrien, Lægemiddelindustriforeningen and Dansk Biotek.

The survey

The questionnaire in the survey is divided into five main themes that are critical to the framework conditions of life science companies:

1. Employees
2. Knowledge
3. Cluster collaboration
4. Regulation and public demand
5. Entrepreneurship

The questionnaire will take approximately 25 minutes to complete.

All individual replies in the questionnaire will be treated with the highest discretion and will not be published or given to any third party.

If you have any questions relating to the survey please do not hesitate to contact analyst Markus Bjerre in FORA, bje@ebst.dk, (+45) 3546 6368.

Your answers are greatly appreciated no later than date.

We thank you for your cooperation!

1.0 – PRIMARY BUSINESS AREA

1.1 Within which sector of the life science industry does your company have its primary focus (you may check only one of the following categories)?

Pharmaceutical raw materials:	
Medical goods:	
Biotech:	
Medical and surgical equipment:	
Perfume, shampoo, toothpaste etc.:	
Whole sale trade in pharmaceuticals, nursing requisites and hospital requisites:	
Other (please specify)	

2.0 – EMPLOYEES

2.1 Access to life science graduates and PhDs

2.1.1 Do the knowledge institutions in the region educate a sufficient number of life science graduates, which are equipped with the right skills in terms of meeting your company's needs (life science graduates cover newly qualified graduates with at least 3 years of education with skills and competences targeting life science companies, i.e. graduates which have pursued a full degree – or specific courses – in developing medical drugs, medical technology, sales and marketing etc. in the area of life science).

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

2.1.7 Please indicate the share of your employees with a master degree:

0-25 %:	
26-50 %:	
51-75 %:	
76-100 %:	

2.2 Collaboration on education between your company and knowledge institutions in the region

2.2.1 Is your company in contact with the knowledge institutions in the region with the purpose of developing life science related education and training?

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

2.3 Access to experienced and specialised life science employees

2.3.1 Does your company have the opportunity to attract experienced employees of high quality?

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

3.0 – KNOWLEDGE

3.1 The company's innovation and research activities
Companies optimise, improve and continuously develop their products and services (incremental innovation)

3.1.1 Has your company carried out incremental innovation within the past two years?

Yes:	
No:	

(The respondent should only reply to 3.1.2, if "yes" to question 3.1.1)

3.1.2 What share of your company's products and services has been improved or further developed over the past two years (incremental innovation)?

0-25 %	
26-50 %	
51-75 %	
76-100 %	

Companies develop entirely new products, solutions, platforms and concept which are new to the company and which may yield long term growth (radical or market shaking innovation).

3.1.3 Has your company carried out with radical or market shaking innovation within the past five years?

Yes:	
No:	

(The respondent should only reply to 3.1.5, if "yes" to question 3.1.3)

3.1.5 What share of last year's total turnover was generated by radical/market shaking innovations completed within the past five years?

0-25 %	
26-50 %	
51-75 %	
76-100 %	

3.1.7 Five years from now what share of your total turnover will be generated by radical/market shaking innovations which have been launched - or will be launched - within the next year?

0-25 %	
26-50 %	
51-75 %	
76-100 %	

In the companies innovation process users are engaged through the inclusion of user needs and user testing of prototypes. Users may also be observed and may participate in experiments to uncover un-acknowledged user needs (ethnographic studies) or the users themselves may innovate for the company (lead users).

3.1.9 In your opinion is the uncovering of un-acknowledged user needs and/or the inclusion of lead users important for successful radical or market shaking innovation?

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

3.1.10 Please indicate the company's R&D expenses as a share of total turnover:

0-10 %	
11-20 %	
21-30 %	
More than 30 %	

3.2 The supply and quality of life science knowledge and advisory services in the region

3.2.1 In your opinion is sufficient life science research relevant for your company being carried out across knowledge institutions in the region?

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

3.2.3 In your opinion does the region's research environment in life science match the world's leading research environments?

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

4.0 – CLUSTER COLLABORATION

4.1 Concentration of life science companies in the region

4.1.1 In your opinion is there a concentration of life science companies in the region?

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

(If the respondent replies “to a high extent” or “to some extent” to 4.1.1, go to 4.1.2)

4.1.2 Does the presence of a large number of life science companies in the region have an impact on your company’s economic development?

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

4.2 Joint activities

4.2.1 Does your company perceive itself as part of a community involving other life science companies in the region?

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

4.2.2 Does your company compete with other life science companies in the region?

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

4.2.3 Has your company engaged in joint activities with other life science companies? (You may check more than one category):

	Purchasing:	Convention or branding activities:	Attracting employees, e.g. knowledge workers and foreign talent:	Developing the entrepreneurial environment:	Access to new markets:	Developing operation, e.g. subcontractor initiatives, new logistic opportunities and new production methods:
To a high degree:						
To some degree:						
To a lesser degree:						
To a low degree:						
Do not know:						

4.3 Collaboration on innovation and research

4.3.1 Has your company collaborated on innovation and research activities with other life science companies in the region during the past few years?

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

4.3.4 In your opinion are other life science companies establishing a presence in the region to gain access to life science knowledge unique to the region?

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

5.0 – REGULATION AND PUBLIC DEMAND

5.1 Quality of regulation

5.1.2 In your opinion are the activities carried out by the regulatory authorities of a high quality (for example the extent to which the regulatory authorities have the proper insight in the market as well as the company's challenges, are new products approved quickly, is testing approved quickly, a speedy case review, transparency in the authorities' assessments and decision making etc.)

	To a high degree:	To some degree:	To a lesser degree:	To a low degree:	Do not know:
Approval of clinical testing					
Approval of test applications					
Approval of new pharmaceuticals					
Overseeing advertising and marketing rules					
Reimbursement/allocation of national subsidies					
Access to data/personal information					
Access to bio banks					
Approval of establishment of private bio banks					
Approval of environment friendly production					
Supervision of GMO etc.					
Inspection of clinical testing					
Other: (please specify)					

5.2 Quality of public demand

5.2.2 In your opinion is there a critical demand for life science products from the region's public market (Do you regard the public regional market as a "Lead Market)?

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

6.0 – ENTREPRENEURSHIP

6.1 New companies in the cluster

6.1.1 In your opinion are there a large number of start-up life science companies in the region?

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

6.1.2 In your opinion are a large number of foreign life science companies establishing a presence in the region?

To a high degree:	
To some degree:	
To a lesser degree:	
To a low degree:	
Do not know:	

6.2. Framework for start-up and growth

6.2.1 Has your company been in contact with the region's advisory services?

	Private advisors:	Venture capital:	Public advisors:	Research parks, incubators etc.:	Other life science companies:	Others: (Please specify)
To a high degree:						
To some degree:						
To a lesser degree:						
To a low extent:						
Do not know:						

7.0 – COMPANY INFORMATION

7.1 In which postal code is your workplace located?

7.2 What is your company's registration number?

7.3 Number of employees in your company (or your best estimate)

7.5 If possible please indicate company turnover in 2007:

Below 0:	
0-100.000 Euro:	
100.000 – 500.000 Euro:	
500.000 – 1.000.000 Euro:	
1 Million – 5 Million Euro:	
More than 5 Million Euro:	

Appendix 9 Test at the company level – further details and results

This appendix documents the results of a set of econometric estimations on firm level data with the aim of uncovering the impact of clustering and cluster policy on the sources of productivity and growth in the life science industry in the Baltic Sea Region. We investigate a statistical link between cluster policy (i.e. framework conditions) and firm-level productivity. The regressions uses a novel set of data collected via a large survey of life science firms which inform us about the firms' perceptions of framework conditions and the innovation activity they undertake.

The next section describes results from the survey of life-science firms in the Baltic Sea Region. This is followed by an investigation of the link between innovation activity and the framework condition reported by the firms. Then, we investigate firm performance linked to the framework condition using regression analysis on firm level data. This is followed by a descriptive section on the connection between the productivity and innovation and framework conditions. Finally, the last section gives a summary of the main findings.

1. Survey of Life Science firms in the Baltic Sea Region

The data from the survey of life science firms in the region yields detailed information on how firms perceive the framework conditions in the regions where they are located and provides data on firms' innovation activities. A more detailed description of the survey can be found in annex 3 and the questionnaire is found in annex 8.

The survey covered life-science firms in a total of 28 regions in the Baltic Sea Region, but in order to understand the influence of cluster policy on firm performance, we have focused on the six regions where there is a cluster concentration. These six regions account for almost 70 percent of the life-science employment (Copenhagen, Stockholm, Kiel, Malmö, Gothenburg and Helsinki). We use the location quotient that measures the how concentrated the life science industry is in a region compared to the rest of the Baltic Sea Region. These six regions are the regions with the highest concentrations of the life-science industry across all the 28 regions.

We calculate the region's share of life science employment relative to all cluster employment in that region. This we compare with the share that life science is on average in the whole Baltic Sea Region, cf. Table 1.1. Copenhagen is the most concentrated, with LQ at 3.63, which means Copenhagen has 263 percent higher share of employment in the life science industry compared to the region share of employment in the Baltic Sea Region.

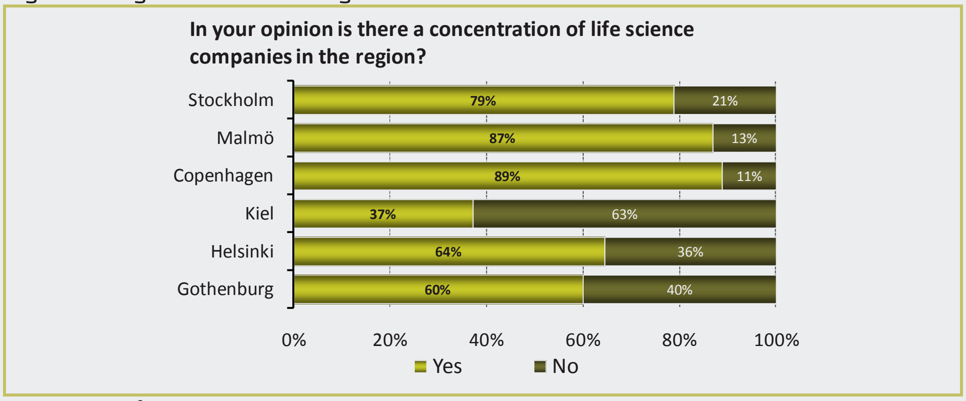
Table 1.1 The six regions have high concentration of life-science

Region	Location quotient, LQ
Copenhagen	3.63
Stockholm	2.34
Kiel	2.28
Malmö	1.90
Gothenburg	1.05
Helsinki	0.96

Note: Location quotient measured as the life-science clusters' share of regions cluster employment relative to the regions share of all cluster employment in the Baltic Sea Region.
Source: BSR Clusterdatabase

The firms in these regions also perceive that they are located in a region with strong concentrations of life-science firms. For most regions the awareness is such that at least 60 percent of firms believe their region hosts a concentration, only Kiel stands out with just 37 percent, cf. Figure 1.1. It is interesting to note that firms own perception of being in a cluster corresponds to the results of the LQ-analysis above.

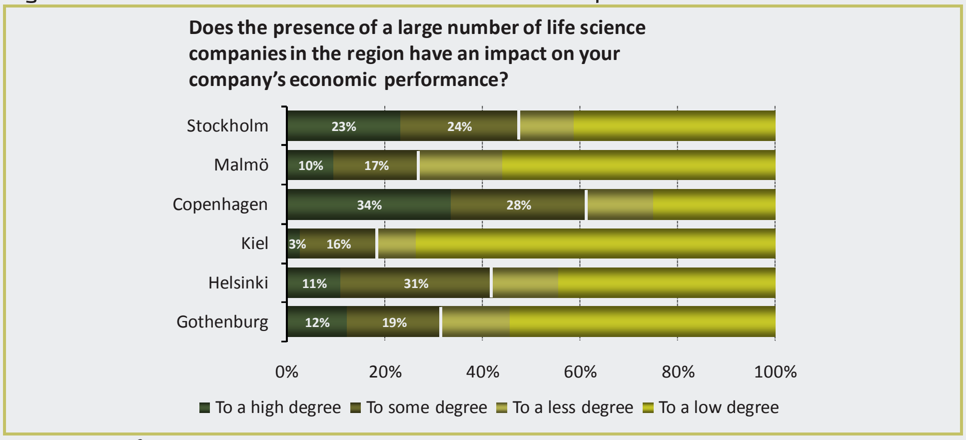
Figure 1.1 High awareness of regional concentration.



Source: BSR Life Science Survey

Consequently, firms also report that the concentration of firms is important to their economic performance. Especially in Copenhagen, Stockholm and Helsinki, where more than 42 percent of firms respond that clusters impact them to some degree and to a high degree, cf. Figure 1.2.

Figure 1.2 Cluster concentration matters for economic performance



Source: BSR Life Science Survey

These results lead to the question why these firms cluster and what types of benefits they can reap from clustering. If the benefits are gains in productivity, we should be able to establish a statistical relationship between clustering and productivity, but before we describe the regression analyses on this question, we describe the firm level data.

2. Identifying firm performance using multifactor productivity

In the literature on estimating firm performance, it is common to establish firm multifactor productivity by assuming a common production function, shared by all firms, and estimating the underlying parameters in this function. From these parameters it is possible to deduce each firm's multifactor productivity component.

We estimate a Cobb-Douglas production function of the following form:

$$Y_i = A_i K_i^{\alpha} L_i^{\beta} \tag{1}$$

Where Y_i is value added for firm i, K_i is capital input and L_i is labour input. The exponents α and β are the technical coefficients when producing, i.e. these are actual cost-shares in the production of the output of the firm. The coefficient A_i is the multifactor productivity of firm i. This last term expresses how good a firm is in combining inputs of capital and labour in the production of the output and therefore an expression of the productivity of firms. If firms improve their ability to produce using the same amount of inputs, they have increased their productivity and this will show up as an increase in the multifactor productivity term A_i. In addition, we add size dummies to control for scale effects in the productivity term. The common criticism of the multifactor productivity estimates found using this type of specification is that the productivity is found from the residual in the estimation, thus the term also incorporates all the noise in the error terms.

The regression is performed on the log-linear version of equation (1) using firm level data from the Amadeus database.[1] The parameters are significant and we find the expected signs, cf. Table 2.1.

Table 2.1 Estimation results of the simple version of Cobb-Douglas

Source	SS	df	MS			
					Number of obs =	730
Model	3251.306	5	650.261		F(5,724) =	793.70
Residual	593.157	724	0.819		Prob > F =	0.000
					R-squared =	0.846
Total	3844.463	729	5.274		Adj. R-squared =	0.845
					Root MSE =	0.905
lnY	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**[95% conf interval]**	
lnL	0.7392	0.0355	20.84	0.000	0.6695	0.8088
lnK	0.0500	0.0207	2.41	0.016	0.0093	0.0907
cate_medium	0.5855	0.1037	5.65	0.000	0.3819	0.7891
cate_large	1.0711	0.1561	6.86	0.000	0.7645	1.3776
cate_very_large	793.7000	0.2119	4.85	0.000	0.6126	1.4446
_cons	1.8540	0.1339	13.84	0.000	1.5910	2.1169

Note: The small firms are the reference firm for this regression
Source: Copenhagen Economics and Bureau van Dijk (2009)

2.1. Investigating the impact of geographic concentration

Many economists have quantified the impact of geographical proximity on productivity. A survey of most of this literature, as provided by e.g. Rosenthal and Strange (2004)[2], shows many examples of this. In these studies, a doubling of the size of a cluster implies generally a productivity increase of 3 to 8 percent.

Vernon Henderson (2003)[3] was one of the first to use firm-level data for such estimates. He found a positive and significant productivity effect of approximately 8 percent from increasing the regional employment within high-tech based on data for the U.S.

A large scale study of French firm-level data, performed by Martin, Mayer and Mayneris (2008)[4], and looking at average concentration effects across many industries showed much

[1] Bureau van Dijk (2009), *The Amadeus database*
[2] See Rosenthal, S. S., and W. C. Strange (2004), "Evidence on the nature and sources of agglomeration economies", in Handbook of Regional and Urban Economics, chapter 49 pp. 2119-2171 (Elsevier).
[3] Vernon Henderson is professor of regional economics at Brown Universitet i Providence, Rhode Island (USA). See Henderson, J. V. (2003), "Marshall's scale economies", *Journal of Urban Economics*, 53(1), side 1-28.

smaller effects from clustering. A ten percent increase in employment of surrounding firms in same industry increased productivity by 0.4 – 0.5 percent.

The cluster effect in the French data is small. The authors conclude on this basis that *"Costly public interventions aimed at increasing the size of clusters is not a policy that is supported by the French evidence"*[5]. They do also continue by saying *"whether cluster policies can, for a given size of clusters, improve collaboration, the exchange of information and knowledge externalities between firms remains to be tested"*[6].

We believe that firm productivity is influenced by geographic concentration *and* the prevailing framework conditions in the region where the firms are located, and therefore we augment the production function to take the surrounding framework conditions into account. Thus, the following equation is estimated,

$$Y_i = A_i K_i^{\alpha} L_i^{\beta}, \qquad \text{where } A_i = f(\ldots) + \gamma LQ_r \tag{2}$$

Here we aim at taking the cluster policy in the region into account through the function f(…), and the concentration of firms in the region into account through the location coefficient in region LQ_r. The last part of introducing geographical concentration in terms of LQ is along the lines of Martin, Mayer and Mayneris (2008), who also try to estimate firm productivity explained by firm concentration.

Our results show that the location quotient measure, *LQ*, is weakly but positively related to the productivity of firms, when we only analyse the firms within the six regions with high concentration. We get a positive estimate on LQ, although, this is insignificant, cf. Table 2.2.

[4] See Martin, P., T. Mayer, F. Mayneris (2008), "Spatial concentration and firm-level productivity in France", CEPR Discussion Paper No. 6858 (CEPR – London).
[5] Comment "Natural clusters: Why policies promoting agglomeration are unnecessary" on the VOX website 4 July 2008: http://www.voxeu.org/index.php?q=node/1354
[6] Idem.

Table 2.2 Estimation results including concentration measure

Source	SS	df	MS			
					Number of obs =	629
Model	2838.770	3	946.256		F(3, 625) =	1266.36
Residual	467.0167	625	946.257		Prob > F =	0.000
					R-squared =	0.859
Total	3305.787	628	5.264		Adj. R-squared =	0.858
					Root MSE =	0.864
lnY	**Coef.**	**Std. Err.**	**t**	**P>t**	**[95% Conf. Interval]**	
lnL	.899	0.0260	34.53	0.000	0.848	0.950
lnK	.0497	0.021	2.40	0.017	0.009	0.090
LQ_rc	.0339	0.067	0.51	0.611	-0.097	0.165
_cons	1.397	0.160	8.71	0.000	1.082	1.712

Source: Copenhagen Economics and Bureau van Dijk (2009)

Martin, Mayer and Mayneris (2008) argued, based on similar estimations, that the benefits in terms of productivity gain resulting from proximity to other firms are already internalised in the firms' location choice. We argue, based on similar estimates, that concentration in a cluster is important to the performance of firms, although only indicative, and the reason is that the concentration of firms allow for provision of cluster based policies that add to the positive externalities from co-location, and that for a given concentration, policies can make a difference.

Our statistical analysis on BSR life-science data show a positive effect of increased cluster concentration: increasing the life-science employment with the six most clustered life science regions by 10 percent will increase firm productivity by 0.5 percent. Recall that this effect is related to an increased concentration within the regions that are already concentrated. The productivity impact of a hypothetical de-location of an average firm from a non-concentrated region to one of the six concentrated regions is like to be much higher.

Furthermore, comparisons with studies such as Henderson (2003) and Martin, Mayer and Mayneris (2008) cannot be readily made, because these studies estimate the effect over time while our data is only a cross-section dataset for one period. We would expect our LQ effect to be much higher in a panel dataset which includes both data over time and both high LQ and low LQ regions.

2.2. Investigating the impact of cluster framework conditions

Next, we have added a variable reflecting firm *i*'s perceived framework conditions as well as the level of innovation they carry out through the explanatory variable FC_i.

$$Y_i = A_i K_i^{\alpha} L_i^{\beta}, \qquad \text{where } A_i = f(\ldots) + \gamma FC_i \qquad (3)$$

In order to investigate this empirically, we have matched firm responses from the life science survey with the firm-level data from the Amadeus database. Although not all firms can be matched, we have an unbiased and large sample for the regressions. The number of observations has been reduced from 856 firm responses in the survey to a matched number of observations of 629 for the firms in the six large regions.

2.3. Construction of the policy variable

In order to construct a policy variable from the survey data, we have grouped the questions from the survey in major groups and created overall indices to describe each firm's view on the cluster framework conditions in their region. We group the survey data into an innovation index and four framework indices. These four indices are Human Resources, Entrepreneurship, Regulation and Knowledge, cf. Table 2.3. From the survey the questions are scored according to the responses and summed to yield indices of the particular type.

Table 2.3 Definition of innovation and framework indices

	Index	Definition (survey questions)
Innovation index	Innovation	Innovation = incremental innovation (s3.1.1*s3.1.2) + radical innovation (s3.1.3*s3.1.5) + R&D (s3.1.10) + knowledge workers (s2.1.7)
Framework indices	Human Resources (HR)	Graduates and PhD's (s2.1.1) + specialists (s2.3.1)
	Entrepreneurship (ENTR)	Establishment of new firms (s6.1.1) + establishment of foreign firms (s6.1.2)
	Regulation (REG)	Regulation (average for s5.1.2) + public procurement (s5.2.2)
	Knowledge (KNOW)	Extend of research (s3.2.1) + World class research (s3.2.3) + Knowledge attracts firms (s4.3.4)
	Innovation	Innovation = incremental innovation (s3.1.1*s3.1.2) + radical innovation (s3.1.3*s3.1.5) + R&D (s3.1.10) + knowledge workers (s2.1.7)

Note: The numbers in parenthesis refer to the specific question numbering from the survey, see appendix on the survey.
Source: Copenhagen Economics and BSR Life Science Survey

We use equal weights in calculating the indices from the question scores. From these firm level indices we calculate the overall index score in a region, from the average perceptions from firms in each region.

Thus, we can rank regions according to their innovation performance. Our ranking of regions reveal that Copenhagen takes the lead in innovation performance followed by Malmö, Stockholm, Gothenburg, Kiel and finally Helsinki, cf. Table 2.4.

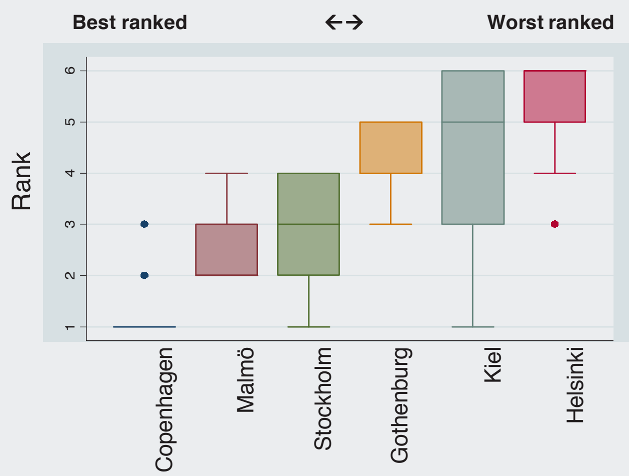
Table 2.4 Innovation performance of life science clusters in the selected BSR regions

Innovation Rank	Region
1	Copenhagen
2	Malmö
3	Stockholm
4	Gothenburg
5	Kiel
6	Helsinki

Source: Copenhagen Economics based on BSR Life Science Survey

As we have used equal weights in the calculation of the innovation index, we have examined if the ranking is independent of the weights used. Instead of using equal weights, we drew random weights and calculated new innovation indices for firms and regions and then ranked the regions. This was repeated 6000 times in order to establish the robustness. The results show that the innovation performance ranking is largely independent of the weights used in the ranking, cf. Figure 2.1.

Figure 2.1 Regional ranking using innovation index is robust



Note: The innovation performance is a composite index of four elements. This robustness analysis shows the results of 6000 random weights of these elements. The box signifies the observations between the 25 pct and the 75 pct quartile. The lower and upper bars indicate 10 pct and 90 pct percentile respectively.
Source: Copenhagen Economics based on the BSR Life Science Survey

We continued the analysis with the hypothesis that better framework conditions affect the level of innovation carried out by firms in the six selected regions. The better the framework conditions the more innovation and ultimately improved productivity and growth. First, we tested the relationship between innovation and framework conditions by examining the correlation between them. Second, we tried a regression analysis to determine if such a relationship could be found.

We have correlated the firm level responses on innovation activity and perceptions of framework conditions, in order to see if there could be a link. From this analysis, we found that only Human Resources and Entrepreneurship framework conditions have somewhat high correlation, although only in the range of 0.18 to 0.17, respectively. Taken together the average of framework indices has a higher correlation of about 20 percent, cf. Table 2.5.

Table 2.5 Correlation of indices – innovation and framework indices

	Innovation	**Overall framework conditions**	**Human Resources**	**Entrepre-neurship**	**Knowledge**
Innovation	1				
Overall framework conditions	0.1950	1			
Human Resources	*0.1702*	0. 5582	1		
Entrepreneurship	*0.1773*	0.7257	0.1066	1	
Knowledge	0.1393	0.7968	0.5623	0.3157	1
Regulation	0.0351	0.6084	0.2277	0.1202	0.2871

Source: Copenhagen Economics based on the BSR Life Science Survey

In the regression analysis, we tested a range of specifications to describe a possible relationship between the innovation performance and the calculated perceptions of framework conditions reported by the firms. The result from the regression analyses show that overall there is a positive and significant relationship between good framework conditions and innovation performance, cf. Table 2.6.

Table 2.6 Regression results – the selected regions

Model	**Sign**	**Significance**	**R^2**
a) Innovation = α Overall framework conditions + ε	Positive	Yes	0.017
b) Innovation = α HR + ε	Positive	Yes	0.019
c) Innovation = α Entrepreneurship + ε	Positive	Yes	0.011
d) Innovation = α Knowledge + ε	Positive	Yes	0.011
e) Innovation = α Regulation + ε	Negative	No	0.001
f) Innovation= α HR + β Knowledge + δ Entrepreneurship + θ Regulation + ε	HR: Positive Knowledge: Positive Entrepreneurship: Positive Regulation: Negative	HR: Yes Knowledge: No Entrepreneurship: Yes Regulation: No	0.037

Source: Copenhagen Economics based on the BSR Life Science Survey

In spite of these identified relationships being significant, the explanatory power of the policy variables is low. Between 1 and 2 percent of the variation in innovation can be explained by framework conditions. The weak relationship is partly because of the few number of regions in the estimations, and because the large variation within regions in the firms' evaluations of the frameworks. Thus, the few regions do not lend much explanatory power to the regressions. A widening of the data material to cover many more life science cluster would enable us to give a better evaluation of the impact of framework conditions on innovation and firm performance.

Although the regression analysis does not give us a strong result, the correlation analysis does give a tentative positive indication of the link between framework conditions and innovation activity.

Next in our work to identify the sources of productivity growth, we turn to firm-level productivity estimates, and link this information with the data on framework conditions from the survey to see if we could find a significant relationship.

We performed several versions of the model in equation (3), but none of them yielded any significant direct relationship between framework conditions and performance. None of the framework indices showed up as significant, in addition, the signs were wrong, cf. Table 2.7.

Table 2.7 Regression results of Multifactor productivity and framework indices

	Model	Sign of framework condition	Significant framework condition
a)	lnY=w1*lnL+w2*lnK+ w3*overall framework conditions+size+ε	Negative	No
b)	lnY=w1*lnL+w2*lnK+αHR+size+ε	Negative	No
c)	lnY=w1*lnL+w2*lnK+αEntrepreneurship+size+ε	Positive	No
d)	lnY=w1*lnL+w2*lnK+αknowledge+size+ε	Negative	No
e)	lnY=w1*lnL+w2*lnK+αregulation+size+ε	Negative	No
f)	lnY=w1*lnL+w2*lnK+αHR+βknowledge+ δentrepreneurship+θregulation+size+ε	HR: Negative Knowledge:Negative Entrepreneurship: Positive Regulation: Negative	HR: No Knowledge: No Entrepreneurship: No Regulation: No
g)	lnY=w1*lnL+w2*lnK+αinnovation+size+ε	Negative	Yes

Source: Copenhagen Economics based on BSR Life Science Survey and Bureau van Dijk

The lack of results probably stem from the very high variation in the perception of framework conditions by firms in the same region. We do not find the expected sign between innovation and productivity, as reported by model g) in Table 2.7.

2.4. Wages as an indicator of firm performance

Another angle in the investigation of firm performance was undertaken using wage levels. Under the hypothesis that more productive firms are able to pay higher wages, we analysed if framework conditions affect the level of wage per employee at the firm level in the six selected regions. To test the hypothesis we regressed framework conditions against the wage per employee, reported by the Amadeus database as cost per employee.

We found a positive and significant relationship between wage and framework conditions, except for the Entrepreneurship index. All other estimates on the indices were positive and significant, although Human Resources changes sign in the pooled regression f), cf. Table 2.8.

Table 2.8 Regression results of Wages and framework conditions

	Model	Sign	Significant
a)	Wage pr emp.=α*Overall framework conditions+ε	Positive	Yes
b)	Wage pr emp.=α*HR+ε	Positive	Yes
c)	Wage pr emp.=α*Entrepreneurship+ε	Negative	No
d)	Wage pr emp.=α*knowledge+ε	Positive	Yes
e)	Wage pr emp.=α*regulation+ε	Positive	Yes
f)	Wage pr emp.=α*HR+β*knowledge+ δ*entrepreneurship+θ*regulation+ε	HR: Positive Knowledge: Positive Entrepreneurship: Negative Regulation: Positive	HR: No Knowledge: Yes Entrepreneurship: Yes Regulation:Yes
g)	Wage pr emp.=αinnovation+ε	Positive	Yes

Source: Copenhagen Economics based on BSR Life Science Survey and Bureau van Dijk

2.5. Inconclusive results from the regression analyses

These results from the regression do not give a clear cut picture or establish a firm link between framework conditions and firm performance. Although, the regression using wages does indicate positive effects from good cluster framework conditions. We have to acknowledge that the available data cannot support our hypothesis that favourable framework conditions directly affect innovation activity and firm productivity. The fact the investigation is focused on only six regions is a strong reason for these results. There is a high variation in firms' perceived framework conditions within each region, but the relatively few regions where we have a significant amount of data do not facilitate any regression analysis that try to utilise exactly a the variation in one region relative to the variation in other regions. A much broader investigation across many more regions will be able to alleviate this problem. Furthermore, the inability to match many firms to underlying performance data from the Amadeus database also cause a unsatisfactory coverage of the life science clusters we want investigate.

3. Framework conditions are important for growth

Based on the results from the regressions analyses alone, we cannot establish statistically, that productivity growth can be *directly* traced from good framework conditions as reported by the firms in the survey. Due to the low number of regions and the high variation in the data within regions, using standard estimation techniques is not fruitful with the data at hand.

The data from the survey still represent a large and unbiased sample of the full population of life-science firms in the selected regions. The quality of the sample enables us to use descriptive analysis of the survey data to identify factors related to good productivity performance for life-science firm. The distribution of all firms in the region compared with the distribution of firms in the survey sample show that the sample is an unbiased sample of all life science firms in the selected regions, cf. Table 3.1.

Table 3.1 Distribution of firms according to size across regions

	Potential firm matches				Actual firm matches			
	Large	**Medium**	**Small**	***Total***	**Large**	**Medium**	**Small**	***Total***
Copenhagen	0%	41%	38%	*15%*	56%	41%	7%	*13%*
Kiel	62%	13%	10%	*20%*	6%	0%	1%	*2%*
Helsinki	0%	13%	16%	*15%*	6%	9%	23%	*20%*
Stockholm	13%	18%	25%	*31%*	22%	38%	44%	*42%*
Malmö	15%	3%	7%	*10%*	0%	6%	11%	*11%*
Gothenburg	10%	13%	4%	*10%*	11%	6%	14%	*13%*
Total for size	100%	100%	100%	100%	100%	100%	100%	100%

Note: Potential matches are firms we identified in the regions while actual matches are firms for which we have collected responses in the survey
Source: Copenhagen Economics and BSR Life Science Survey

This shows us that we have a large random sample of firms, thus allowing us to use descriptive analysis of the survey data. Linking with the estimates of firm performance on productivity reveals some striking results.

- High innovation activity is positively linked to productivity. Innovative life-science firms have, on average, higher productivity than the less innovative life-science firms.
- Innovative firms collaborate more. We have shown that the most innovative life-science firms also collaborate more with local partners within the region were they cluster. The innovative firms collaborate more than their less-innovative neighbouring firms in the same regions. This indicates that there are local innovation spillovers between firms that positively impact on innovation and in turn on productivity.
- Cluster framework conditions matter for innovation and collaboration. Not only does the most innovative firms collaborate more with local partners within their cluster region, they also value the quality of the local framework conditions more. There is high level of inter-firm collaboration when there are good framework conditions, thus cluster policies seems to matter for innovation and collaboration and through those channels leading to higher productivity.

These results enable us to reaffirm that firms who invest in innovation have higher multifactor productivity. From the innovation activities, these firms are able to produce and earn more than less innovative firms with similar size of workforce and production factors, and the productivity of innovative firms is on average higher than less innovative firms.

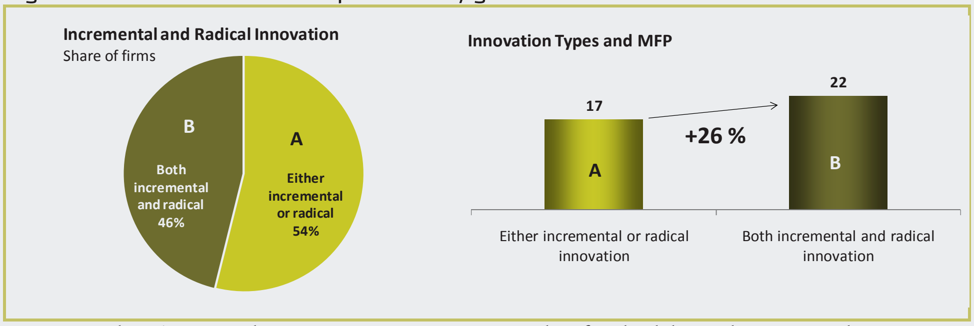
Another finding is that high innovation activity is not just found within a single firm. Often innovation takes place as a result of collaborative efforts, where firms engage in inter-firm research and development projects, e.g. we see that 41 percent of firms report a high level of collaboration on research. Thus, firms utilises knowledge and new ideas developed in cooperation with other firms. This collaboration can take place between direct competitors or between firms over supply chains, i.e. horizontal or vertical collaboration respectively.

Finally, we see that firms have a high level of collaboration in regions where framework conditions are better. It is the framework conditions that, to some extend, are created by active policies. Thus, we are lead to the tentative proposition that active policies that establish good framework conditions ultimately leads to higher firm performance. The evidence from the descriptive analysis suggests that good framework conditions are relevant for firm collaboration, firm collaboration and innovation go hand in hand, and innovation is crucial in productivity gains and firm performance. The next section describes these results in more detail.

3.1. Innovation important for productivity

We find a clear picture that firms that carry out incremental and radical innovation also show the best performance regarding productivity. From the survey, 46 percent of firms engage in both radical and incremental innovation. These firms have, on average, 26 percent higher multifactor productivity compared to those only, cf. Figure 3.1.

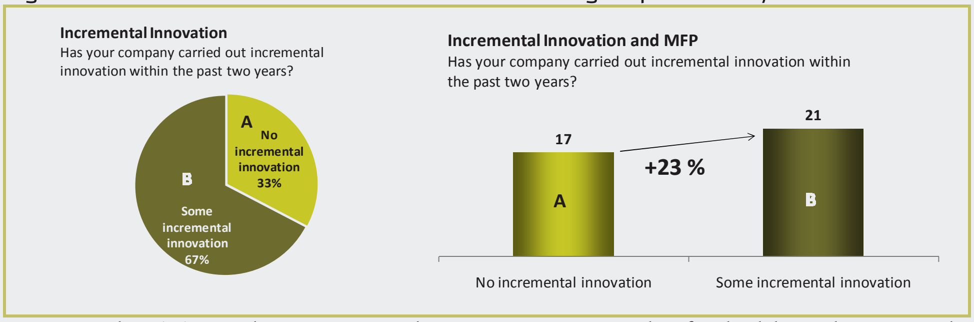
Figure 3.1 Innovation and firm productivity go hand in hand



Note: Based on 622 respondents on innovation. MFP estimated on firm level data and size corrected.
Source: BSR Life Science Survey and Copenhagen Economics Performance Estimations

Examination of firm productivity together with the type of innovation the firms engage in reveals that incremental innovation is the present in the high productivity firms. So, with these data we have shown the importance of innovation for firm productivity. Innovation is key to productivity gains and to stay on the technology frontier, cf. Figure 3.2

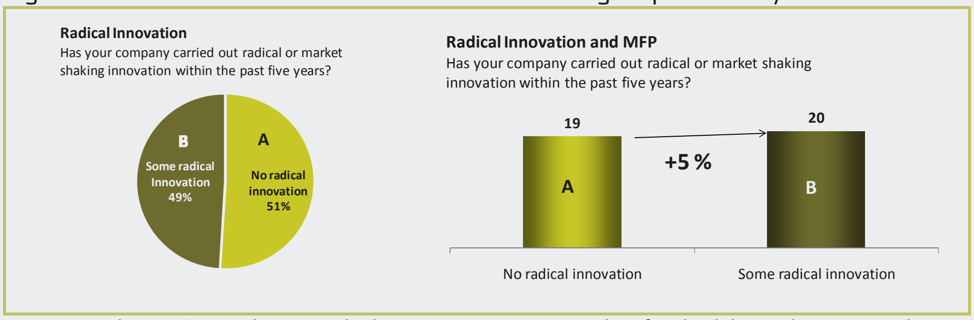
Figure 3.2 Firms with incremental innovation show higher productivity



Note: Based on 626 respondents on incremental innovation. MFP estimated on firm level data and size corrected.
Source: BSR Life Science Survey and Copenhagen Economics Performance Estimations

Equivalently, there only seems to be a little gain in firm productivity when they undertake radical innovation activities, cf. Figure 3.3.

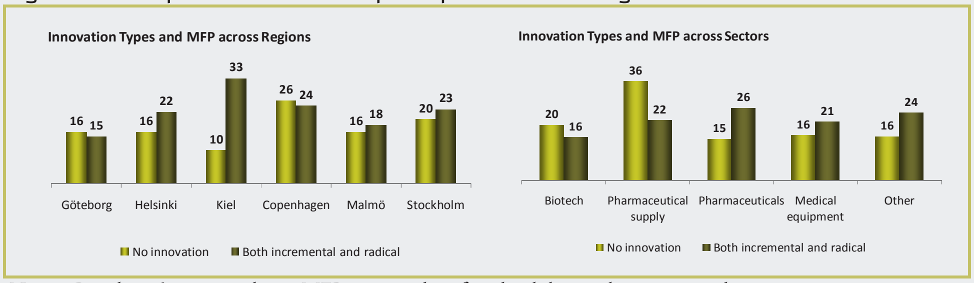
Figure 3.3 Firms with radical innovation have a little higher productivity



Note: Based on 206 respondents on radical innovation. MFP estimated on firm level data and size corrected.
Source: BSR Life Science Survey and Copenhagen Economics Performance Estimations

The result that innovative firms are more productive is found in four of the six regions, where Life Science firms are located. This is the case for Helsinki, Kiel, Malmö and Stockholm, but not in Gothenburg and Copenhagen. Comparing innovation and productivity across subsectors in the life science segment, we also find the relationship of innovation and productivity, except for biotech and pharmaceutical supply, cf. Figure 3.4.

Figure 3.4 The positive relationship is repeated across regions and sectors



Note: Based on 635 respondents. MFP estimated on firm level data and size corrected.
Source: BSR Life Science Survey and Copenhagen Economics Performance Estimations

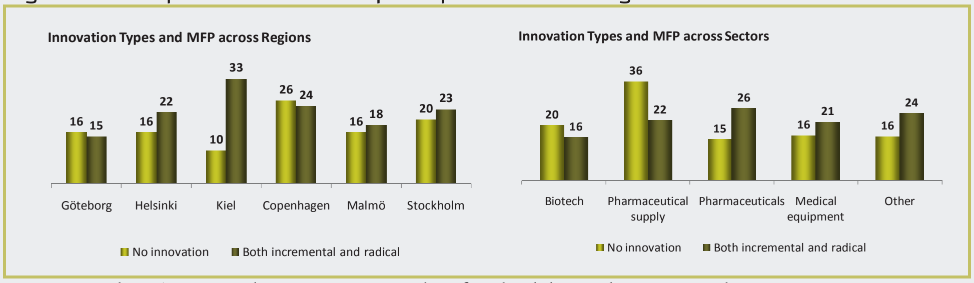
For the pharmaceutical supply sector, this result is not surprising given the low research content in the sector, so innovation is not so important. For the biotech sector the result is puzzling, since this sector engages in huge research and development in order to gain innovation. However, the sector covers both basic research firms and production firms, where the most innovation is carried out in the former and then sold off to the latter. Thus, firms in basic research will not show huge productivity gains, since the technology gains are sold off. And the production firms will show huge gains without engaging in innovation, since they buy in the innovation gains others have found. Thus, the resource intensive innovation activities are undertaken in one firm and utilised in another.

3.2. Firms that innovate also collaborate more

The survey covered 28 regions out of which we have focused on the six main regions in the Baltic Sea Region where the concentration of life science firms is highest. The location of firms in relatively small geographic areas opens for the opportunity for firms to better engage in collaboration on research and development. The geographical proximity gives firms opportunities to engage in corporation and the literature also notes that the geographical proximity is important in order to utilise knowledge spillovers between firms in clusters.

The survey shows that it is a core of firms that collaborate on research and development, ranging from 41 percent of firms in Kiel to 22 percent in Malmö, cf. Figure 3.5.

Figure 3.4 The positive relationship is repeated across regions and sectors



Note: Based on 635 respondents. MFP estimated on firm level data and size corrected.
Source: BSR Life Science Survey and Copenhagen Economics Performance Estimations

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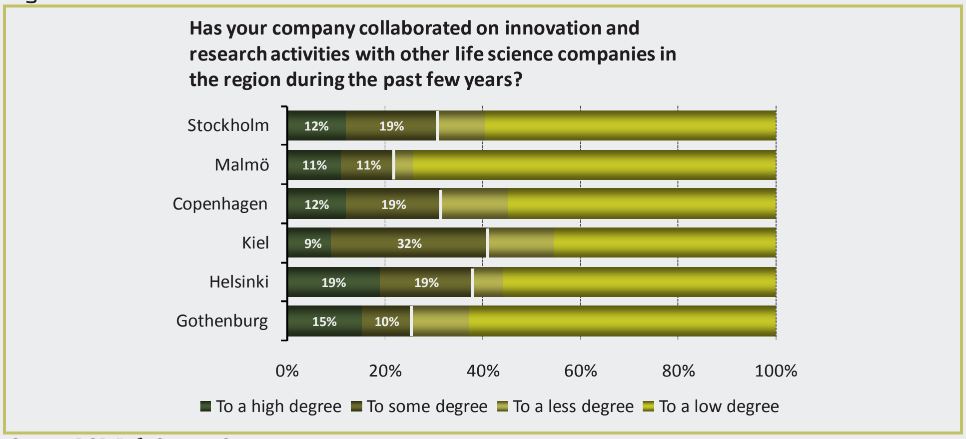
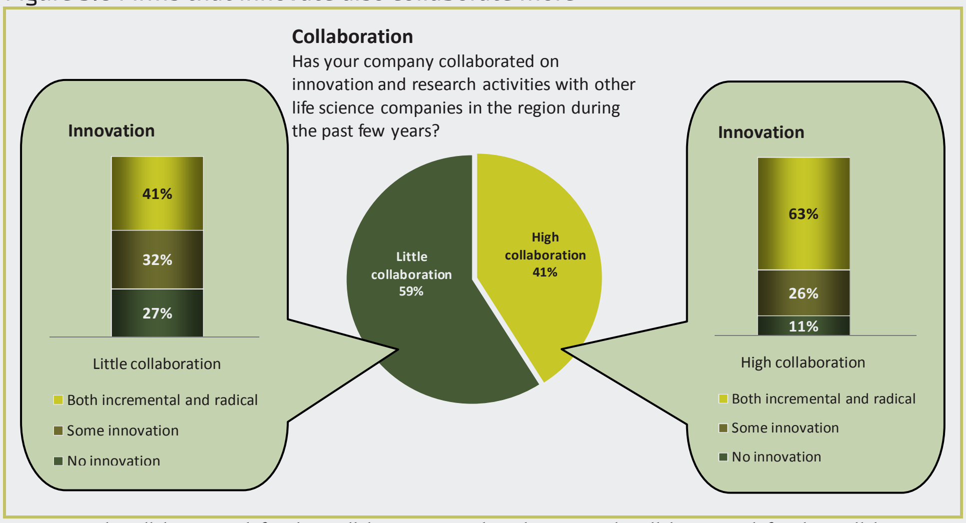
Figure 3.5 A core of firms collaborate on innovation and research



Source: BSR Life Science Survey.

Interestingly, there seems to be a tendency for firms that engage in innovation to also engage in active collaboration with other firms, cf. Figure 3.6.

Figure 3.6 Firms that innovate also collaborate more



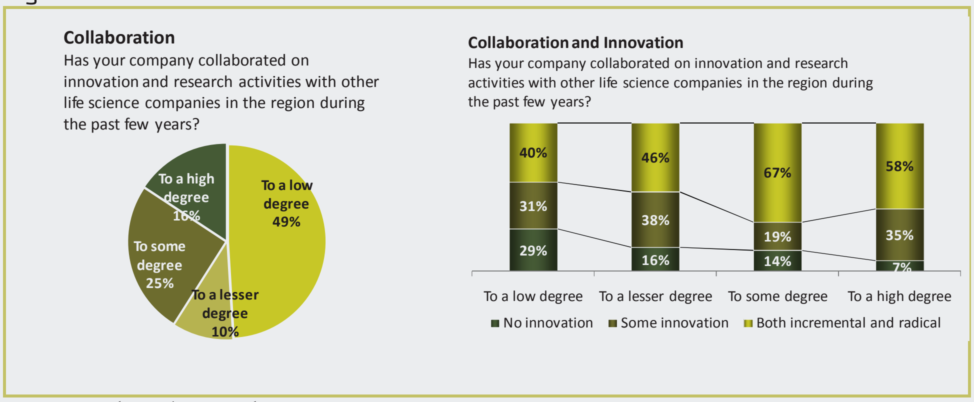
Note: Little collaboration defined as collaboration to a low degree. High collaboration defined as collaboration to a lesser, to some and to a high degree. Based on 545 respondents.
Source: BSR Life Science Survey.

41 percent of firms collaborate with other firms, and from these 63 percent engage in both incremental and radical innovation. While the pattern for firms not collaborating, only 41 percent invest in both types of innovation. The most innovative firms clearly tend to collaborate more, while the less innovative firms show less interest in participating in collaboration with partners.

A further breakdown of the level of collaboration firms engage in confirms the pattern. The most innovative firms are the ones who collaborate on innovation and research the most.

The results further shows that firms who collaborate to some degree and to a high degree, carry out much more innovation than firms that collaborate to a less on to a low degree. Out of all the firms, 16 percent respond that they collaborate to a high degree, and of these 58 percent are firms that engage in both types of innovation. Of all firms, 25 percent respond they collaborate to some degree, and of these 67 percent undertake innovation. At the same time, innovation is not that outspoken for firms that do not collaborate that much, cf. Figure 3.7.

Figure 3.7 Further breakdown of collaboration confirms the innovation content



Note: Based on 545 respondents.
Source: BSR Life Science Survey.

These results indicate that innovation and collaboration on research and development are closely related, perhaps because research and development are time and resource consuming activities, requiring a pooling of resources to achieve fruitful innovation for firms.

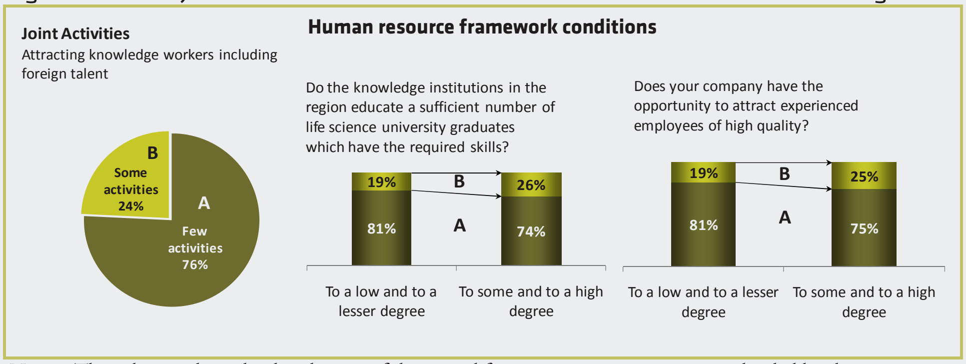
3.3. Higher collaboration the better the framework conditions

Firms are influenced by the framework conditions present in the regions where they are located. The surveyed firms have also indicated the perceptions of the framework conditions in their region. Framework conditions are of interest, since it is these conditions that policy-makers and governments, local and national, can influence.

We do not find evidence of a direct causal relationship between the framework conditions and firm performance, as measured by their productivity. However, we can see that collaboration concerning human resources and knowledge creation are stronger in regions with favourable framework conditions. We, therefore, assume that the link from framework conditions to performance is indirect and goes via collaboration.

From the survey data, we find that firms who collaborate on recruitment also evaluate the availability of highly qualified professionals to be good in their respective regions. 24 percent of firms report a joint recruitment effort, while these firms also report that they have a better job market to recruit from, cf. Figure 3.8.

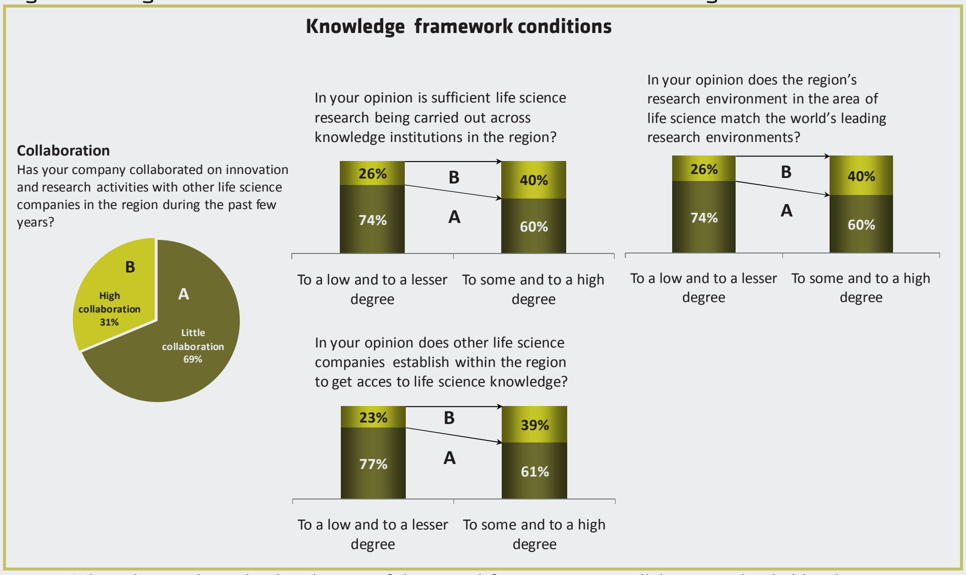
Figure 3.8 More joint activities when human resource framework conditions are good



Note: The columns show the distribution of the extend firms engage in joint activities divided by their perceptions of the human resource framework conditions.
Few activities defined as participation in joint activities to a low degree. Some activities defined as participation in joint activities to a lesser, some and to a high degree. Based on 545 respondents.
Source: BSR Life Science Survey.

Equivalently, firms that collaborate on research and development also respond that the overall framework condition of knowledge production in their region is much better, cf. Figure 3.9.

Figure 3.9 High collaboration on research the better the knowledge framework



Note: The columns show the distribution of the extend firms engage in collaboration divided by their perceptions of the knowledge framework conditions.
Few activities defined as participation in joint activities to a low degree. Some activities defined as participation in joint activities to a lesser, some and to a high degree. Based on 552 respondents.
Source: BSR Life Science Survey.

These results indicate the importance for firms to gain access to the knowledge production in the region. A better availability of research and access to researches at universities seem to engage firms in wider cooperative networks where they can develop new products and production methods.

This result is in line with other research on productivity in life science. In a detailed analysis of productivity growth and knowledge spreading amongst U.S. based life-science firms over a ten year period[7], the economists Furman, Kyle, Cockburn and Henderson asked the key question: has spillovers an effect on productivity? And are they local?

The answer to both questions was "yes". The team of researchers from the Duke University showed that pharma firms benefit from research results from all over the world. The local effect, though, is nearly twice as strong. That is, firms around the world are better off when researchers in the Copenhagen area publish more articles related to a specific disease or treatment, but the firms with drug discovery labs in the Copenhagen area realize the most gains.

[7] Se Furman, J.L., M.K.Kyle, I. Cockburn, and R. Henderson (2004),"Public and Private Spillovers, Location, and the Productivity of Pharmaceutical Research", Mimeo, Duke University.
http://www.duke.edu/~mkyle/Spillovers%20Location%20Productivity%20-%20Sept-04.pdf

4. Policies matter

From the regression analyses, we were unable to establish a significant relationship between favourable framework conditions and firm performance. The data did not allow for the regression analysis to establish a strong significant relationship that good framework conditions are the source of growth in the life-science industry. This, however, could indeed be improved by a wider and broader investigation of the life-science industry, not just in the Baltic Sea Region, but covering more regions with strong clustering. This way, much richer data can be collected and will most certainly provide stronger results on the impact of framework conditions on productivity and growth in the industry.

From the descriptive results, we can see that improvement of the framework conditions in a life science cluster region will enable *and* engage firms in more collaborative efforts, spurring the overall innovation effort of the life science firms in the region. In turn, this increases the level of innovation for these firms leading to higher firm-level productivity, and finally more growth in the region hosting the life science cluster. We conclude that cluster policies matter for productivity of life-science firms in the Baltic Sea region.

Appendix 10 Leverances of WP4 in the BSR InnoNet

Reports

Towards fact-based cluster policies – Learnings from a pilot study of life sciences in the Baltic Sea Region
FORA, 2009

Internal Summary Report WP4, BSR InnoNet
FORA, 2008

The use of data and analysis as a tool for cluster policy – an overview of international good practices and perspectives prepared for the European Commission
Emily Wise, Lotte Langkilde and FORA, 2008

Benchmarking Cluster Performance – A Tool for Policy. Technical Background Report on Cluster Compositions
FORA, 2007

The Cluster Benchmarking Project. Benchmarking cluster in the knowledge based economy. Project pilot report
FORA, 2006

Working Papers

Policy paper – recommendations on how to work with fact-based cluster policy in the future
FORA, 2008

Cluster Dynamics in the BSR's 31 regions – background paper
FORA, Copenhagen Economic, Emily Wise, 2008

Life science klyngedata I BSR: Beskriver de danske tal den klynge vi kan observere?("Life science cluster data in the BSR. Does the Danish data describe the cluster that we are observing?")
Riis Consulting, 2008

Den danske life science klynge: performance i den samlede klynge samt dynamik og performance i delklyngerne. ("The Danishlife science cluster: performance in the overall cluster – and dynamics and performance in the sub-clusters").
Riis Consulting, 2008

Den danske life science klynge: Hvilke rammebetingelser er afgørende for klyngens succes?("The Danish life science cluster: Which framework conditions are critical to the cluster's success?")
Riis Consulting, 2008

Workshops

Methodologies and Indicators for Analyzing and Benchmarking Cluster-Specific Framework Conditions
FORA, 2008

Using Statistical Cluster Data for Policy Making
FORA, 2007

Database

BSR Cluster database
FORA, 2009

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