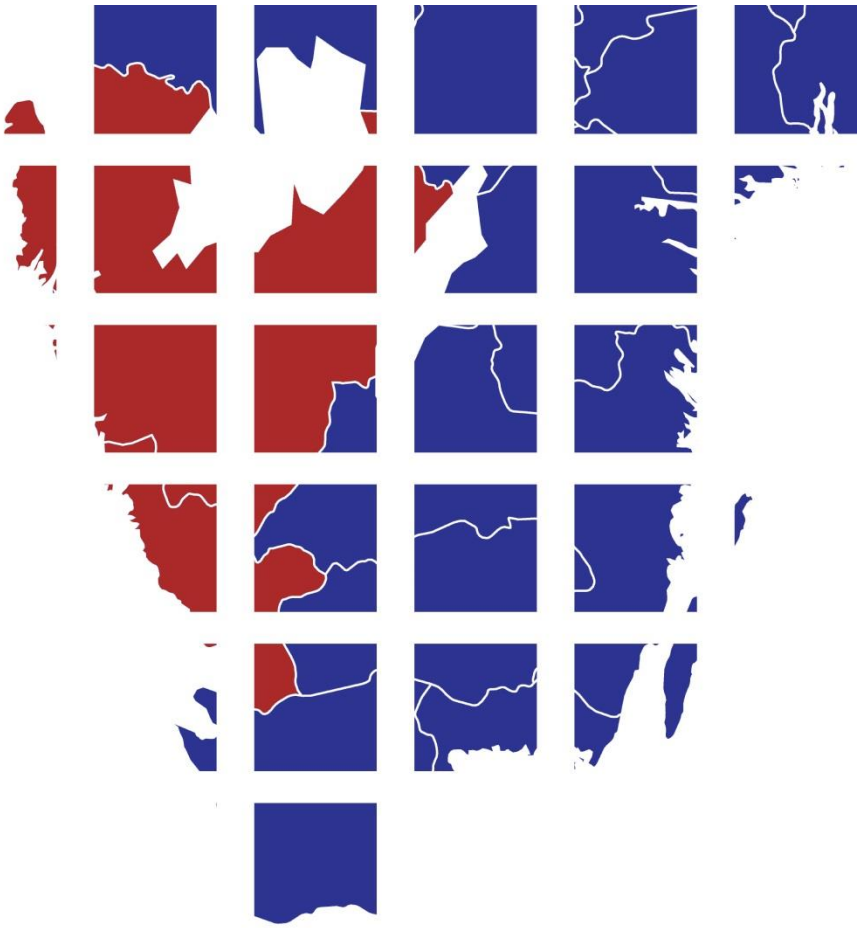
Cutting Edge Technologies in West Sweden

November 2017



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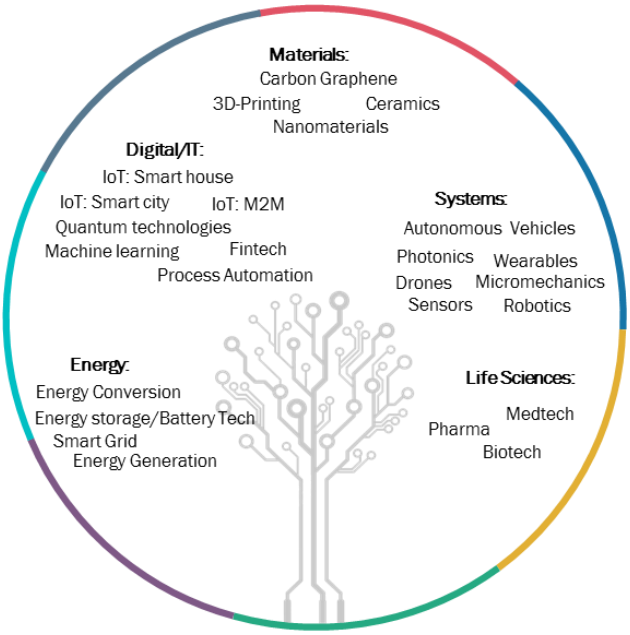
1 Introduction

Technological progress is the most important driver of competitiveness and prosperity and its importance will likely become even more pronounced as increasing tendencies towards protectionism negatively affect other traditional growth drivers such as world trade. Unfortunately, up until now, technological progress has been hard to measure and is usually measured either as a residual variable or with auxiliary variables such as research expenditure or the number of researchers. Moreover, most of these analyses are done on the industry level which has its limitations because companies are only categorized into one sector regardless of their countless activities and their specific usage of technologies.

BAK Economics, together with the Swiss Federal Institute of Intellectual Property, has, therefore, developed a new approach that allows the measurement, analysis and assessment of research and technology activities of companies, regions and countries in a global comparison based on the international patent system.[1] This means strengths, weaknesses and dynamics in the technology portfolios of companies and regions can be analysed more effectively, and consistent comparisons can be drawn. To do this, the definition of "technology fields" has had to be refined given that the current definition of "technology fields" by the World Intellectual Property Organization (WIPO) does not cover the latest technological trends. BAK has developed new technology definitions that make it possible to evaluate activities in cutting edge technologies that will be crucial for future economic growth.[2]

Fig. 1-1 Cutting edge technologies



Source: BAK Economics, Swiss Federal Institute of Intellectual Property

[1] Patents are analysed according to the researcher's address on the patent filed. This approach allows for the identification of the region where the research has actually taken place and circumvents the potential problems arising from international companies which apply for patent ownership via their headquarters.
[2] See annex for the complete list of cutting edge technologies and its sub-technologies.

In addition, instead of merely conducting a volume analysis of patent developments, this new approach also focuses on evaluating the research efficiency of companies and regions. Every single patent worldwide is categorized (according to region, country, company/institute, technology) and rated according to patent strength. The evaluation of patent strength (asking, i.e., how many patents in a specific technology can be considered world class innovations) makes it possible to connect quality and quantity in an intelligent manner. The patent strength is evaluated for each patent worldwide and is comprised of two components: the patent activity and the patent quality.

The patent activity corresponds to its market coverage, i.e. the statutory coverage of the patent protection, and it shows how companies assess the importance of their own inventions (revealed preferences). Since patent protection is costly, an extensive international market coverage signals that the patent applicant thinks that its patent is promising (self-assessment). The patent quality corresponds to the relevance of the technology and, based on the references and citations of the patent by third parties, shows how important an invention is in comparison to other patents in the corresponding technology (competitors' assessments).

Taken together, patent quality and patent activity comprise the overall evaluation of the patent or patent portfolio and can be evaluated according to a wide variety of criteria, in particular, according to specific technologies. The result is a rating in deciles where the top 10% of patents in every technology in the world are defined as top impact patents. The number of top impact patents can then be interpreted as reflecting the quality of the research, while the share of top impact patents can be taken as a sign of the efficiency of the research.

This new approach has been used in this report to analyse the technology development in West Sweden since 2000. Six technology sets (total cutting edge technologies, Systems, Energy, Materials, Digital/IT, Life Sciences) have been defined to compare West Sweden with relevant sample regions (Oslo, Stockholm, Oresund, Hamburg, Stuttgart, Randstad, Torino, San Francisco, Detroit and Boston) with regard to their competitiveness in these technologies. In the first part of the analyses, a time series analysis is used to show the development of both total patents and world class patents in West Sweden and in the sample regions in each of the selected cutting edge technologies since 2000. It is possible to specifically show where West Sweden is positioned in certain future technologies around the world and how its performance has evolved compared to the sample regions.

In the second part of the study, technology profiles for each of the cutting edge technologies are produced for the most important innovative companies in West Sweden (Ericsson, Volvo, Geely, Autoliv, Borealis, General Electric, General Motors and Astra Zeneca). The comparison of a company's worldwide patent activities with the regional activities in West Sweden shows the specific technology focus of these companies in West Sweden.

2 Cutting edge technologies in West Sweden and sample regions

This chapter will present a comparison of West Sweden with ten relevant sample regions regarding innovation abilities in cutting edge technologies. The first step of the analysis was to find and choose the most relevant regions to compare to West Sweden. This choice followed several, specific criteria. First, regions such as Stuttgart with a similar sector focus to West Sweden (with a high share of automotive industries and/or manufacturing) were chosen. Second, regions such as Oslo and Stockholm with similar population and geographical situation were included. Third, US regions such as San Francisco and Boston that are currently leading regions in cutting edge technologies were also added in order to compare West Sweden with the most innovative regions in the world.

To achieve a high quality regional benchmarking, it is essential to choose the right definition and size of the region. Within this parameter, economic actors cooperate, workers flow and new ideas pass through the innovation chain. Today, a city relies more than ever on its economic outskirts. Therefore, the concept of functional urban regions was used for the geographic delimitations of the regions. A functional urban region consists of a core city and the functionality associated with surrounding areas that heavily depend on one another. In particular, commuting patterns are an important factor in determining the size of a functional urban region.

As a result, the following regions were chosen and compared:

Tab. 2-1 Sample regions

Regions	Core City	Country	Region Type	Population (2015)
Metropolitan Region Stuttgart	Stuttgart	DE	Metropolitan Region	4'363'191
Metropolitan Region Hamburg	Hamburg	DE	Metropolitan Region	4'792'397
Metropolitan Region Turin	Torino	IT	Metropolitan Region	3'305'962
Oresund	Copenhagen-Malmo	DK/SE	Border Region Copenhagen-Skane	3'872'392
Oslo, Akershus and Östfold	Oslo	NO	Metropolitan Region	1'521'221
Randstad	Amsterdam	NL	Metropolitan Region	8'022'870
Stockholm	Stockholm	SE	Riksområden	2'198'040
Detroit-Warren-Dearborn	Detroit	US	Metropolitan Statistical Area	4'302'043
Boston-Cambridge-Newton	Boston	US	Metropolitan Statistical Area	4'774'321
San Jose-San Francisco-Oakland	San Francisco	US	Metropolitan Region	8'571'458
West Sweden	Gothenborg	SE	Riksområden	1'942'680

Source: BAK Economics

For a better readability, the name of the core city was used to denote most regions in this report with the exception of Oresund, Randstad and West Sweden.

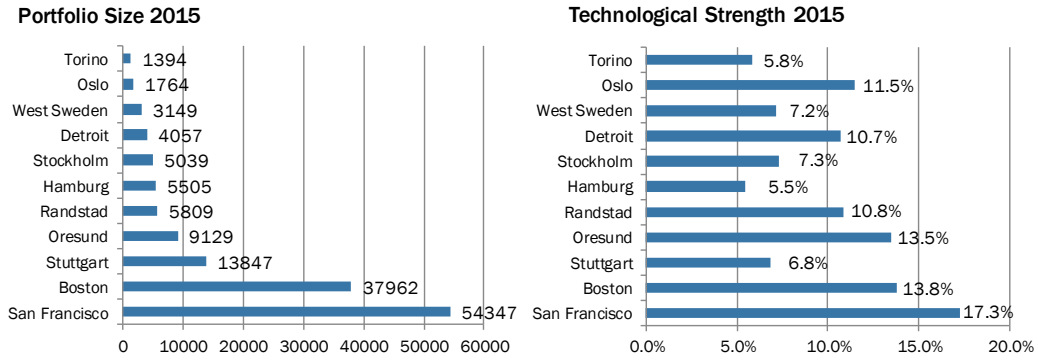
2.1 Development of total patents in cutting edge technologies

2.1.1 Patent portfolios in cutting edge technologies

The patent portfolio size in cutting edge technologies varies significantly between the different sample regions. In 2015[3], the US regions of San Francisco and Boston held by far the largest patent portfolios with 54'347 and 37'962 patents respectively. Torino held the smallest number of cutting edge technology patents with only 1'394. In West Sweden, there were 3'149 active cutting edge patents in 2015.

Moreover, there are noticeable differences concerning each region's technological strength which is measured by how many of its total cutting edge patents are considered world class patents. In San Francisco, 17.3% of all patents in cutting edge technologies can be included in the global top 10% of patents with the most competitive impact. This equals a total amount of 9'407 world class patents from San Francisco alone and proves that research efficiency is particularly high in San Francisco. By contrast, Hamburg's share of world class patents reached only 5.5% in 2015. West Sweden's technological strength is also below average compared to the sample regions. Only 7.2% of all patents from West Sweden in cutting edge technologies are part of the global top 10%. In absolute terms, this amounts to 226 active world class patents from West Sweden in 2015.

Fig. 2-1 Portfolio size / technological strength in cutting edge technologies

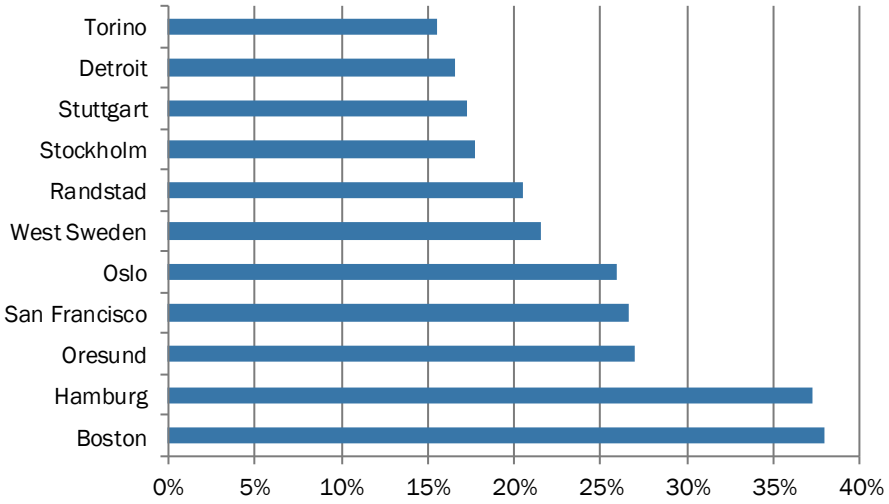


Portfolio Size: Number of patents in 2015 by region (residence of named researcher) in cutting edge technologies
Technological Strength: Share of patents belonging to the global top 10% patents with the most competitive impact
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

When comparing the number of cutting edge patents in a region with the number of total patents in all technology fields, Boston and Hamburg clearly show the strongest focus on cutting edge technologies. In each of these regions in 2015, more than 35% of all their patents belonged to cutting edge technologies. By contrast, this share is only slightly above 15.5% in Torino. In West Sweden, 21.6% of all patents are cutting edge patents.

[3] Patent numbers are measured by the end of a calendar year.

Fig. 2-2 Share of cutting edge patents of total patents in 2015



Share of cutting edge patents of total patents in all technologies in 2015 in %
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

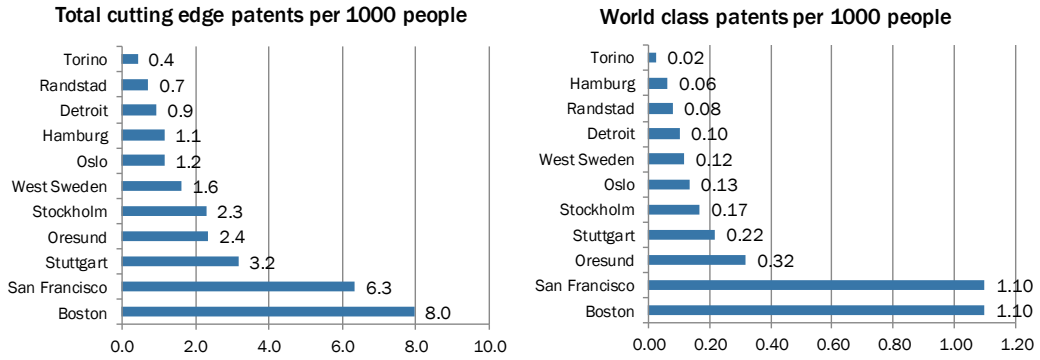
2.1.2 Patent portfolios per capita in cutting edge technologies

When the population size of the sample regions is taken into account, Boston and San Francisco remain the leading regions regarding patent portfolios in cutting edge technologies. In 2015, in Boston there were 8.0 cutting edge technology patents per 1000 people and in San Francisco, there were 6.3. These two US regions also achieved the best results with respect to world class, cutting edge patents per capita. In both regions, there were 1.1 world class, cutting edge patents per 1000 people in 2015.

Among the European sample regions, Stuttgart reached the highest score with 3.2 total cutting edge patents per 1000 people. However, in terms of world class, cutting edge patents, Oresund was slightly better with 0.32 per 1000 people (Stuttgart: 0.22). In West Sweden, there were 1.6 total cutting edge technology patents and 0.12 world class, cutting edge patents per 1000 people in 2015. As a consequence, when population size is accounted for, West Sweden's benchmarking result is slightly better than it is in absolute terms.

However, it should be noted that absolute cutting edge patent numbers are a more relevant indicator of innovation ability than relative numbers since it is important for regions to reach a certain “critical mass” in technologies in order to be attractive as a research location, and to benefit from positive cluster and network effects. Therefore, the analysis in the rest of this chapter will be based on absolute patent numbers.

Fig. 2-3 Portfolio size per 1000 people in cutting edge technologies

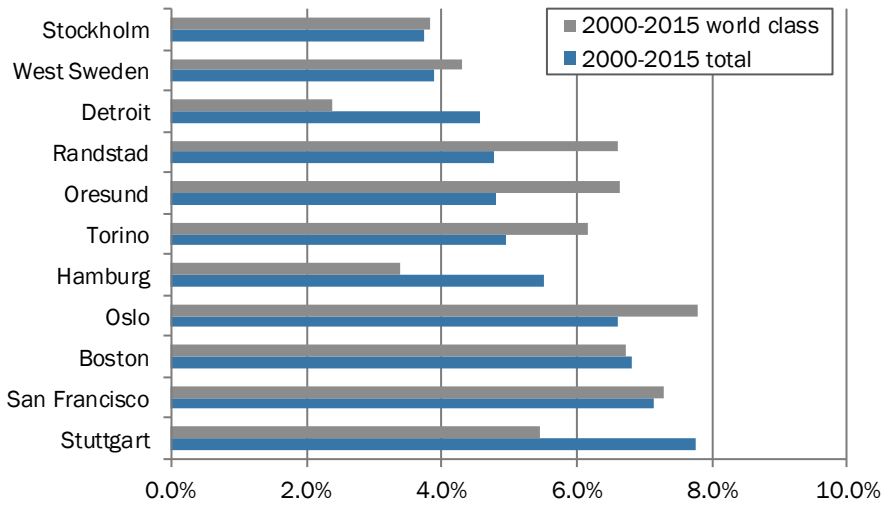


Number of patents per 1'000 people in 2015 by region (residence of named researcher) in cutting edge technologies
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

2.1.3 Patent development in cutting edge technologies

Between 2000 and 2015, the relevance of cutting edge technologies increased significantly. This is reflected in the growth of patent numbers in these technologies. The US regions of San Francisco and Boston not only own the largest patent portfolios in cutting edge technologies, they have also achieved dynamic growth rates in their patent numbers. Between 2000 and 2015, the number of patents in cutting edge technologies increased by 7.1% per year in San Francisco and 6.8% in Boston. The number of world class patents rose at roughly the same rate in these two US regions. Despite this laudable increase, the most dynamic region has been Stuttgart with an average patent growth of 7.8% per year. By contrast, Stockholm and West Sweden experienced the lowest growth rates of all selected regions. When looking only at world class patents, Oslo reached the highest growth rate in the last 15 years. However, despite this growth, Oslo's portfolio of world class, cutting edge patents is still quite small with only 203 in 2015 – the second lowest value of all sample regions.

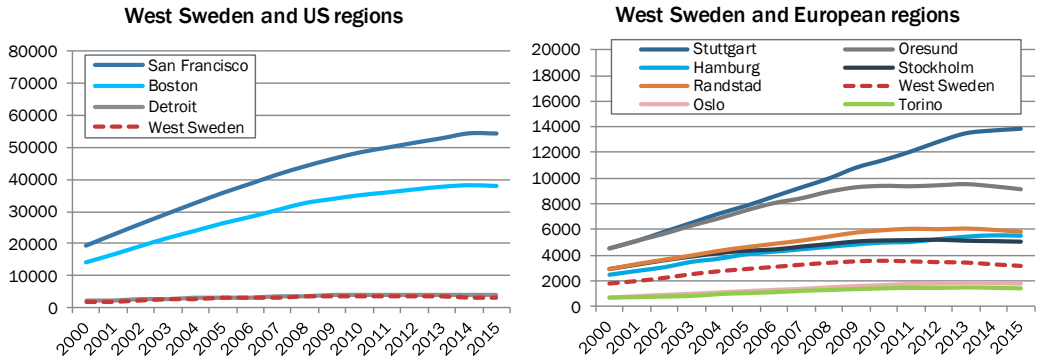
Fig. 2-4 Patent growth in cutting edge technologies



Patent growth in cutting edge technologies per year between 2000 and 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

Remarkably, patent growth in cutting edge technologies has slowed down in all sample regions over the last five years. While the number of patents increased by an average of 8.0% per year in the selected regions between 2000 and 2010, patent growth has only been slightly positive since 2010 (+0.8% per year). This is also the case in West Sweden, where the number of patents in cutting edge technologies actually decreased by 2.4% per year between 2010 and 2015. The main reason for this trend is that the number of active Life Sciences patents has decreased in many regions in recent years. By contrast, the number of patents is still growing in the other cutting edge technologies (such as Materials, Systems, Energy, Digital/IT).

Fig. 2-5 Patent development in cutting edge technologies



Total number of patents in cutting edge technologies
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

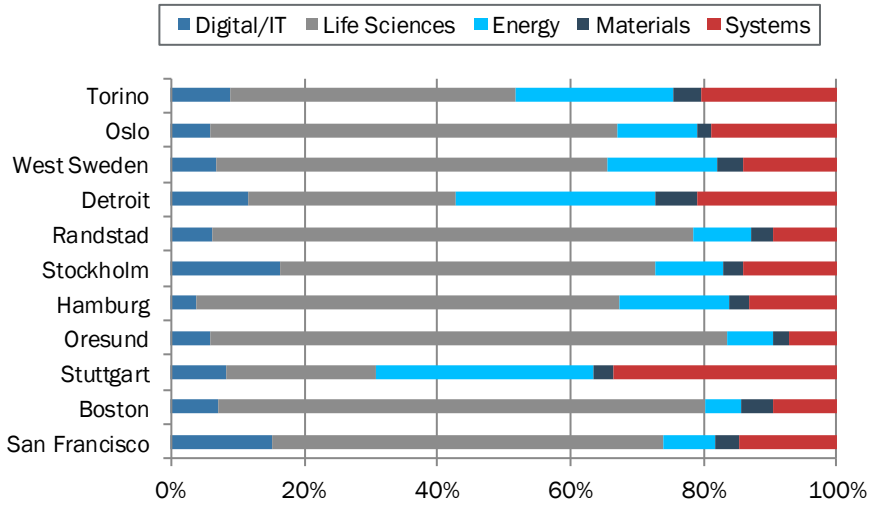
2.1.4 Technology profiles of cutting edge technologies in the sample regions

In many sample regions, a major part of cutting edge patents belongs to the Life Sciences technology segment. By contrast, the number of patents in the materials segment is still relatively small in all regions.

In Oresund, Boston and Randstad, Life Sciences patents account for more than 70% of all patents in cutting edge technologies. Only in Stuttgart is the number of patents higher in other technology segments (Energy and Systems). Like Stuttgart, Detroit has a similar technology focus with a relatively even distribution of patents in three segments (Life Sciences, Energy and Systems). In West Sweden, Life Sciences patents account for almost 60% of all patents in cutting edge technologies. However, its share of Life Sciences patents of total cutting edge patents decreased from 75.8% in 2000 to 58.9% in 2015. Energy (16.3%) and Systems (14.0%) were its two other important technology segments in 2015.

In most regions, the distribution of world class patents follows a similar pattern to the distribution of total patents in cutting edge technologies. However, there are some differences. For example, Torino's share of world class Energy patents of all world class, cutting edge patents is significantly higher than its share of Energy patents of all cutting edge patents. This shows that Torino's research efficiency is particularly high in this cutting edge technology segment.

Fig. 2-6 Technology profiles of cutting edge technologies in benchmark regions



Share of the different technology segments of total cutting edge patents in % at the end of 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

2.2 Development of patents in Digital/IT

2.2.1 Patent portfolios in Digital/IT

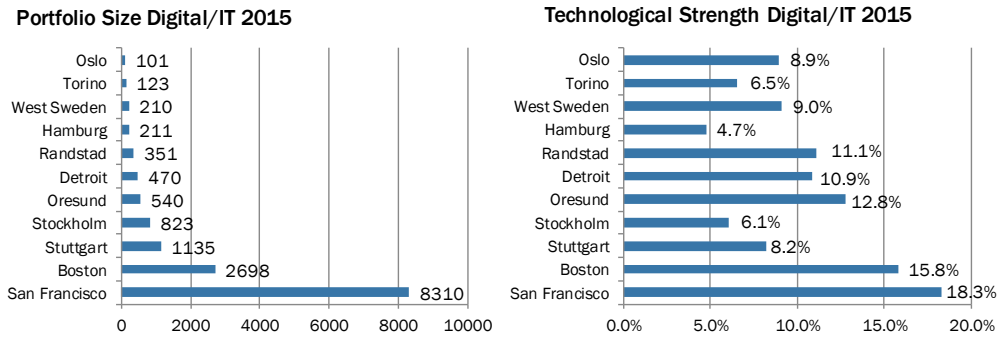
Digital/IT is one of the most dynamic cutting edge technologies. In many sample regions, research activities have intensified substantially in recent years. This is reflected in the high growth rates of Digital/IT patents. Digital/IT consists of the categories Machine Learning, Fintech, Internet of Things: Machine to Machine (IoT:M2M), Smart House, Smart City, Process Automation and Quantum Technologies.

In the technology segment of Digital/IT, the US regions of San Francisco and Boston are the leading research regions. There were 8'310 active Digital/IT patents originating from the San Francisco region in 2015. Moreover, its research efficiency is excellent as 18.3% of its patents are world class patents. The region has a particularly strong research focus in the fields of Machine Learning and Fintech. Boston is a distant second with 2'698 total Digital/IT patents that include 426 world class patents. The focus of research in the Boston region is on Quantum Technologies.

In Europe, Stuttgart is a leading research hub among the sample regions. In 2015, 1'085 Digital/IT patents were developed there, however, its research efficiency is not particularly high and only 8.2% of these patents are world class patents. Stuttgart's research focus is clearly on the field of Process Automation.

West Sweden owned 210 active Digital/IT patents in 2015. This research efficiency is slightly below average as only 9% of these patents are world class patents. The two most important research segments in West Sweden are IoT:M2M (58 patents) and Process Automation (47). However, its highest number of world class Digital/IT patents can be found in the field of Machine Learning (6 patents).

Fig. 2-7 Portfolio size / technological strength in Digital/IT



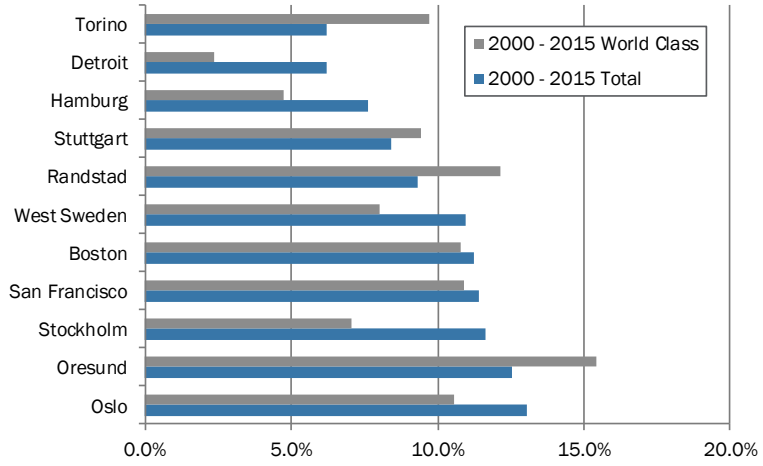
Portfolio Size: Number of active patents in 2015 by region (residence of named researcher) in Digital/IT
Technological Strength: Share of patents belonging to the global top 10% patents with the most competitive impact
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

2.2.2 Patent development in Digital/IT

Since 2000, technology development in Digital/IT has been dynamic in all selected regions. When looking at total patents, Oslo achieved the strongest growth between 2000 and 2015 (+13.1% per year). However, the absolute number of Digital/IT patents developed there is still the lowest of all sample regions (101 in 2015). Regarding world class Digital/IT patents, Oresund has seen the most powerful development (+15.4% per year). San Francisco and Boston, despite their already large patent portfolios, also experienced high patent growth rates both in total patents and in world class patents in Digital/IT. Therefore, since 2000, San Francisco and Boston have further increased their lead in absolute terms in Digital/IT patents.

Growth of total Digital/IT patents has also been high in West Sweden as the number of patents increased from only 44 in 2000 to 210 in 2015. This is an average growth rate of 11% per year. However, its number of world class patents has risen a little bit less dynamically (from 6 in 2000 to 19 in 2015).

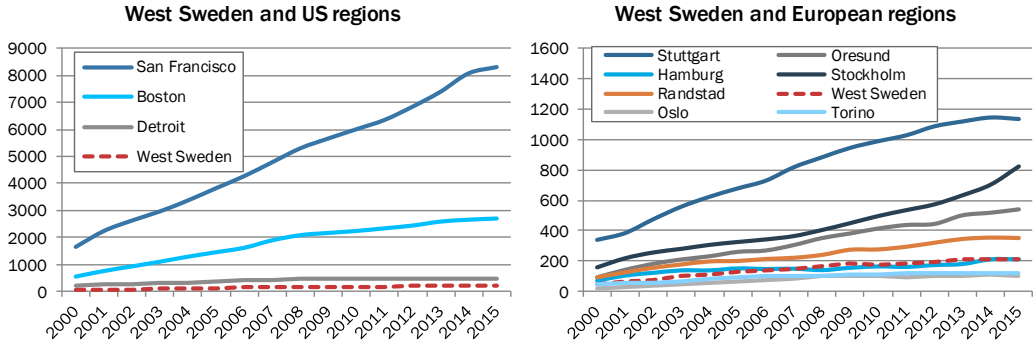
Fig. 2-8 Patent growth in Digital/IT



Average patent growth by region per year between 2000 and 2015 in Digital/IT
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

Although patent growth in Digital/IT has been relatively steady in most regions over the last 15 years, it has recently slowed down in Stuttgart and has accelerated in Stockholm.

Fig. 2-9 Patent development in Digital/IT



Total number of patents by region in Digital/IT
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

2.3 Development of patents in Life Sciences

2.3.1 Patent portfolios in Life Sciences

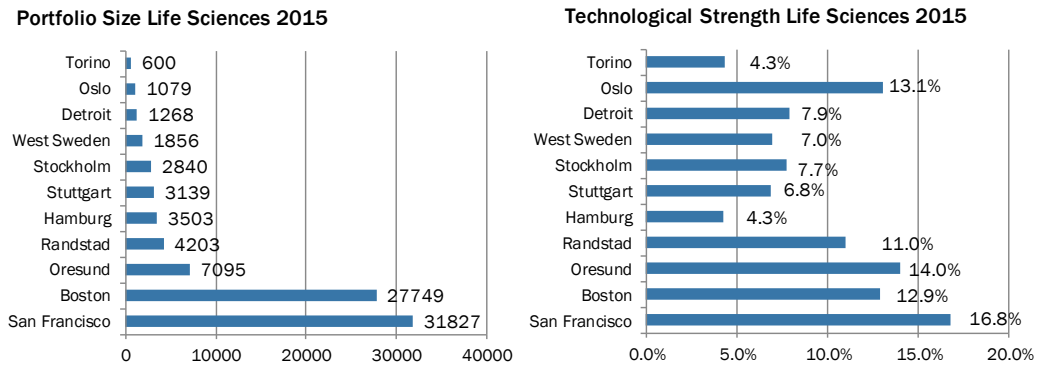
Life Sciences is one of the most mature cutting edge technologies and there are sizeable research activities in most of the sample regions. This is reflected in the very high number of patents. Indeed, of all cutting edge patents the share of Life Sciences patents is higher than 50% in most selected regions. Life Sciences consists of the categories Medtech, Pharma and Biotech.

As in most of the other cutting edge technologies, the US regions of San Francisco and Boston are the leading research regions in Life Sciences. In 2015, there were 31'827 active Life Sciences patents from San Francisco and 27'749 from Boston. These two regions also excel at research efficiency. As a result, 12.9% of all Life Sciences patents from Boston and an impressive 16.8% of all Life Sciences patents from San Francisco are considered to be world class patents. Most Life Sciences patents from San Francisco belong to the Medtech category, while the most important Life Sciences categories in Boston are Pharma and Biotech.

Among the European regions, Oresund is a major Life Sciences research hub. In 2015, there were 7'095 Life Sciences patents from Oresund and 861 of these patents were world class patents. This shows that in Oresund, not only is the quantity of research quantity, but the efficiency of that research is also above average.

In West Sweden, the number of Life Sciences patents reached 1'856 in 2015. However, only 7.0% of these patents were classified as world class patents. Around 60% of all Life Sciences patents from West Sweden belong to the Medtech subcategory.

Fig. 2-10 Portfolio size / technological strength in Life Sciences



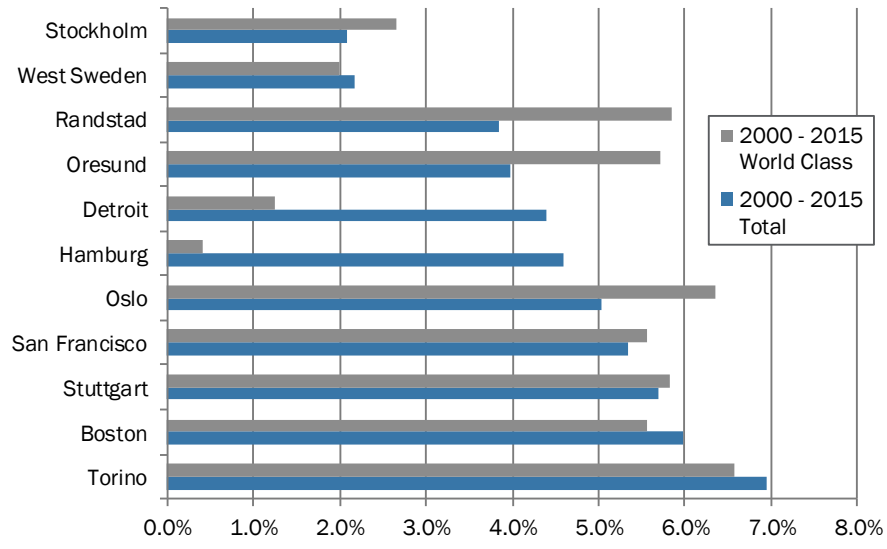
Portfolio Size: Number of active patents in 2015 by region (residence of named researcher) in Life Sciences
Technological Strength: Share of patents belonging to the global top 10% patents with the most competitive impact
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

2.3.2 Patent development in Life Sciences

While Torino saw the highest growth rate of Life Sciences patents between 2000 and 2015, this growth started from a very low level meaning that its number of Life Sciences patents remains smaller than in every other sample region. Thus, its scope of research activities is also still limited. Oslo has seen very dynamic development of world class patents over the last 15 years with an average growth of 6.3% per year. Most of its research activities focus on the Pharma field. However, the absolute level of Life Science patents developed in Oslo is still relatively small.

In West Sweden, the growth of Life Sciences patents has been disappointing given that the number of patents only increased from 1'345 in 2000 to 1'856 in 2015. This is an average growth rate of 2.2% per year. Its number of world class patents has risen even more slowly (from 96 in 2000 to 129 in 2015).

Fig. 2-11 Patent growth in Life Sciences

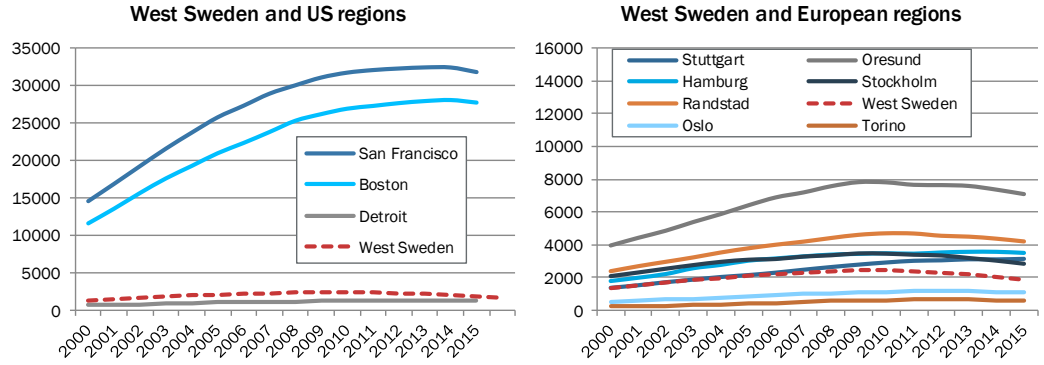


Average patent growth per year in Life Sciences between 2000 and 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

The development of Life Sciences patent portfolios over the last 15 years shows a similar pattern in most of the sample regions. While the number of Life Sciences patents increased very dynamically between 2000 and 2009, patent numbers have been decreasing since then. In particular, many Pharma patents have expired in the last few years and the number of new patent applications has not been high enough to compensate for this. In West Sweden, the number of Pharma patents reached a peak in 2009 (with 772 patents), but has declined significantly since then, arriving at 438 in 2015.

In general, there has been a trend of decreasing Pharma patent numbers in industrial countries in the last few years. This is mainly caused by the shrinking patent portfolios of many big pharmaceutical companies in the West. However, it is worth noting that the number of both total and world class Pharma patents from Asia and, in particular, from China is still growing dynamically.

Fig. 2-12 Patent development in Life Sciences



Total number of patents in Life Sciences by region
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

2.4 Development of patents in Energy

2.4.1 Patent portfolios in Energy

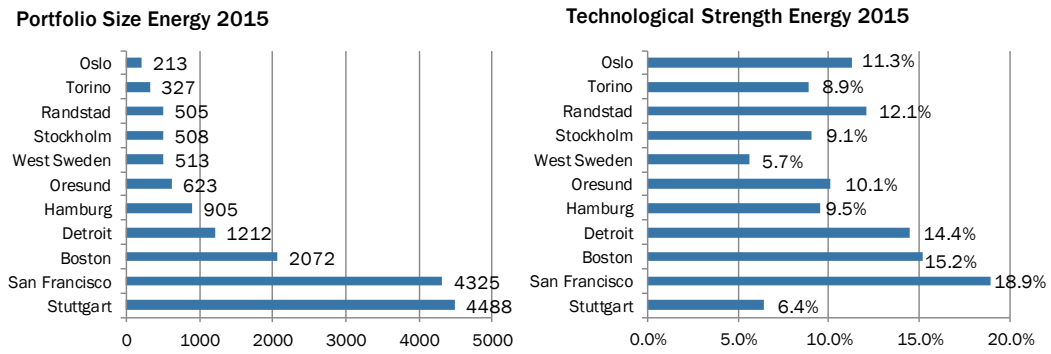
The cutting edge Energy segment consists of the subcategories Energy Conversion, Energy Generation, Smart Grid and Energy Storage /Battery Tech.

Stuttgart is a leading research hub in the Energy technology segment and in 2015, its patent portfolio reached 4'488 patents. San Francisco, with 4'325 valid patents, ranks a close second, but its research efficiency is substantially higher. As a result, there are 818 world class Energy patents from San Francisco compared to only 287 from Stuttgart. In Stuttgart, most of its research activities focus on Energy generation (2'106 patents in 2015). In San Francisco, the majority of patents are in Energy Generation and Energy Conversion. Boston is another important Energy research location with 2'072 patents and 315 world class patents.

West Sweden held 513 valid Energy patents in 2015. The research efficiency is below average as only 5.7% of these patents are world class patents. As is the case in

most sample regions, the majority of West Sweden's Energy patents belong to the category of Energy Generation (348 patents).

Fig. 2-13 Portfolio size / technological strength in Energy

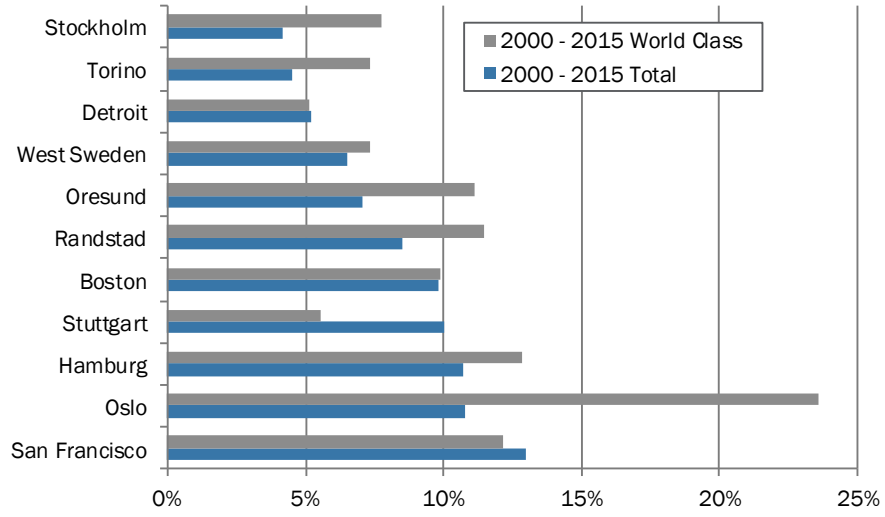


Portfolio Size: Number of active patents in 2015 by region (residence of named researcher) in Energy
Technological Strength: Share of patents belonging to the global top 10% patents with the most competitive impact
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

2.4.2 Patent development in Energy

In terms of total patent numbers, San Francisco has experienced the most dynamic development among the sample regions since 2000 (+13.0% per year) and, as a result, has almost closed the gap to Stuttgart in the Energy segment. In terms of world class patents, Oslo leads the ranking with an average growth of 23.6% per year. It should be noted, though, that this growth started from a very low level (Oslo had only one world class Energy patent in 2000) and to this day, the total amount of world class patents remains low in Oslo with 24 world class Energy patents in 2015. In West Sweden, the amount of Energy patents has increased by 6.5% per year since 2000. Its number of world class patents grew slightly faster at 7.4% per year.

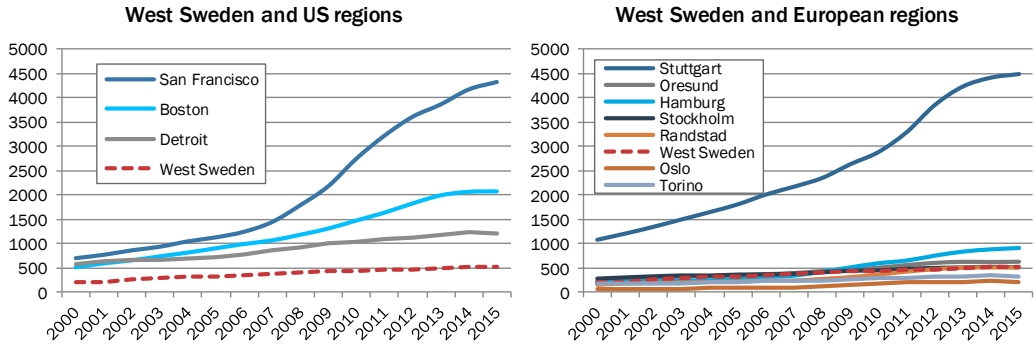
Fig. 2-14 Patent growth in Energy



Average patent growth per year in Energy between 2000 and 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

In leading research hubs such as San Francisco, Boston and Stuttgart, patent growth accelerated significantly between 2008 and 2012. However, since then, patent portfolios have expanded at a much slower pace.

Fig. 2-15 Patent development in Energy



Total number of patents by region in Energy
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

2.5 Development of patents in Materials

2.5.1 Patent portfolios in Materials

The Materials segment consists of the subcategories 3D-Printing, Carbon Graphene, Ceramics and Nanomaterials. These technologies are mostly in the early stages of their growth and this is reflected in the relatively small number of patents attributed to the segment. However, there are high expectations for growth in Material technologies and research activities are expected to intensify in the coming years.

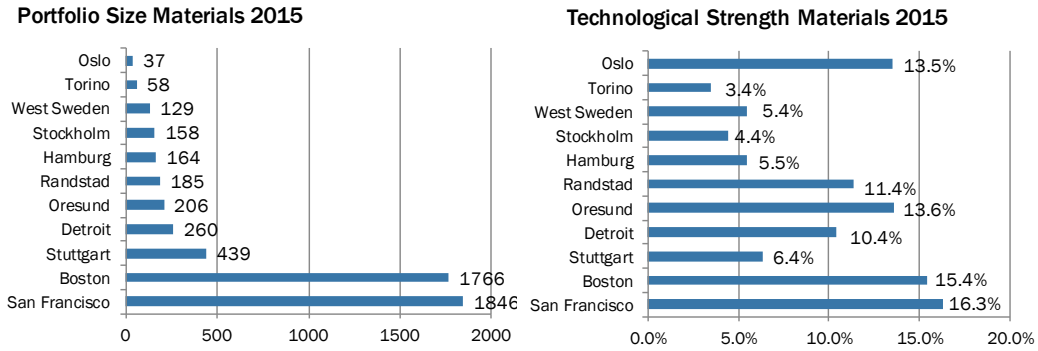
The two US regions of San Francisco and Boston are by far the leading research centres among the selected regions in the cutting edge technology field of Materials. In 2015, there were 1'846 patents from San Francisco and 1'766 patents from Boston. Of these Materials patents, 15.4% (Boston) and 16.3% (San Francisco) respectively are considered world class patents meaning that these two regions also have the highest research efficiency. In both regions, most patents belong to the subcategory of Nanomaterials.

In Europe, the German region of Stuttgart is a leading research hub in the technology segment of Materials. In 2015, the Materials patent portfolio of Stuttgart consisted of 439 patents. However, the research efficiency in Stuttgart is rather low and only 6.4% of all Materials patents are considered world class patents. The most important Materials subcategory in Stuttgart is Ceramics (258 patents in 2015).

In West Sweden, there were 129 valid Materials patents in 2015. This research efficiency is quite low as only 5.4% of these patents are world class patents. Its two most important Materials subcategories are Nanomaterials (51 patents) and 3D-Printing (42 patents). It is remarkable that no other sample region, not even San Francisco or Boston, has as many valid patents in 3D-Printing as West Sweden. However, Boston

is still the leader in terms of world class 3D Printing patents (8 versus 3 in West Sweden).

Fig. 2-16 Portfolio size / technological strength in Materials

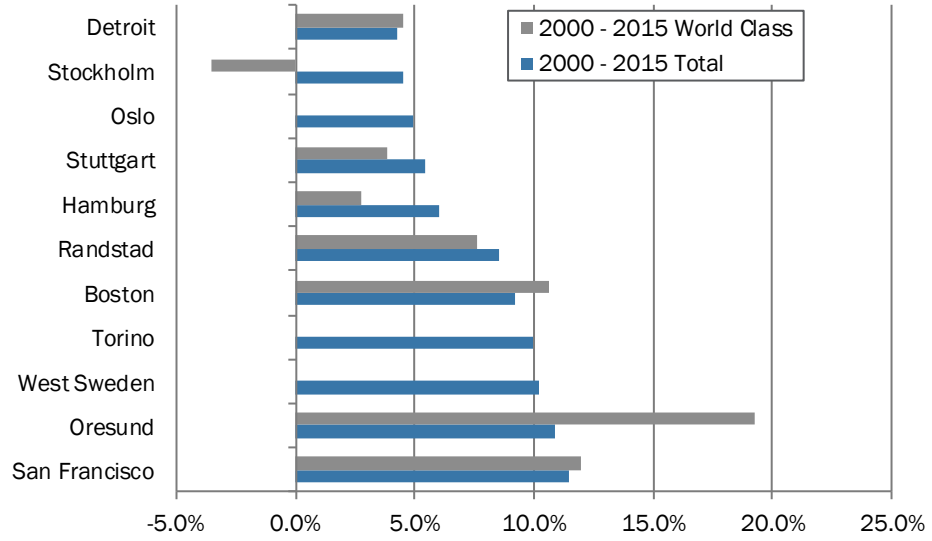


Portfolio Size: Number of active patents in 2015 by region (residence of named researcher) in Materials
Technological Strength: Share of patents belonging to the global top 10% patents with the most competitive impact
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

2.5.2 Patent development in Materials

Since 2000, the technology development in Materials has been dynamic in most sample regions. When looking at total patents, San Francisco, Oresund and West Sweden achieved the strongest patent growth between 2000 and 2015. Regarding world class Materials patents, Oresund has seen the most powerful development (+19.2% per year; from 2 to 28 world class patents). This was mainly caused by the rise of world class patents in Nanomaterials in Oresund.

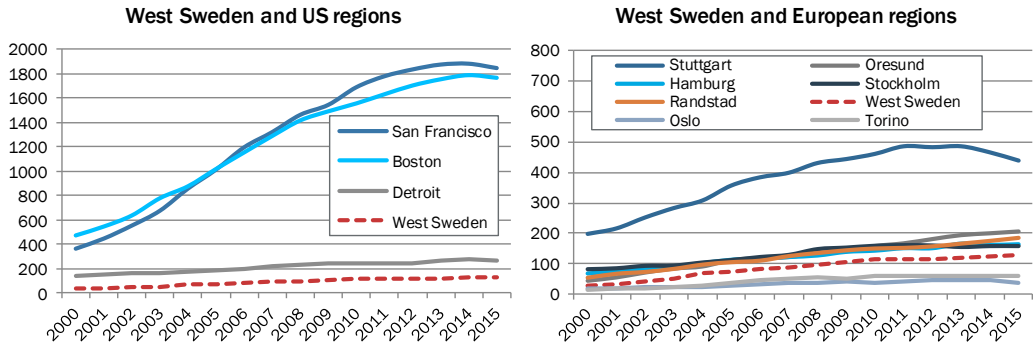
Fig. 2-17 Patent growth in Materials



Average patent growth per year between 2000 and 2015 in Materials. No values for world class patent growth in West Sweden, Oslo and Torino available, as there were no valid patents in the year 2000.
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

In most sample regions, patent growth in Materials was very dynamic between 2000 and 2010, but growth rates have somewhat slowed down since then. In Stuttgart and Oslo, patent numbers even declined slightly between 2010 and 2015.

Fig. 2-18 Patent development in Materials



Total number of patents by region in Materials
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

2.6 Development of patents in Systems

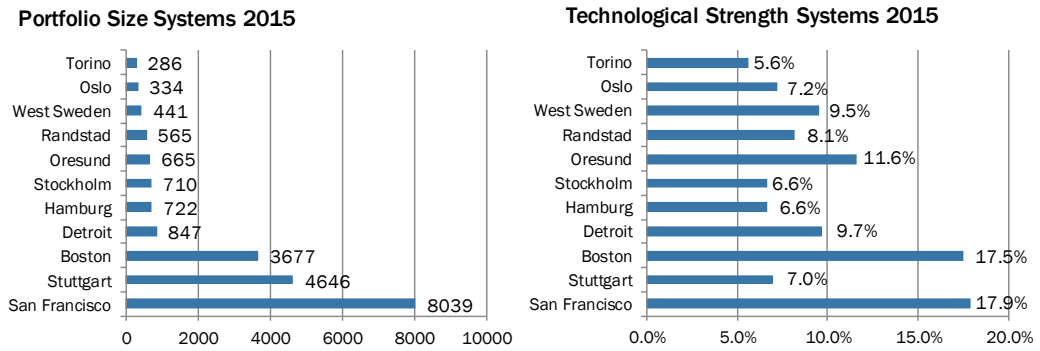
2.6.1 Patent portfolios in Systems

The cutting edge Systems segment consists of the subcategories Autonomous Vehicles, Drones, Photonics, Robotics, Sensors, Micromechanics and Wearables.

In terms of total patent numbers, San Francisco (8'039 patents), Stuttgart (4'646) and Boston (3'677) are the technology leaders in the segment of Systems. Among these regions, research efficiency is much higher in the two US regions, a fact which is reflected in the number of world class Systems patents which are by far the highest in San Francisco (1'438) and Boston (644). Sensors and Photonics are the most important research categories in San Francisco in terms of patent numbers. In both Boston and Stuttgart, the majority of patents fall into the Sensors category.

In 2015, West Sweden held a total of 441 valid Systems patents, of which 9.5% were world class patents, putting its research efficiency at an average level. As is the case in most sample regions, the majority of West Sweden's Systems patents belong to the category of Sensors (218 patents).

Fig. 2-19 Portfolio size / technological strength in Systems

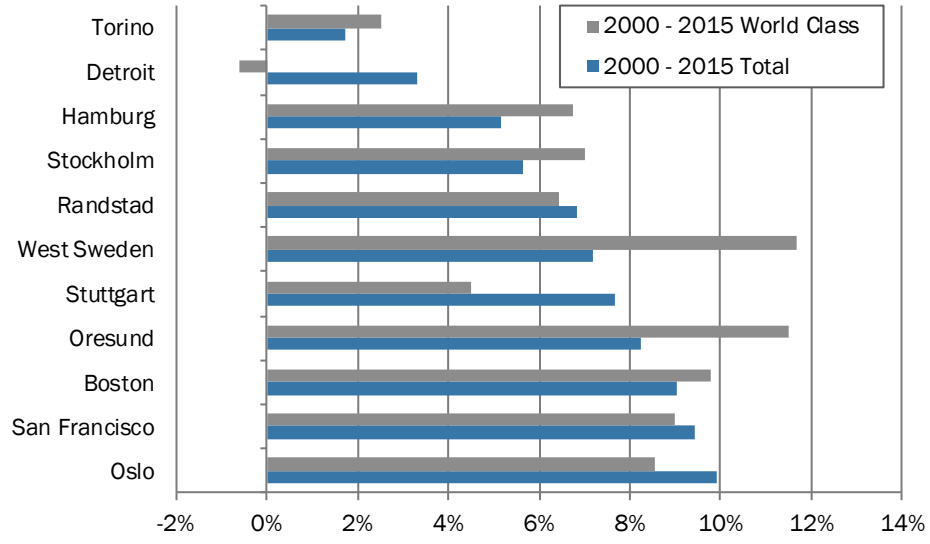


Portfolio Size: Number of active patents in 2015 by region (residence of named researcher) in Systems
Technological Strength: Share of patents belonging to the global top 10% patents with the most competitive impact
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

2.6.2 Patent development in Systems

Since 2000, the technology development in Systems has been dynamic in almost all of the selected regions. In terms of total patents, Oslo achieved the strongest growth between 2000 and 2015 (+9.9% per year). San Francisco and Boston, despite their already very large patent portfolios, also experienced high patent growth rates in both total patents and world class patents. However, the highest overall growth rates in world class patents took place in Oresund (+11.5%) and West Sweden (+11.7%). It should be noted, though, that West Sweden held only 42 world class Systems patents in 2015 despite its dynamic growth of the last 15 years.

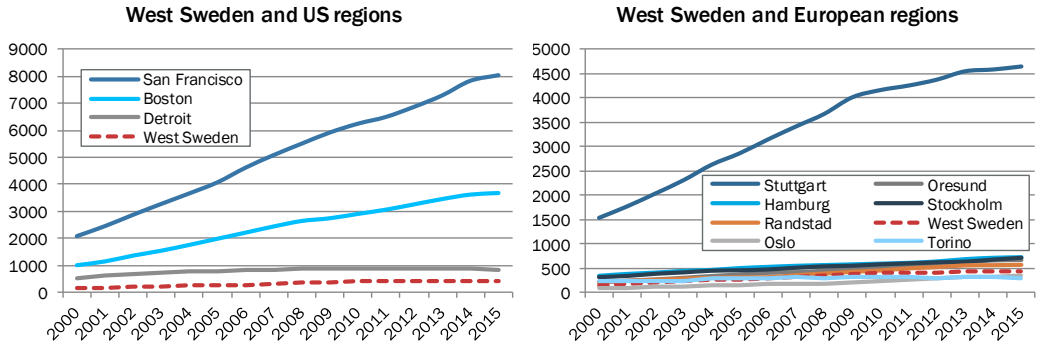
Fig. 2-20 Patent growth in Systems



Average patent growth per year in Systems between 2000 and 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

Since 2000, in terms of patent numbers, San Francisco's lead has steadily increased. In West Sweden, patent growth rates were high between 2000 and 2010, but have slowed down since 2010.

Fig. 2-21 Patent development in Systems



Total number of patents by region in Systems
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

2.7 Summary

Among the selected sample regions of this report, the US regions of San Francisco and Boston are the leading research hubs in cutting edge technologies. Even when San Francisco's large population size is accounted for, the two US regions remain the most innovative regions. In all of the five cutting edge technologies, Boston and San Francisco are consistently among the top regions regarding the size of patent portfolios. Moreover, Boston and San Francisco also have very high research efficiencies which are reflected in their above average shares of world class patents.

In Europe, Stuttgart is an important research location with the most active patents among the European sample regions in the cutting edge technologies of Systems, Materials, Energy and Digital/IT. In addition, Stuttgart has been the most dynamic region with an average patent growth of 7.8% per year since 2000. However, research efficiency is significantly lower in Stuttgart than in San Francisco, Boston or Oresund. Oresund has the largest patent portfolio of the European sample regions in the important technology field of Life Sciences. Moreover, Oresund is the leading European sample region regarding total world class, cutting edge patents. Hence, Oresund is the most innovative of the European sample regions.

West Sweden's patent portfolio in cutting edge technologies is relatively small compared to the sample regions. In 2015, there were 3'149 active, cutting edge patents developed in West Sweden. Its Life Sciences patents accounted for a major share of all patents in cutting edge technologies, similar to most sample regions. However, its share of Life Sciences patents of total cutting edge patents decreased from 75.8% in 2000 to 58.9% in 2015. Hence, the relevance of other cutting edge technologies has been increasing. In 2015, Energy (16.3%) and Systems (14.0%) were its two other important technology segments. However, a troubling sign is that West Sweden, along with Stockholm, experienced the lowest growth rates of all selected regions in terms of cutting edge patent numbers between 2000 and 2015. The main reason for this is

that the number of active Life Sciences patents has decreased in recent years in West Sweden.

Nevertheless, there are also some encouraging results for West Sweden. For instance, the region has seen relatively high growth rates in Systems and Materials technologies. Indeed, West Sweden achieved the highest growth rates of all sample regions in world class patents in Systems technologies between 2000 and 2015. More precisely, many world class Sensor patents were developed in West Sweden. Regarding Materials technologies, Nanomaterials and 3D-Printing are important in West Sweden. It is remarkable that no other sample region, not even San Francisco and Boston, has as many active patents in 3D-Printing as West Sweden.

3 Cutting Edge technologies in selected companies

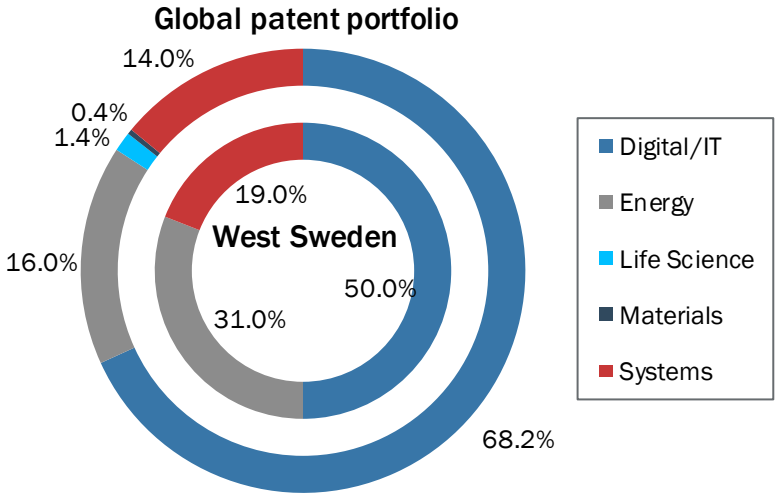
3.1 Ericsson

3.1.1 Patent portfolio in cutting edge technologies

The Swedish company Ericsson is a leading research company in the field of Digital/IT technologies and in 2015, it held 1'339 patents in cutting edge technologies. On a global level, 68.2% of all cutting edge patents developed by Ericsson belong to the field of Digital/IT. The company also holds many patents in the cutting edge technology fields of Energy and Systems.

Regarding patents developed in West Sweden,[4] Ericsson's cutting edge patent portfolio included 84 patents in 2015. Half of these patents were Digital/IT patents; in fact, Ericsson held 20% of all Digital/IT patents developed in West Sweden. Additionally, regarding Energy patents, Ericsson's share of was significantly higher in West Sweden than it was on a global level.

Fig. 3-1 Ericsson: Patent portfolio in 2015



Patent portfolio in cutting edge technologies in 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

3.1.2 Patent development in cutting edge technologies

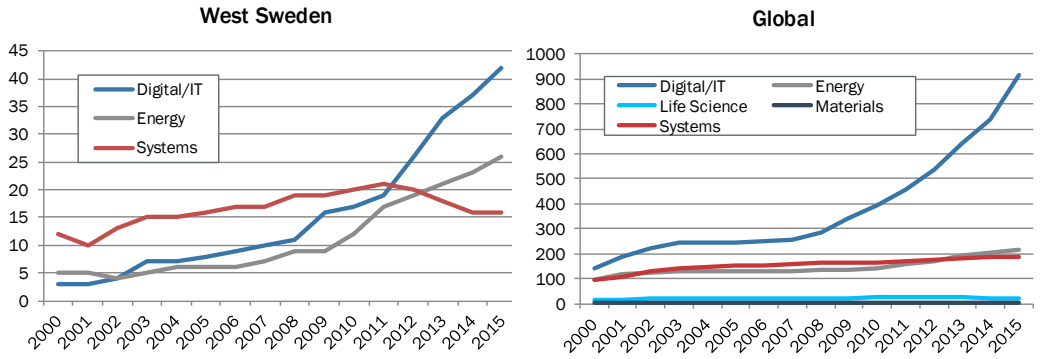
Since 2000, the technology development in Digital/IT has been dynamic in all sample regions of this report. This is also reflected in the development of Ericsson's patent portfolio. Since 2008, its patent growth in Digital/IT has been much stronger than in

[4] Patents are analysed according to the researcher's address on the patent filed. This approach allows for the identification of the region where the research has actually taken place and circumvents the potential problems arising from international companies which apply for patent ownership via their headquarters.

the other cutting edge technologies. As a result, its number of patents in Digital/IT multiplied from 140 in 2000 to 913 in 2015.

In West Sweden, the cutting edge field of Systems has been Ericsson's most relevant research area for several years. However, in the last few years, Digital/IT and Energy have surpassed Systems in terms of patent numbers. In 2015, Ericsson held 42 active Digital/IT patents that were developed in West Sweden – 26 Energy patents and 16 Systems patents.

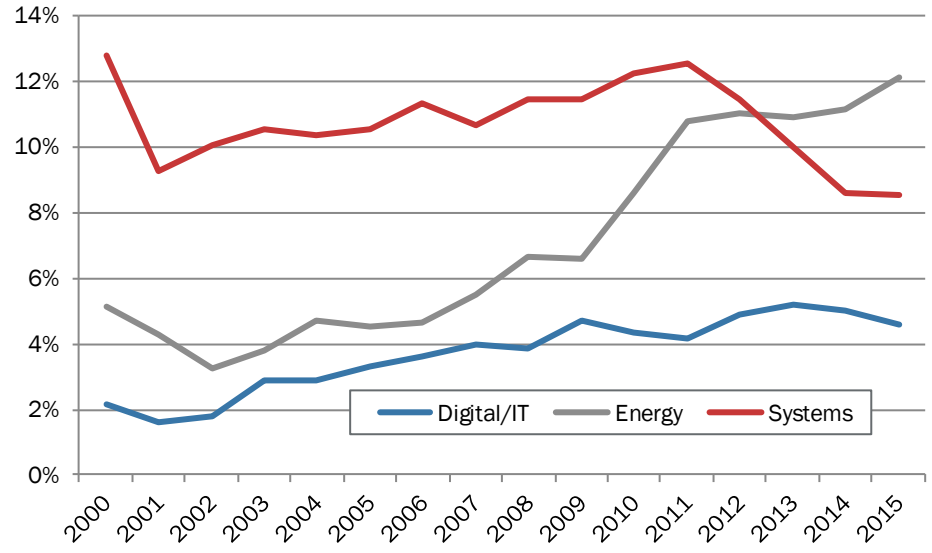
Fig. 3-2 Ericsson: Patent development in cutting edge technologies



Patent development in cutting edge technologies between 2000 and 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

West Sweden is an important research location for Ericsson. This is particularly true regarding the cutting edge technology field of Energy. In 2015, around 12% of Ericsson's Energy patents were developed in West Sweden. By contrast, in the field of Systems, the relevance of West Sweden for new research has decreased in recent years.

Fig. 3-3 Ericsson: Share of cutting edge patents developed in West Sweden



Share of cutting edge patents developed in West Sweden
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

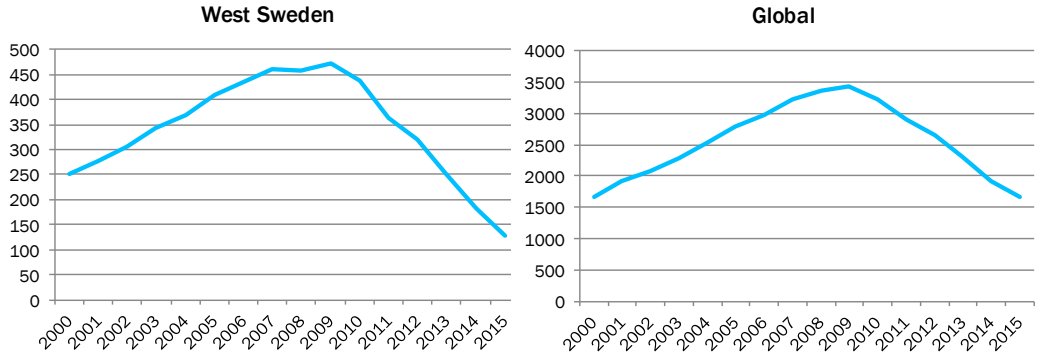
3.2 AstraZeneca

3.2.1 Patent development in Life Sciences technologies

British AstraZeneca is one of the biggest Pharma companies in the world. Unsurprisingly, it has a large patent portfolio in Life Sciences technologies. While it held only a small number of patents in other cutting edge technologies in 2015, the company held around 1'650 active Life Sciences patents on a global level. On the regional level in West Sweden, AstraZeneca also had 102 Life Sciences patents thanks to its research laboratories in Gothenburg.

While AstraZeneca remains a major player in Life Sciences research, the size of its patent portfolio of valid patents has decreased significantly in recent years because many of its Life Sciences patents have expired and could not be replaced. In 2009, AstraZeneca's patent portfolio reached its peak with more than 3'400 Life Sciences patents worldwide, of which almost 500 patents were developed in West Sweden. Although, in general, there has been a global trend of decreasing patents in the last few years, the decrease of AstraZeneca's patent portfolio has been exceptionally pronounced.

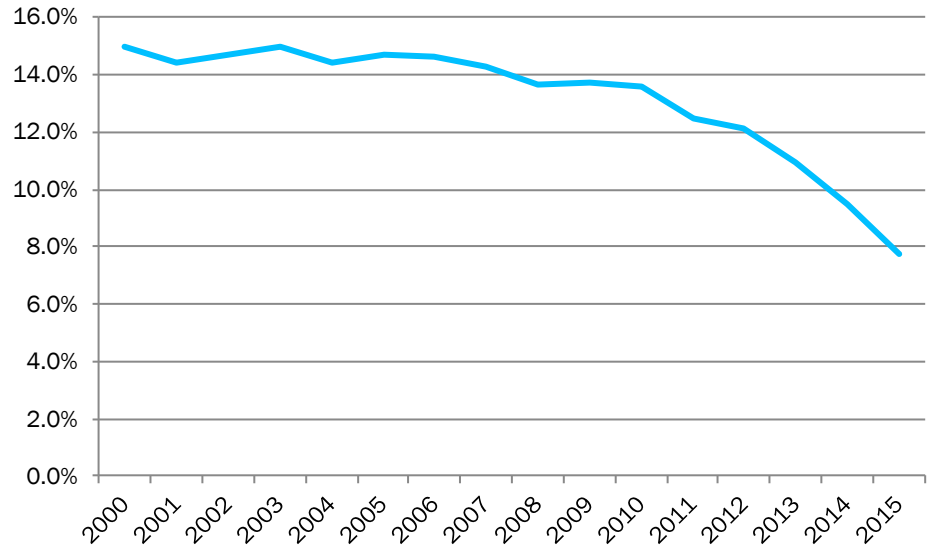
Fig. 3-4 AstraZeneca: Patent development in Life Sciences technologies



Patent development in Life Sciences between 2000 and 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

The relevance of West Sweden for AstraZeneca's research activities has declined over the last 15 years. While in 2000, 15% of all Life Sciences patents were developed there, this share dropped to 7.7% in 2015.

Fig. 3-5 Astra Zeneca: Share of Life Sciences patents developed in West Sweden



Share of Life Sciences patents developed in West Sweden
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

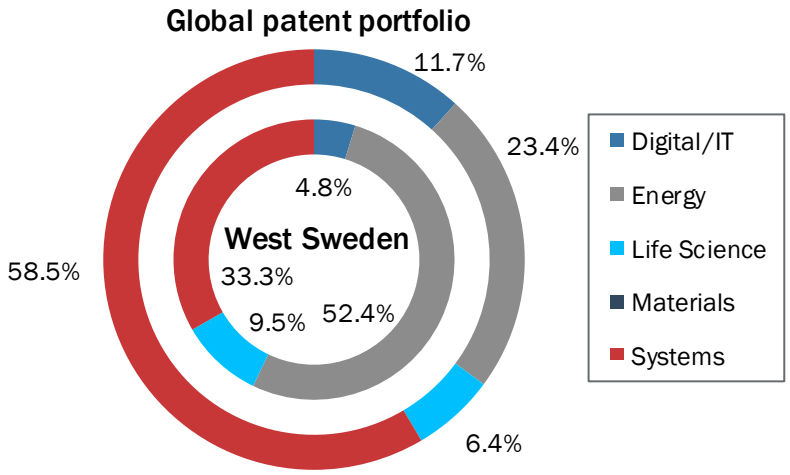
3.3 Autoliv

3.3.1 Patent portfolio in cutting edge technologies

On a global level, the Swedish-American company Autoliv held 94 cutting edge patents in 2015. Autoliv manufactures protection systems for automobiles which are reflected in the composition of the company's patent portfolio. In 2015, 58.5% of Autoliv's global cutting edge patents were Systems patents. Almost all of these Systems patents belong to the subcategory of Sensors. In addition, Autoliv has sizeable research activities in the fields of Energy (mainly Energy Storage / Battery Tech), Digital/IT (mainly Smart City) and Life Sciences (mainly Medtech).

In West Sweden in 2015, Autoliv had 21 cutting edge patents and currently, its research focus is on Energy technologies (amounting to 52.3% of all its cutting edge patents there). The number of patents in Energy Storage / Battery Tech has increased in particular in recent years. Apart from Energy patents, Autoliv also holds some patents in Systems, Digital/IT and Life Sciences that were developed in West Sweden.

Fig. 3-6 Autoliv: Patent portfolio in 2015



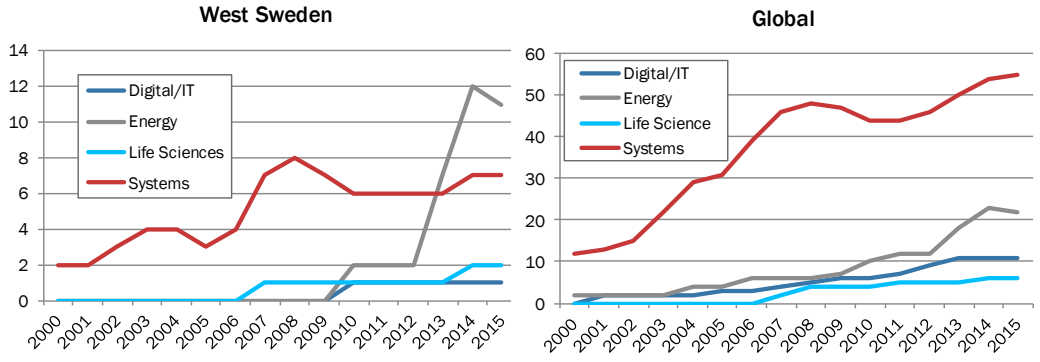
Patent portfolio in cutting edge technologies in 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

3.3.2 Patent development in cutting edge technologies

Autoliv has intensified its research activities in cutting edge technologies in recent years. As a result, the number of Autoliv's patents has increased significantly, both globally and in West Sweden. In the most important research category of Systems, patent numbers rose from 12 in 2000 to 55 in 2015. Patent growth in Energy patents has also been robust over the last 15 years.

In West Sweden, the most dynamic patent growth took place in the field of Energy. From 0 patents in 2009, Autoliv's patents climbed to more than 10 in 2015. The technology field of Systems is another research focus of Autoliv in West Sweden and patent numbers in that field rose from 2 in 2000 to 7 in 2015.

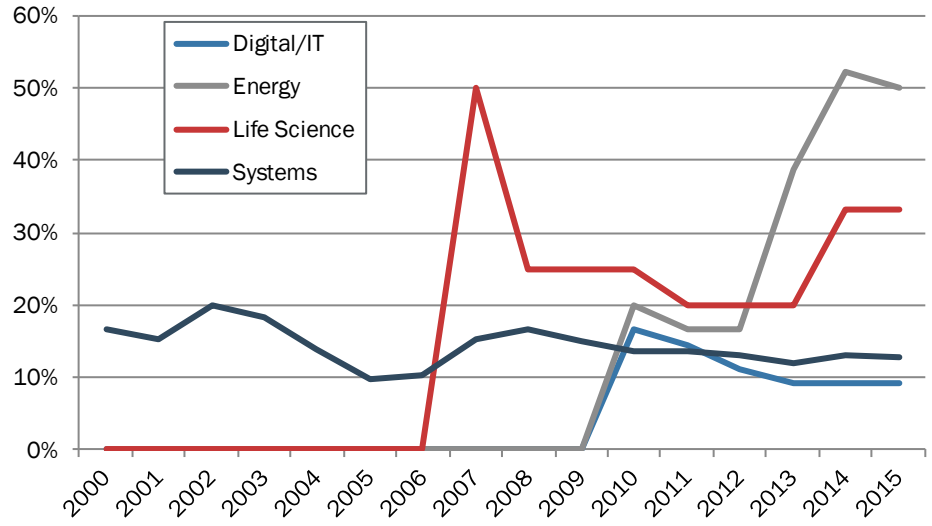
Fig. 3-7 Autoliv: Patent development in cutting edge technologies



Patent development in cutting edge technologies between 2000 and 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

West Sweden is a very important research location for Autoliv. In 2015, around 50% of Autoliv's active Energy patents were developed there. In the cutting edge technology field of Systems, West Sweden's share of patents is also high, amounting to more than 30%. In general and according to patent numbers, the relevance of West Sweden as a research location for Autoliv has increased in recent years.

Fig. 3-8 Autoliv: share of patents developed in West Sweden



Share of cutting edge patents developed in West Sweden
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

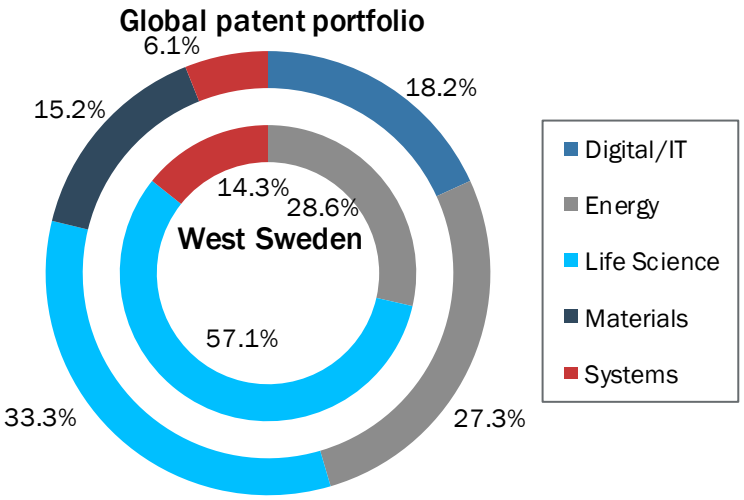
3.4 Borealis

3.4.1 Patent portfolio in cutting edge technologies

Borealis is the second largest producer of polyethylene and polypropylene in Europe. Nevertheless, its patent portfolio size in cutting edge technologies is relatively small compared to the other companies analysed in this report. In 2015, Borealis held 33 valid, cutting edge patents. The majority of these patents fall into the categories of Life Sciences and Energy, but Borealis also has some research activities in Digital/IT, Materials and Systems.

In West Sweden, Borealis's research activities are focused on Life Sciences technologies (57.1% of all cutting edge technologies), followed by Energy and Systems. However, its patent portfolio is still quite small with only 7 active patents in cutting edge technologies in 2015.

Fig. 3-9 Borealis: Patent portfolio in 2015



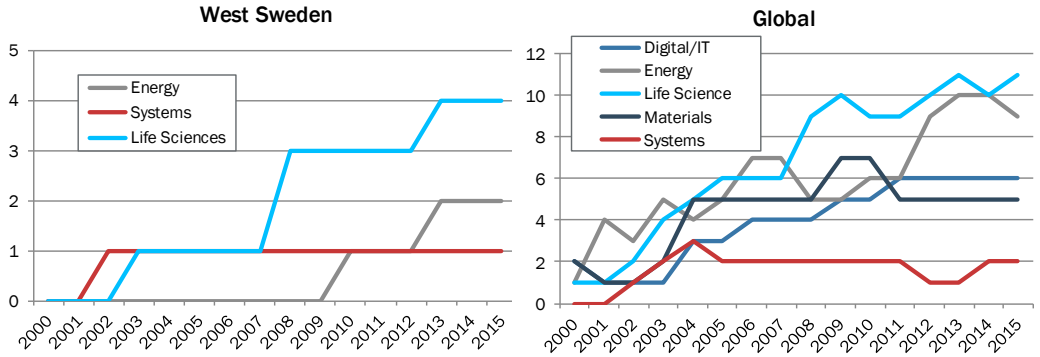
Patent portfolio in cutting edge technologies in 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

3.4.2 Patent development in cutting edge technologies

Borealis has steadily expanded its patent portfolio in recent years. On a global level, the number of patents in cutting edge technologies rose from only 6 patents in 2000 to 33 in 2015. The highest patent growth rates were seen in the Life Sciences and Energy technologies. Borealis has mainly developed new patents in Medtech and in Energy Generation.

In West Sweden, Borealis has developed 3 new Pharma patents and 1 Medtech patent in research facilities since 2000. In addition, the company holds two Energy patents and one Systems patent.

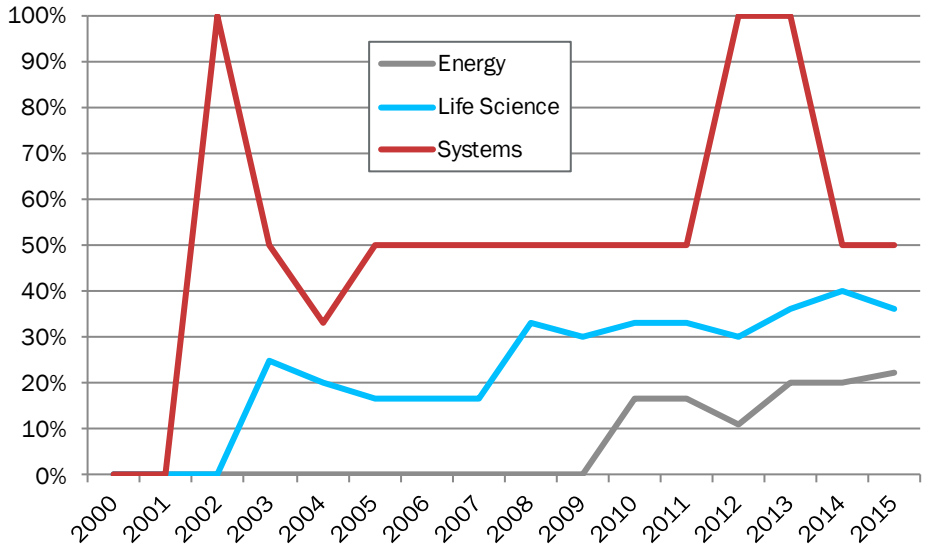
Fig. 3-10 Borealis: Patent development in cutting edge technologies



Patent development between 2000 and 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

More than 30% of Borealis' Life Sciences patents were developed in West Sweden. In the field of Systems, this share is even higher, yet Borealis still hardly has any Systems patents on a global level.

Fig. 3-11 Borealis: Share of patents developed in West Sweden



Share of cutting edge patents developed in West Sweden
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

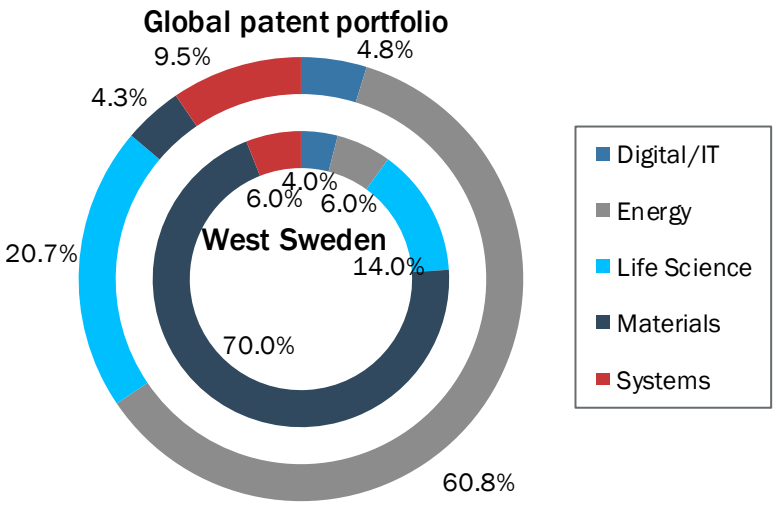
3.5 General Electric

3.5.1 Patent portfolio in cutting edge technologies

General Electric (GE) is an American multinational technology corporation that operates in various technology segments. The company owns one of the largest patent portfolios in the world. In total, GE held 11'782 patents in cutting edge technologies in 2015. According to patent numbers, GE's most important cutting edge research field is Energy technologies (share of 60.8% of all cutting edge patents). More precisely, the company has almost 5'500 valid patents in the subcategory of Energy Generation. Apart from that, GE also does a lot of research in the cutting edge technologies of Life Sciences and Systems.

Fifty of GE's active cutting edge patents were developed in West Sweden. GE's most important research is in Materials. In 2015, there were 34 patents developed by GE in the subcategory of 3D-Printing and 70% of GE's patents belong to the Materials segment. In addition, GE has developed some Life Sciences patents in Biotech and Medtech in West Sweden.

Fig. 3-12 General Electric: Patent portfolio in 2015



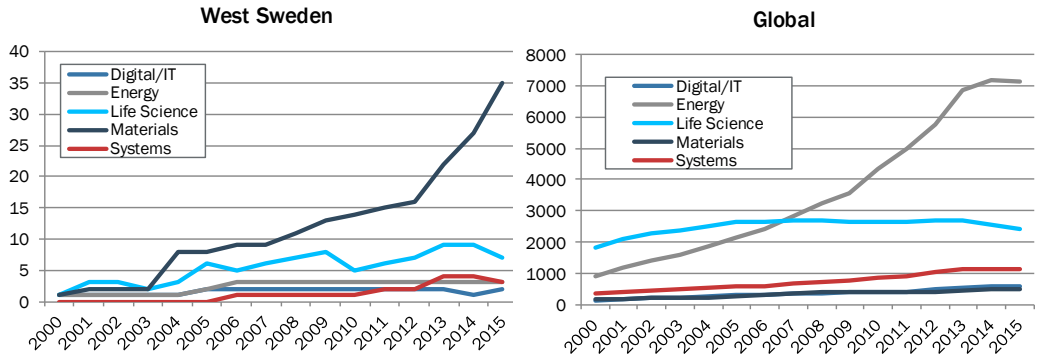
Patent portfolio in cutting edge technologies in 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

3.5.2 Patent development in cutting edge technologies

GE is one of the leading research companies in the world which is reflected in its patent numbers. Between 2000 and 2015, the number of valid, cutting edge patents developed by GE climbed from 3'352 to 11'782, reflecting an average annual growth of 8.7%. In this time, the most impressive growth took place in Energy, where the number of patents rose from 897 to more than 7'000. By contrast, GE's patent portfolio in Life Sciences has decreased moderately since its peak in 2008.

In West Sweden, GE's research activities in the Materials segment have increased substantially. One explanation for this is GE's recent acquisition of the Swedish company Arcam AB, an inventor of electron beam melting machines for metal-based additive manufacturing. GE now holds 34 patents in 3D-Printing in West Sweden.

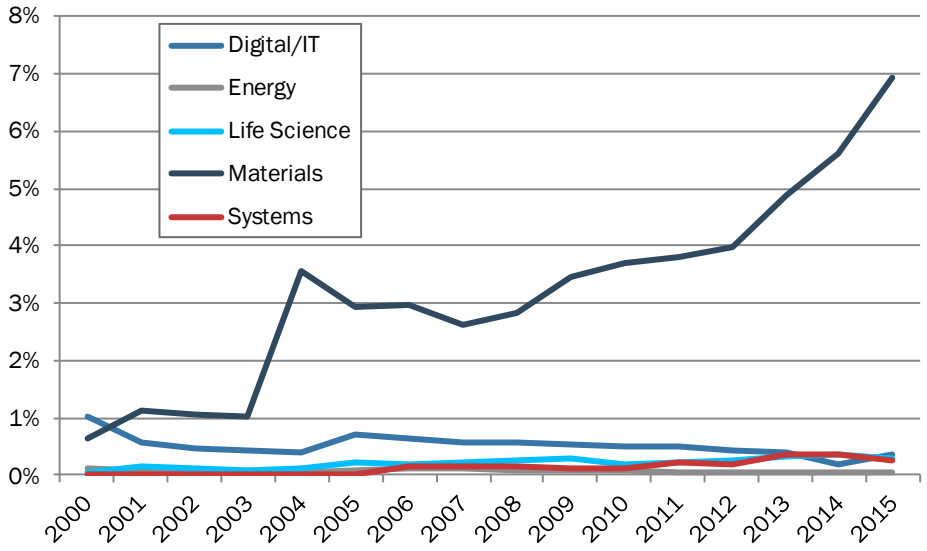
Fig. 3-13 General Electric: Patent development in cutting edge technologies



Patent development between 2000 and 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

As GE is one the largest technology companies in the world with various locations worldwide, the share of cutting edge patents it develops in West Sweden alone is very small. The one exception to this is in the technology segment of Materials, or more precisely, in 3D-Printing. In 2015, an impressive 7% of all GE's Materials patents and almost 45% of all its 3D-Printing patents were developed in West Sweden.

Fig. 3-14 General Electric: Share of patents developed in West Sweden



Share of cutting edge patents developed in West Sweden
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

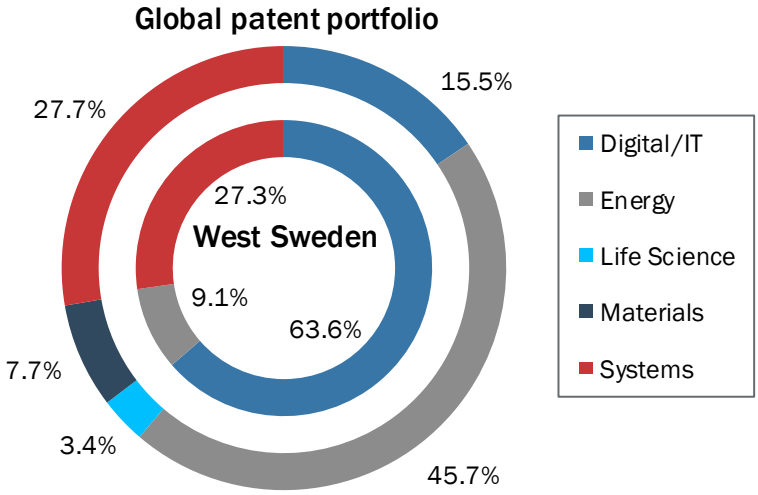
3.6 General Motors

3.6.1 Patent portfolio in cutting edge technologies

General Motors (GM) is the largest American automobile manufacturer. The company also owns a large patent portfolio in cutting edge technologies. In 2015, GM held almost 450 cutting edge patents. The majority of these patents belong to either the Energy segment or the Systems segment (with shares of 45.7% and 27.7% respectively).

In West Sweden, GM's research focus is on Digital/IT technologies. It should be noted, however, that the total number of patents developed by GM is still small. In 2015, only 11 cutting edge patents were held by GM in West Sweden.

Fig. 3-15 General Motors: Patent portfolio in 2015



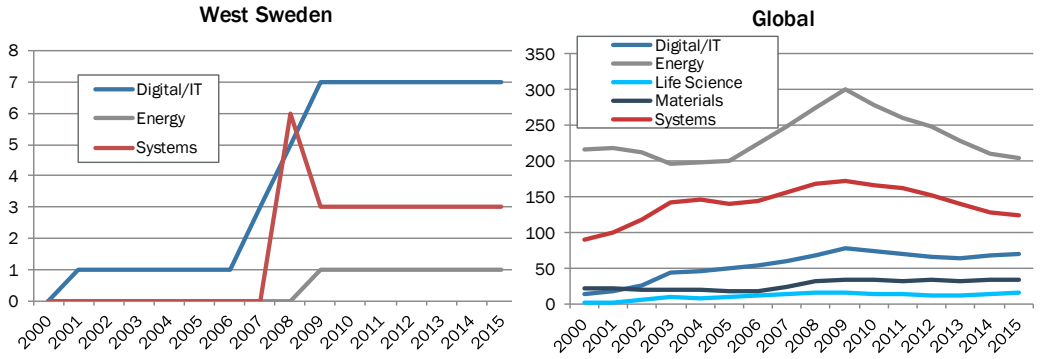
Patent portfolio in cutting edge technologies in 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

3.6.2 Patent development in cutting edge technologies

The global patent portfolio of GM reached a peak in 2009 with almost 600 valid, cutting edge patents. Since then, GM's patent numbers have decreased noticeably in the Energy and Systems technology segments. This goes against global trends since total cutting edge patents in these two segments have increased dynamically in almost all sample regions of this report.

In West Sweden, the number of Digital/IT patents from GM climbed from 0 to 7 patents. In addition, GM currently holds 3 Systems patents and 1 Energy patent that were developed in West Sweden.

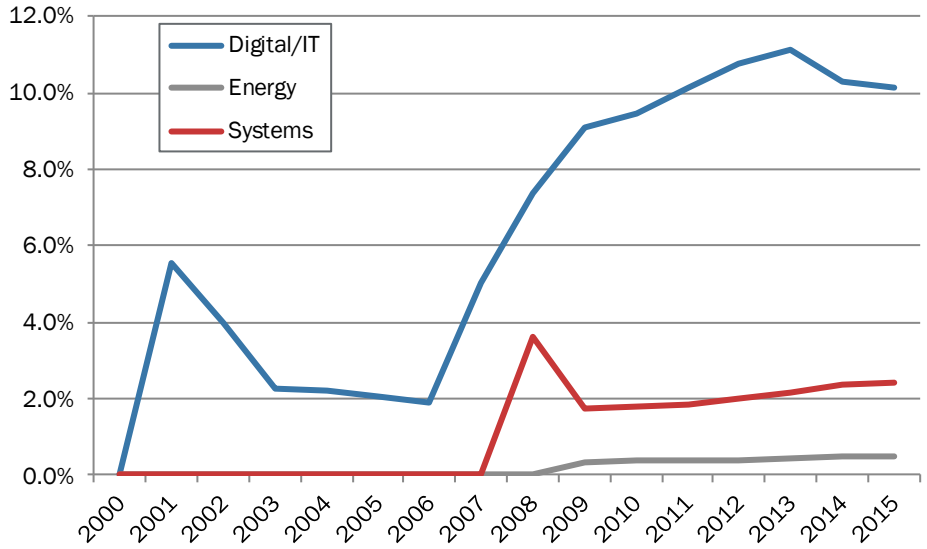
Fig. 3-16 General Motors: Patent development in cutting edge technologies



Patent development between 2000 and 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

Regarding Digital/IT technologies, the relevance of West Sweden as a research location for GM has risen sharply in recent years. In 2015, more than 10% of GM's global Digital/IT patents were developed in West Sweden.

Fig. 3-17 General Motors: Share of patents developed in West Sweden



Share of cutting edge patents developed in West Sweden
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

3.7 Volvo

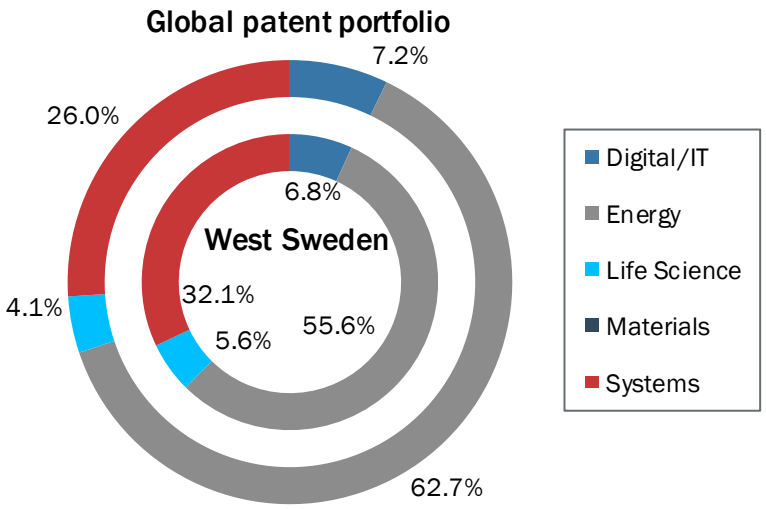
3.7.1 Patent portfolio in cutting edge technologies

Volvo is a leading Swedish manufacturing company whose core business is the production, distribution and sale of trucks, buses and construction equipment. Volvo sold its car business Volvo Cars to Ford in 1999. Since 2010, Volvo Cars has been owned by Geely.

Volvo is one of the most important research companies in Sweden. In 2015, Volvo's patent portfolio in West Sweden consisted of 234 cutting edge patents of which 55.6% belonged to the Energy segment, and 26% belonged to the Systems segment. More precisely, Volvo had many patents in the subcategory of Energy Generation (97 in 2015). Regarding Systems technologies, Volvo does extensive research in the subcategories of Drones (28 patents) and Sensors (31 patents).

On a global level, Volvo held 461 cutting edge patents in 2015. The distribution of its international patent portfolio is very similar to its patent portfolio in West Sweden.

Fig. 3-18 Volvo: Patent portfolio in 2015

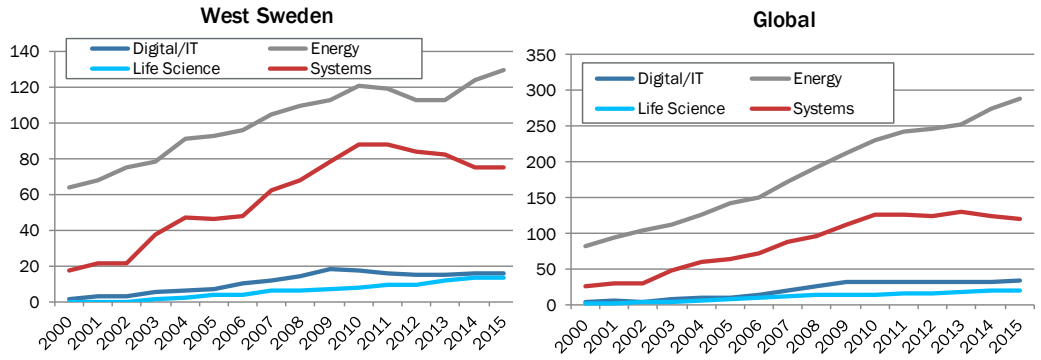


Patent portfolio in cutting edge technologies in 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

3.7.2 Patent development in cutting edge technologies

Volvo's patent portfolio in cutting edge technologies has increased significantly over the last 15 years. Between 2000 and 2015, its global number of patents rose from 112 to 461, while its patents developed in West Sweden climbed from 82 to 234. This means that outside of West Sweden, Volvo's patent growth has been a little bit more dynamic. It is noteworthy that both in West Sweden and on a global level, Volvo's patent portfolio in Energy technologies has continued to increase, while its number of Systems patents has stagnated in recent years.

Fig. 3-19 Volvo: Patent development in cutting edge technologies

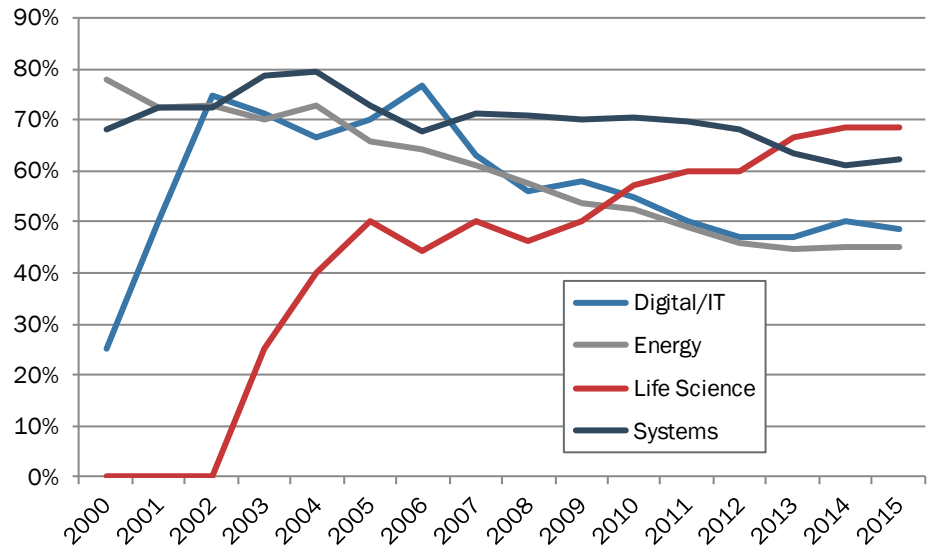


Patent development between 2000 and 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

In general, West Sweden remains Volvo's key research location with around 50% of its cutting edge patents being developed there. However, this share has decreased

fairly steadily over the last 15 years (from 73.2% in 2000), meaning the role of foreign research locations is gradually becoming more and more important for Volvo.

Fig. 3-20 Volvo: Share of patents developed in West Sweden



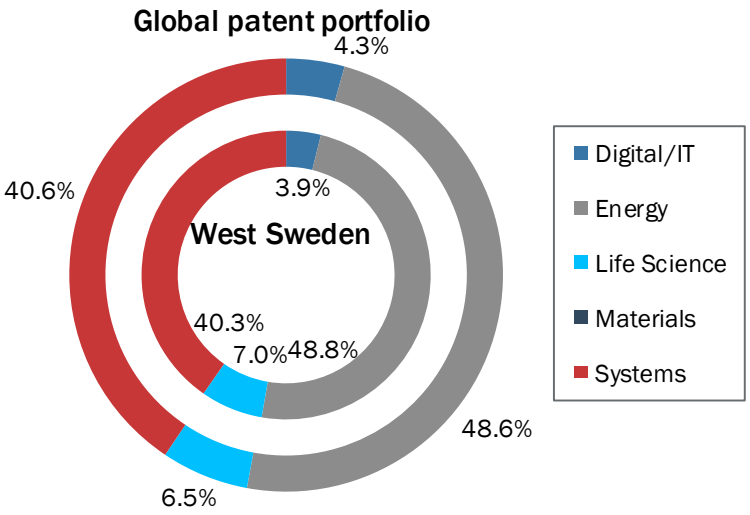
Share of cutting edge patents developed in West Sweden
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

3.8 Geely

3.8.1 Patent portfolio in cutting edge technologies

Geely is a Chinese multinational, automotive manufacturing company and the owner of Volvo Cars since 2010. Due to the acquisition of Volvo Cars, West Sweden is a crucial research location for Geely in cutting edge technologies. In 2015, the company held 138 cutting edge patents, of which a substantial 129 were developed in West Sweden. Geely's research mainly focuses on Energy and Systems technologies. The company has several patents in Energy Generation, Energy Storage / Battery Technologies, Autonomous Vehicles and Drones.

Fig. 3-21 Geely: Patent portfolio in 2015

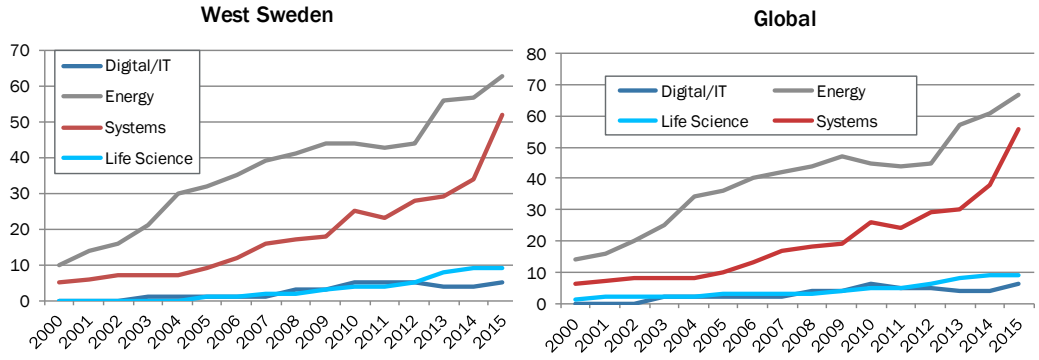


Patent portfolio in cutting edge technologies in 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

3.8.2 Patent development in cutting edge technologies

Since 2000, the number of Geely's cutting edge patents has increased significantly. On a global level, Geely's patent portfolio climbed from 21 cutting edge patents in 2000 to almost 140 patents in 2015, with similar development taking place in West Sweden. This was mainly due to its dynamic patent growth in Systems and Energy technologies.

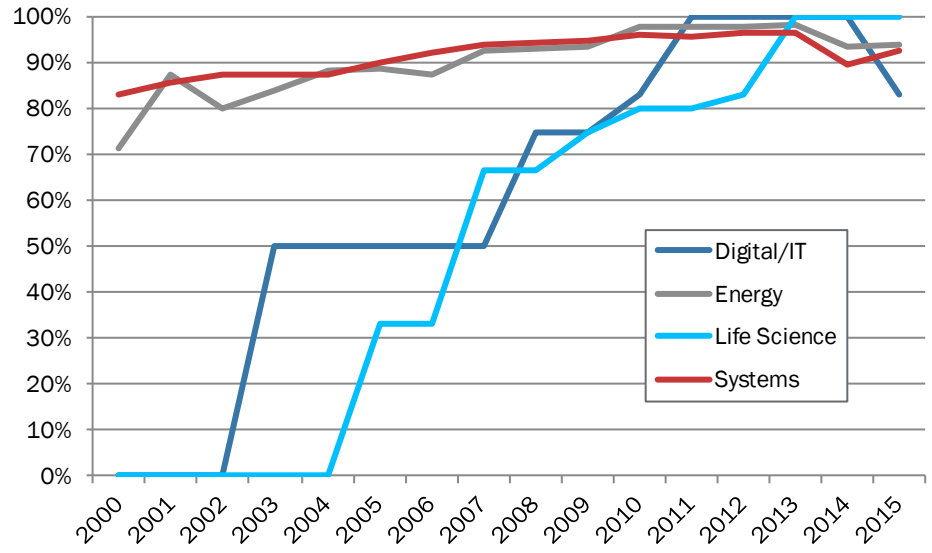
Fig. 3-22 Geely: Patent development in cutting edge technologies



Patent development between 2000 and 2015
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

West Sweden is by far the most important research location for Geely concerning its development of cutting edge technologies. In 2015, around 93% of Geely's cutting edge patents were developed in West Sweden. In 2017, Geely signed a Letter of Intent to build a large innovation center in Gothenborg.

Fig. 3-23 Geely: Share of patents developed in West Sweden

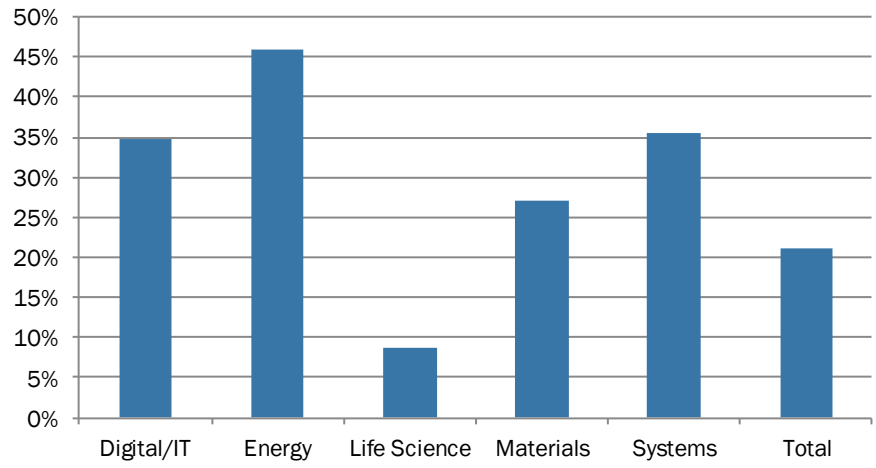


Share of cutting edge patents developed in West Sweden
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

3.9 Summary

In 2015, the companies analysed in this report (Ericsson, AstraZeneca, Autoliv, Borealis, General Electric, General Motors, Volvo, Geely) when taken together held 664 patents in cutting edge technologies that were developed in West Sweden. This is a share of 21.1% of the total of 3'149 patents in cutting edge technologies developed in West Sweden. While the share of these companies' patents reached 46% in the cutting edge field of Energy, in Life Sciences, the relevance is relatively small (with a share of only 8.8% of Life Sciences patents in 2015).

Fig. 3-24 Share of sample companies of cutting edge patents in West Sweden



Share of cutting edge patents developed in West Sweden by the companies Ericsson, AstraZeneca, Autoliv, Borealis, General Electric, General Motors, Volvo, Geely
Source: BAK Economics, Swiss Federal Institute of Intellectual Property

Besides being one of the leading IT companies in Europe, Ericsson is the most important research company in West Sweden for Digital/IT technologies and, in addition, it is also active in Energy and Systems.

In Life Sciences, AstraZeneca is an important researcher in West Sweden. The company owns 128 active Life Science patents that were developed in West Sweden - a share of 6.9% of all its Life Science patents. However, AstraZeneca's portfolio of valid patents has decreased in recent years both in West Sweden and on a global level.

Volvo and Geely are West Sweden's two major players in the Energy and Systems segments. Both companies have sizeable research activities there and the region remains both Volvo's and Geely's key research location.

Among the selected companies, only General Electric (GE) has patents in Materials that were actually developed in West Sweden. This can be attributed to GE's acquisition of Swedish additive manufacturing company Arcam AB in 2016.

In general, the focus of the research of the sample companies in West Sweden is quite similar to the focus of their global research activities even though in West Sweden there is somewhat more emphasis on Systems and somewhat less emphasis on Energy. The share of Systems patents of total cutting edge patents developed in West Sweden (23.6%) is higher than the respective share of Systems patents developed globally (10.5%) and the share of Energy patents developed in West Sweden is smaller (35.5% in West Sweden, 49.9% in the world).

Tab. 3-1 Company innovation worldwide and in West Sweden (2015)

	DIGITAL/IT GLOBAL PATENTS (WEST SWEDEN)	ENERGY GLOBAL PATENTS (WEST SWEDEN)	LIFE SCIENCES GLOBAL PATENTS (WEST SWEDEN)	MATERIALS GLOBAL PATENTS (WEST SWEDEN)	SYSTEMS GLOBAL PATENTS (WEST SWEDEN)
Ericsson	913 (42)	214 (26)	19 (0)	5 (0)	188 (16)
AstraZeneca	10 (0)	0 (0)	1'654 (128)	11 (0)	3 (0)
Autoliv	11 (1)	22 (11)	6 (2)	0 (0)	55 (7)
Borealis	6 (0)	9 (2)	11 (4)	5 (0)	2 (1)
General Electric	536 (2)	7'158 (3)	2'434 (7)	506 (35)	1'121 (3)
General Motors	69 (7)	203 (1)	15 (0)	34 (0)	123 (3)
Volvo	33 (16)	289 (130)	19 (13)	0 (0)	120 (75)
Geely	6 (5)	67 (63)	9 (9)	0 (0)	56 (52)
Total of selected companies	1'584 (73)	7'962 (236)	4'167 (163)	561 (35)	1'668 (157)

Number of active patents in cutting edge technologies in 2015, worldwide and developed in West Sweden
Source: BAK Economics

4 Conclusion

The findings of this report lead to the following conclusions about West Sweden.

Assuming that technological progress is the most important driver of future competitiveness and prosperity, it is in West Sweden's best interest to be active in cutting edge technologies. Consequently, West Sweden should strengthen its position as an attractive location for research and innovation in these technologies. This can be done by encouraging the expansion of the research activities of companies already present in West Sweden or by attracting new research intensive companies. At the moment, West Sweden's potential to attract foreign companies might be hampered by the absence of a “critical mass” of companies already located in the area.

Between 2000 and 2015, West Sweden, together with Stockholm, experienced the lowest growth rates of all selected regions in terms of total cutting edge patent numbers. This was mainly caused by the decrease in Life Sciences patents in these years.

While Life Sciences technologies remain a major focus of research in West Sweden, the share of Life Sciences patents of total cutting edge patents has decreased from 75.8% in 2000 to 58.9% in 2015. This recent decline has followed the general trend in industrial countries of decreasing Pharma patent numbers mainly caused by the shrinking patent portfolios of big pharmaceutical companies. West Sweden’s declining share of Life Sciences patents was, in fact, primarily due to AstraZeneca’s shrinking patent portfolio. However, the decreasing relevance of Life Sciences in West Sweden can also be seen as a positive development since it means the risks associated with specialized clusters have also decreased as other cutting edge technologies have become more important. In other words, its research sector has differentiated itself in recent years instead of continuing its specialization in Life Sciences.

West Sweden has seen high growth rates in Systems and Materials technologies. In fact, it achieved the highest growth rates of all sample regions regarding world class patents in Systems technologies between 2000 and 2015. More precisely, many world class Sensor patents were developed there, which means it should be promising to endeavour to attract further research activities in these technology fields.

It is noteworthy that some companies such as GE have already established sizeable and important research activities in the cutting edge field of Materials in West Sweden. By contrast, other companies such as Borealis are not yet doing research in Materials in West Sweden even though Borealis does research in this field in other countries. Therefore, it might be a promising strategy to target companies like Borealis in order to convince them to expand their research activities in Materials to West Sweden. It is particularly remarkable that no other sample region included in this report, not even San Francisco or Boston, has as many active patents in the Materials subcategory of 3D-Printing as West Sweden does.

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