

Deloitte.

**Innovation and broadband
Fibre infrastructure as the
future-proof choice and
its impact on innovation**



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Contents

Summary	2
Background and aim	4
Approach and method	7
Analysis and results of case studies	15
Conclusions and recommendations	22
Appendix I - Sources	25
Appendix II - Acronyms	28
Appendix III – Definitions and classification systems	29
Appendix IV – <i>The innovation capability of Berlin – elaboration on market factors.</i>	31
Appendix V – Survey: The impact of the fibre infrastructure	37

Summary

In recent decades, the constant evolution of new technologies, digitalisation, increased globalisation and new consumer expectations has resulted in ever more rapidly changing markets and more complex competition. In pace with this development, innovation has become an essential capacity for business and, indeed, countries in the EU to maintain their positions and competitiveness.

Viewed across industries, innovation in high-tech, ICT and digitalisation is also driving innovation and development in other industries and other sectors of society, often creating new business models that most closely compares to complex ecosystems. One clear example of this is Apple and the introduction of smartphones, which have not only changed how we call and converse with each other, but have had profound impact on other areas, such as transport services, music consumption and banking, to name only a few. High-tech, the ICT industry and digitalisation are thus key drivers for innovation and growth for a wide range of industries and society as a whole. In this context, Stockholm has been successful and is home to five “unicorns”¹ – Skype, Klarna, King, Spotify, Mojang – which all do business in the digital sector.

In discussions with several key actors in the high-tech and ICT sector, it clearly emerged that a well-developed broadband infrastructure is one of the cornerstones of favourable development of the high-tech and ICT industries. These actors have inter alia expressed that access to fibre infrastructure “*creates new opportunities for us and our customers to use and develop new, innovative services*”² and that “*The fibre infrastructure has profound impact on the diversity of services we can offer, which ultimately affects the opportunities provided to our consumers.*”³

The importance of being prepared for the future with a broadband infrastructure that covers future needs was also emphasised in interviews with a number of small and medium-sized enterprises (SMEs). A majority of the interviewed firms report that fibre has been virtually or utterly critical to business and service development, which has in turn determined their capacity to drive growth. The broadband infrastructure has also impacted the opportunities of these SMEs to reach new markets. The importance of access to a good broadband infrastructure to economic development, growth and innovation was also highlighted in a recently published OECD report, which shows that high speed broadband networks foster economic growth.⁴ The study makes it clear that fibre infrastructure coverage is an important investment in innovation and future growth. Moreover, Deloitte has conducted several studies that have shown the impact of access to open and operator-neutral fibre infrastructure, inter alia through its promotion of the possibility for operators and service providers to develop and drive service development and innovation.⁵

In the light of the above and on behalf of Stokab, Deloitte has studied the links between a city’s fibre infrastructure and its innovation capacity in high-tech, ICT and the digital sector. The study covered six cities: Stockholm, London, Copenhagen, Paris, Berlin and Amsterdam. Three innovation indicators were studied: number of patent applications, the number of employees in the high-tech and ICT sector and the volume of venture capital investments in the digital sector. Thereafter, the significance of the fibre infrastructure was

¹ Unicorns are tech startups valued at more than USD 1 billion.

² Net4Mobility (2016): Interview

³ Bahnhof (2016): Interview

⁴ Mölleryd, B. (2015): *Development of High-speed Networks and the Role of Municipal Networks.*

⁵ Deloitte (2013): *Kommunikationsinfrastrukturens betydelse för bredbandsmarknaden.*

analysed by correlating the innovation indicators with fibre infrastructure coverage in the selected cities.

The case studies show that there is a definite positive relation between innovation in the high-tech and ICT industry and a city's fibre infrastructure and that Stockholm ranks highest with regard to both innovation and coverage, thanks to its well-developed fibre infrastructure. The study clarifies the importance of investing in and securing a good fibre infrastructure to enable high innovation capacity within high-tech, ICT and digital products and services. In addition, as the specified industries are often drivers of development and innovation in other industries as well, the study highlights the importance of a good fibre infrastructure for innovation and growth in the market and in society generally. This applies to an even greater extent to cities with smaller domestic markets, as well as the competitiveness of smaller cities vis-à-vis larger cities.

The report illustrates the impact of the fibre infrastructure today, but also that it is going to be increasingly significant to future growth and innovation in areas such as the Internet of Things (IoT), 5G and "smart cities." Explosive growth has been predicted for all three of these areas, which will require very good underlying fibre infrastructure to fully meet the technical requirements and prerequisites, thus providing even clearer reason to invest in an expansive fibre infrastructure. This is also underlined in the interviews with SMEs included in the report, which made it clear that access to good fibre infrastructure already has tremendous potential to promote SMEs.

As innovation performance in high-tech and the ICT industry is playing an increasingly important role for innovation in both traditional service markets and mature industrial markets, investing in an expansive fibre infrastructure is a key concern for cities and regions that want to be at the forefront of innovation. This requires strategic decisions already today. In this respect, future projects and studies that illustrate the links between innovation and investments in fibre infrastructure and its importance to European growth and development can provide support.

Background and aim

In recent decades, the constant evolution of new technologies, digitalisation, increased globalisation and new consumer expectations has resulted in ever more rapidly changing markets and more complex competition. In pace with this development, innovation has become an essential capacity for business and, indeed, countries in the EU to maintain their positions and competitiveness.⁶

Many industries are undergoing profound changes and society in general has experienced a faster pace of development. Nowadays, the historical successes of a company are not necessarily a strong indicator that the company will continue to succeed in the future, as was once the case. If one compares the Fortune 500 list of the largest companies in the United States from the mid-1950s with the same list today, one finds that only around 10% of the companies still exist, and those companies' businesses have usually undergone significant change.⁷ Nearly 90% of the companies no longer exist, even though they were once market leaders. This, combined with the fact that the average company lifespan has declined from 70 years in the mid-1950s to 15 years today, clarifies the need to invest in innovation-promoting processes and new products and services to withstand accelerating competition and an ever more rapidly changing market.⁸

Innovation is defined by the OECD as “the implementation of a new or significantly improved product, process, marketing or organisational method in the firm’s business practices, workplace organisation or external relations.”⁹ The transformative power of an innovation may mean that a particular product made by a company is improved in a particular respect, but may also lead to the change and development of entire markets or industries. The Apple iPhone is one famous example. Although many phone manufacturers believed it had no future when it was introduced, it has since reshaped the entire mobile phone market and how we use our mobile phones.

The accelerating pace of development and the rapid changes have delivered other more recent examples of innovative companies, such as Spotify, Uber and AirBnB, which have been able to revolutionise and rewrite the rules of the game for several traditional industries. Upon closer examination of these rapid-growth companies, it becomes clear that several have very strong links to high-tech, ICT and digitalisation. In this context, Stockholm has been successful and is home to five “unicorns”¹⁰ – Skype, Klarna, King, Spotify, Mojang – which all do business in the digital sector.

Viewed across industries, innovation in high-tech, ICT and digitalisation is also driving innovation and development in other industries and other sectors of society, often creating new business models that most closely compares to complex ecosystems. To continue with the Apple example cited above, the introduction of smartphones has clearly not only changed how we call and converse with each other, but has had profound impact on other areas, such as transport services, music consumption and banking, to name only a few. High-tech, the ICT industry and digitalisation are thus key drivers for innovation and growth for a wide range of industries and society as a whole.

⁶ EU Commission (2010): *Turning Europe into a true Innovation Union*.

⁷ American Enterprise Institute (2014): *Fortune 500 firms in 1955 vs. 2014*.

⁸ Forbes (2013): “Staying in Business Forever”; See also Foster (2001): *Creative Destruction*.

⁹ OECD (2009): *Innovation in firms: A microeconomic perspective*.

¹⁰ Unicorns are tech start-ups valued at more than USD 1 billion.

The connection between high-tech and ICT and other industries is also confirmed by a recently published report, *Stockholm FinTech – An overview of the FinTech sector in the greater Stockholm Region* by the Stockholm School of Economics in collaboration with Stockholm Business Region Development.¹¹ The report emphasises that it is remarkable that Stockholm demonstrates such strong results in FinTech, in the light of the size of the city and the absence of a comprehensive financial ecosystem of accelerators, incubators and niche investors, as found in many other European financial centres. This is explained in part by the expansive development of the ICT sector and high internet and smartphone penetration, which have created an advantageous climate, as evidenced by businesses such as Klarna and iZettle as well as Nordnet and Avanza, which are competitors to the traditional banks.

In discussions with several key actors in high-tech and ICT, it clearly emerged that an expansive broadband infrastructure is one of the cornerstones of favourable development of the high-tech and ICT industries. For example, Net4Mobility, a leading mobile network operator, has said that:

*...without access to an efficient fibre infrastructure and especially dark fibre, we would not have been able to deliver a mobile network of the quality that we do today. The expansive fibre network in Stockholm has also given us a solid foundation to stand on when, for example, the next-generation 5G mobile network is deployed. This is creating new opportunities to use and develop new and innovative services, for us and our customers alike.*¹²

Also the operator, Bahnhof, which provides fixed line broadband, has said that:

*...for us, as a medium-sized network operator – not among the top three, but perhaps one of the top ten in Sweden – the ability to rent dark fibre on equal terms is critical to our business. Without access to dark fibre, we would be unable to push down our prices and it would be impossible to develop new products. The fibre infrastructure has very strong impact on the diversity of services we can offer. Ultimately, this also affects the opportunities provided to consumers.*¹³

Interviews and surveys of several SMEs in commercial areas in Stockholm also clearly indicate that access to an expansive broadband infrastructure is business-critical. A majority report that fibre has been virtually or utterly critical to business and service development, which has in turn determined their capacity to drive growth. For example, an SME whose business is renting office space to communications professionals said, “*No one would locate their enterprise in our premises if we did not have fast, effective and stable fibre because it is critical to their business.*”¹⁴

Yet another example of how SMEs have been promoted by a good broadband infrastructure is found in an SME that sells CAD software in the Nordic region, which reported, “*Nowadays, we can run online training programmes without a hitch. Our old ADSL connection was simply not good enough. Today, thanks to the capacity of the fibre connection, we have what we need to run our own servers.*”

The broadband infrastructure has also affected the opportunities of these enterprises to reach new markets. One SME, whose business is software management, reported that access to fibre has been essential and noted, “*We have many customers and suppliers abroad. Distance is no longer measured only in kilometres; it is also measured in milliseconds.*” A common denominator for the SMEs above is that all of them (at the time of the survey) gained access to fibre relatively recently, which illustrates that access to a good fibre infrastructure already has tremendous potential to promote SMEs. This is likely to accelerate as future needs impose higher and higher demands on the broadband infrastructure.

¹¹ Wesley-James, N. (2015): *Stockholm FinTech: An overview of the FinTech sector in the greater Stockholm Region*.

¹² Net4Mobility (2016): Interview

¹³ Bahnhof (2016): Interview

¹⁴ Survey (2016): *The Impact of the Fibre Infrastructure*. See Appendix V.

The importance of access to a good broadband infrastructure to economic development, growth and innovation was also highlighted in a recently published OECD report, which shows that high speed broadband networks foster economic growth.¹⁵ The study makes it clear that fibre infrastructure coverage is an important investment in innovation and future growth.

Ericsson has also highlighted the connection between ICT and social development in its annual benchmarking study, the *Networked Society City Index*.¹⁶ For the second consecutive year, Stockholm was ranked number one in this benchmarking study. The report emphasises that ICT is a foundation for more radical innovation and a process that reshapes existing industries and defines new markets.

Deloitte has previously conducted several studies of the impact of the fibre infrastructure. The studies have shown, for example, that open and operator-neutral access to fibre infrastructure fosters competition and diversity. The capacity of operators and service providers to drive and improve service development and innovation is facilitated, thus creating a wider variety of service providers and a broader range of services for consumers.¹⁷

Against this background, Stokab has commissioned Deloitte to analyse the connection between the broadband infrastructure – with focus on the fibre infrastructure – of a city or region and its innovation capacity within high-tech, ICT and the digital sector. This study describes this connection is for Stockholm and five other major European cities.

¹⁵ Mölleryd, B. (2015): *Development of High-speed Networks and the Role of Municipal Networks*.

¹⁶ Ericsson (2014): *Networked Society City Index 2014*.

¹⁷ Deloitte (2013): *Kommunikationsinfrastrukturens betydelse för bredbandsmarknaden*.

Approach and method

This chapter describes the approach and method of this study. The case study cities are described first, followed by the innovation indicators and infrastructure parameters that were analysed. Definitions and assessment criteria have also been described for each innovation indicator and the infrastructure parameters in the respective sections.

Studied cities

Six European cities were selected as case study subjects to investigate the correlation between broadband infrastructure and innovation in high-tech, ICT and the digital sector. The selection criteria were that the cities must be capital cities, including some of relatively comparable size to Stockholm, and that three of the larger capital cities in Europe must be included. The selected cities were:

- Amsterdam
- Berlin
- Copenhagen
- London
- Paris
- Stockholm

The metropolitan regions for the cities are defined according to the EU's official regional classification system, "Nomenclature of Territorial Units for Statistics" (NUTS), which is divided into three hierarchical levels. In most cases, the cities were defined at the NUTS 2 level, except for London, which has been defined at the NUTS 1 level. In some cases, Paris has been defined as an aggregate of NUTS 3 regions to enable fairer comparisons between the cities. See Appendix III for complete definitions.

Innovation indicators

Comprehensive inputs are required to measure the innovation performance of a city/region because a wide variety of factors influence innovation and there are several different innovation indices that measure various aspects of innovation.¹⁸ This study is based on measuring innovation performance based on statistically significant data available at the city level.

Based on a compilation of the indicators commonly used in reliable international innovation studies – and because this study concentrates on innovation in high-tech, ICT and the digital sector – the following three main indicators were selected:

- Patent applications in the high-tech and ICT sector
- Workforce in the high-tech sector
- Venture capital invested in start-ups in the digital sector

To a great extent, these indicators reflect the outcomes of innovation – new products, new services and job growth. A rating scale of one to three was also introduced to enable analysis of the comparative innovation performance of cities. The cities were ranked

¹⁸ Examples include the Global Innovation Index, the Innovation Union Scoreboard and the Bloomberg Innovation Index

according to low, medium or high innovation performance in relation to each other. The following section will discuss the selected indicators described above, in order.

Additional factors that may indicate innovation performance are found, for example, in the volume of capital invested in research and development activities or a city's "entrepreneurial culture." However, these factors were not included due to the lack of reliable data at the industry and regional levels and thus the ability to compare different regions and cities.

Innovative companies make up only a fraction of total business activity. Innovation may refer to both technology and business models. Despite their limited numbers, innovative companies can contribute to reshaping how an entire industry works. Innovative companies are therefore an important factor in digital development and thus for society in general. The number of innovative companies in relation to total business activity cannot be measured, however, as there are no statistics available at the city/regional level.

Patent applications in the high-tech and ICT sector

Definition

One of the most common ways of estimating the innovative capacity of a particular city or region is to measure the number of patent applications originating from this city or region. An innovative city generates a large number of novel products and solutions and the city produces a large percentage of new patent applications as a result.

In order to compare the selected cities on equal terms, we studied patent applications filed directly with the European Patent Office (EPC patents) and applications filed under the international Patent Cooperation Treaty (PCT) designed for the European Patent Office (Euro-PCT patents). Only patents included in EU definitions of high-tech and ICT patents were included. For the sake of readability, "patent applications in high-tech and ICT" are referred to as "patent applications" in the following sections of this study.

Data have been derived from the European Patent Office's statistical database, PATSTAT.¹⁹ See Appendix III for complete classification information.

Assessment

A city with a higher number of patent applications is assessed as more innovative. The total number of patent applications from a city is compared with its population in order to more easily illustrate which cities have a high number of patent applications relative to their size.

The limits for the rating scale of low, medium and high were calculated based on the median value of the number of patent applications per million inhabitants for the cities. Thereafter, the upper limit for the "mid-range", or median, was defined at 150% of the median value and the lower limit for the same range to 50%. The limits have been marked on the following chart.

¹⁹ EPO Worldwide Patent Statistical Database (PATSTAT).

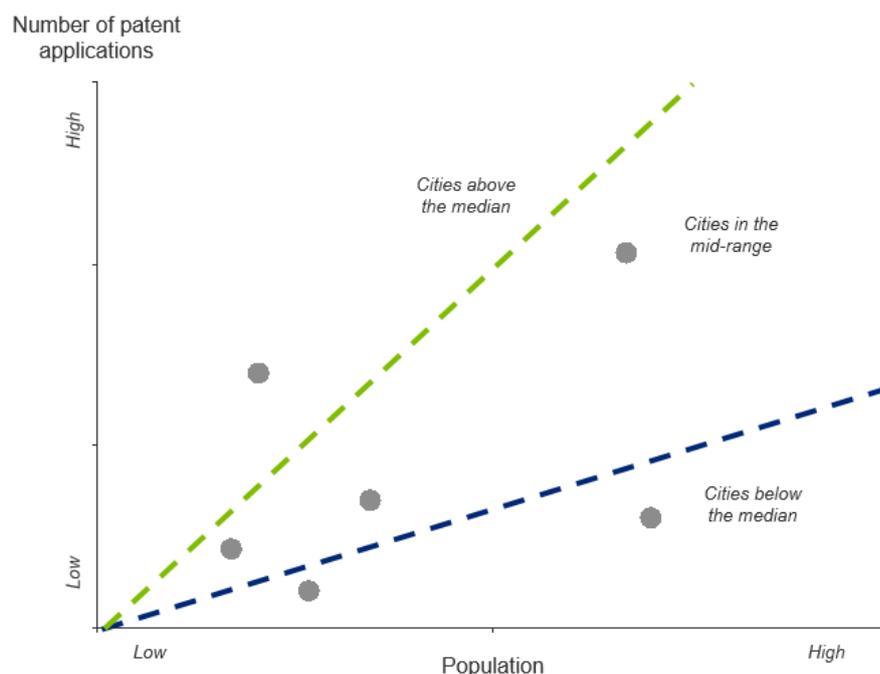


Figure 1. Illustrative chart for assessment of patent applications in high-tech and ICT.

Number of employees in the high-tech sector

Definition

A high percentage of the total workforce in the high-tech and ICT sector is assessed as increasing a city's capacity to run innovative processes. For this innovation indicator, the high-tech sector has been defined according to the EU Commission's classification of economic activities in the European Community, NACE.²⁰ Here, the high-tech sector has been defined as the industrial sectors that fall under the category of "high-tech industry and knowledge-intensive services" and includes activities such as telecommunications services, computer and programming services, information sharing services, etc. See Appendix III for a complete definition.

The percentage of the workforce employed in the high-tech sector is calculated by taking the number of employees in high-tech divided by the total number of employed inhabitants in the studied city.

Assessment

The higher the percentage of the workforce in high-tech in a city, the more capacity to drive innovation the city is assessed as having. Like the preceding indicator, the limits of the rating scale are defined based upon the median value of the percentage of the workforce in high-tech for all studied cities. The upper and lower limits were set at 125% and 75%, respectively, of the median value because the range of the final values was narrower than for the preceding indicator (number of patent applications).

²⁰ Statistical Classification of Economic Activities in the European Community, Rev. 2 (abbreviated NACE, Rev 2).

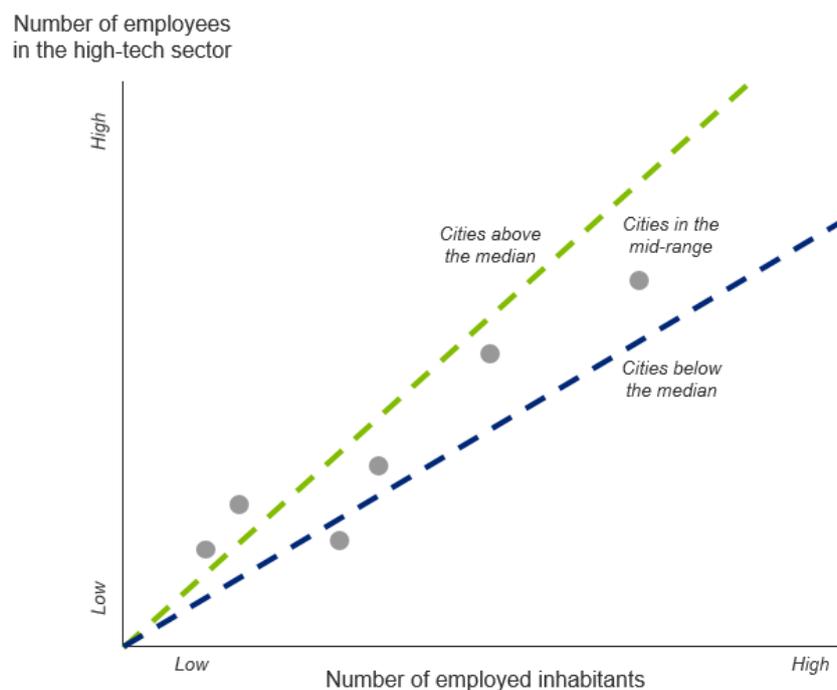


Figure 2. Illustrative chart for assessment of percentage of the workforce in the high-tech sector.

Venture capital invested in start-ups in the digital sector

Definition

Nowadays, innovation is often discussed in connection with growing interest in entrepreneurship. Entrepreneurship is often described as an important driver of innovation and, as previously mentioned, there are both initiatives at the EU level aimed at promoting entrepreneurship and institutions explicitly dedicated to this purpose.²¹

In order to assess the entrepreneurial performance – and in so doing, innovation performance as well – of a city, Deloitte studied the volume of venture capital invested in start-ups. “Start-ups” refers to all companies in the launch phase (seed investment), early development phase (early stage investment), or the expansion phase (later stage VC investment).

Only capital invested in start-ups in the digital sector was taken into account.²² In this case, the “digital sector” refers to companies with a high percentage of activities in the sectors of internet software and services, mobile software and services, eCommerce, mobile commerce and comparable closely related industries. See Appendix III for a complete definition.

Assessment

In order to compare the cities to each other, the quotient of the volume of venture capital invested and GDP (adjusted for purchasing power) was compared for each city.

The higher the quotient, the more innovative the city is assessed as being.

As for the preceding indicators, the median value was also calculated in order to define the rating scale. The upper and lower limits for the mid-range were defined as 150% and 50%, respectively, of the median value. These have been marked on the following chart.

²¹ See e.g., World Economic Forum (2015) – *How can Europe become more innovative?*; Confederation of Swedish Enterprise (2013) – *Ökat intresse för företagande bland studenter*; European Institute of Innovation & Technology (2015), European Commission (2014) – *Entrepreneurship and Innovation Programme*.

²² The definition of the digital sector was taken from the data source, CB Insights.

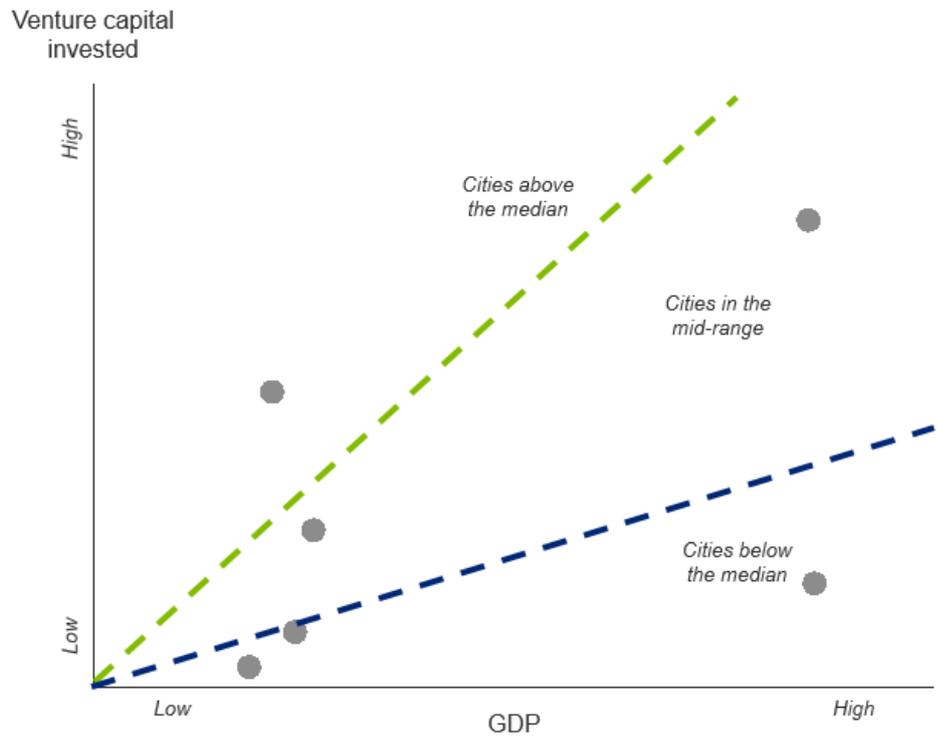


Figure 3. Illustrative chart for assessment of venture capital invested in startups in the digital sector.

Broadband infrastructure

There are mainly three underlying broadband infrastructures that enable delivery of fixed line broadband. These three are the fibre network (used for all forms of electronic communication, but mainly for high-speed broadband), the copper network (originally built for fixed line telephony) and the coaxial cable network (originally built for cable TV).

In the following sections, a brief comparison of the various infrastructures and their associated broadband technologies is presented first. Thereafter, the selected parameter – coverage – is defined in order to analyse the level of broadband infrastructure in the studied cities.

A comparison of the characteristics of these three networks follows, with respect to broadband delivery:²³

	Fibre (FTTH/B)	Coax	Copper
Top commercial technology	GbE/GPON	DOCSIS 3.0	VDSL2
Data rate (down/up)	1/1 Gbps (or higher)	300/50 Mbps	60/10 Mbps
Transmission reach	Up to 80 km	0.5 - 3 km (high - low speed)	0.2 - 1.5 km (high - low speed)
Infrastructure characteristics	<p>Fibre is installed all the way to the end-user's home (FTTH) or building (FTTB).</p> <p>The fibre network itself has no technical limitations for maximum capacity – the limit is determined by the active equipment used to transmit light through the fibre cables</p> <p>The only broadband infrastructure assessed as future-proof. Low latency and not limited by distance.</p>	<p>Uses fibre to “feeder stations”, then coax cables for the “last mile” to reach the end user at the home or building.</p> <p>The speed must be shared among users, which means that a household can rarely reach the top speed a coax cable is able to deliver (because coax cables are almost always shared among several households).</p> <p>The further development of DOCSIS 3.1 should be able to deliver speeds of up to 10 Gbps downstream and 1 Gbps upstream. The first roll-outs are expected within 1-2 years.²⁴</p>	<p>from the operator to a telecoms cabinet on the street and sent from there via copper cables to the end-user's home (FTTC).</p> <p>The resistance of copper imposes serious limitations on the distance over which signals can be transmitted – this applies especially to high-frequency signals.</p> <p>The further development of VDSL, called G.Fast, is supposed to be able to deliver (asymmetrical) speeds of up to 300-500 Mbps downstream. However, transmission reach is sharply limited and G.Fast has been judged to have a reach of less than 100 m.^{25 26}</p> <p>The latest further development, XG.FAST, has reached speeds of 5 Gbps in lab trials. However, this technology has been assessed as having a long way to go before it is commercially viable.²⁷</p>

²³ European Commission (2014): *Guide to High-Speed Broadband Investment*.

²⁴ Cable Labs (2015): “Featured Technology – DOCSIS 3.1”.

²⁵ A symmetrical connection means that it has the same data rate, or speed, both downstream and upstream.

²⁶ Light Reading (2014): “G.fast: The Dawn of Gigabit Copper?”

²⁷ Telecoms.com (2015): “BT, Alcatel-Lucent reach 5Gbps over copper in XG.Fast lab trial”.

VDSL2 is the most common technology for the copper network, which can deliver speeds of about 60 Mbps downstream and 10 Mbps upstream. Newer technologies for the copper network are in trials, where G.Fast, for example, has the potential to deliver up to 500 Mbps when distribution points are used within 100 m of the end-user (FTTdp). Due to the inherent resistance in the copper lines, however, capacity declines rapidly as distances increase, which also means that G.Fast is limited to only shorter distances.

For operators that utilise the coax network, the next development of the technology is the DOCSIS 3.1 protocol. This protocol has demonstrated the ability to deliver speeds of 1-10 Gbps, but the speed has to be shared among end-users. The technology does not deliver symmetrical data transmission and upload speed is generally significantly lower than download speed. Like the copper network, the capacity of the coax network is sharply limited by the distance between the end-user and the distribution point.

FTTH/B delivers symmetrical and considerably higher speeds that do not have to be shared by end-users and capacity is distance-independent. As FTTH/B is the most complete and future-proof technology of all existing infrastructures, it has been used as the basis for assessing the broadband infrastructure in this study.²⁸

FTTH/B and underlying fibre infrastructure

In order to analyse the level of fibre infrastructure in a given city, we studied the coverage of FTTH/B connections. A detailed definition and assessment criteria are described in the section below.

Competition, market models and regulations are parameters that affect the coverage of FTTH/B connections. However, these parameters were not examined in this study for the various cities, because this would require a detailed discussion of conditions in each market. As well, there are no reliable data for these parameters in many cases.

FTTH/B coverage

Definition

Coverage is defined as the percentage of households within a metropolitan region that are able to connect with an FTTH/B connection (also called FTTP) without having to build new fibre infrastructure. Other types of fibre connections, such as FTTC and FTTdp, are not included in the definition: only FTTH/B is included in the definition of coverage in this report.

Assessment

The degree of FTTH/B coverage was selected because it was deemed to reflect both current capacity and how well-equipped the fibre infrastructure is for future needs. FTTH/B is usually considered the most future-proof technology. Therefore, higher FTTH/B coverage was assessed as indicative of a fibre infrastructure that is better equipped for the future.

Coverage for the cities is presented in ranges, rather than actual percentages. This is primarily due to confidentiality standards related to data collection. The ranges are divided into 0%, 0-35%, 35-65% and 65-100%, where 0 indicates that the city has zero coverage (or a very small, negligible percentage) and where 65-100% indicates that the degree of coverage is between 65 and 100% in the associated metropolitan region.

²⁸ Broadband World Forum (2015): "FTTX: Delivering the future of connectivity".

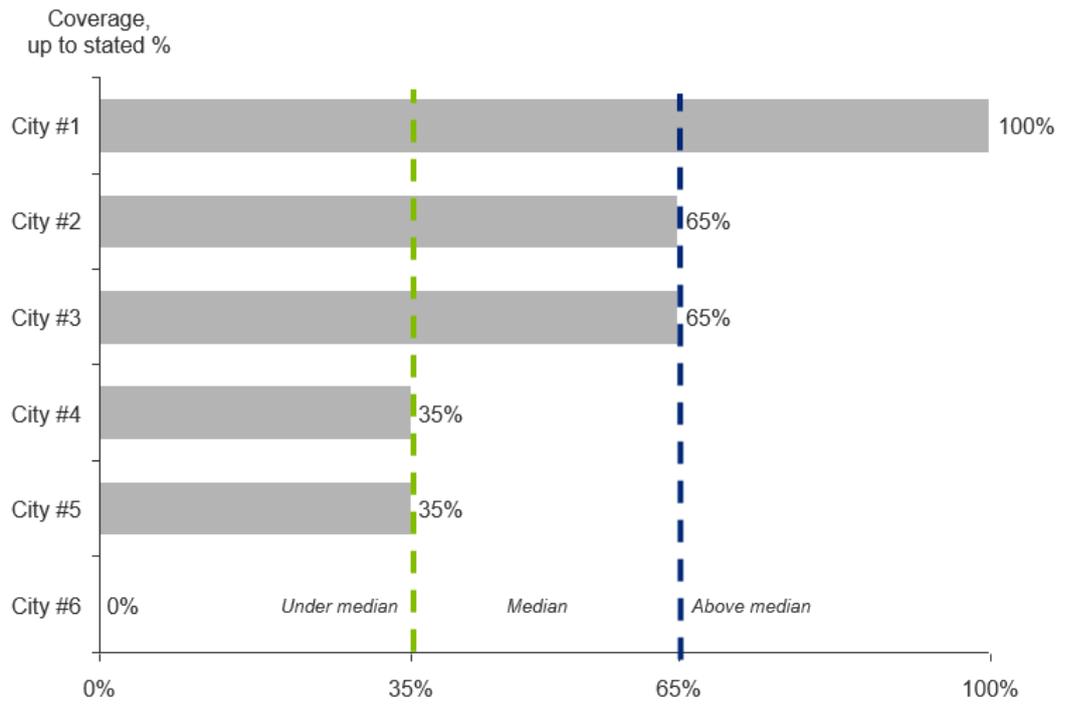


Figure 4. Illustrative chart for assessment of FTTH/B coverage.

Analysis and results of case studies

The resulting innovation performance and fibre infrastructure ratings for the selected cities above are presented in two separate sections of this chapter. The relationships between innovation indicators and fibre infrastructure in each city are presented at the end of the chapter.

Innovation indicators

The cities have been rated on a three-point scale for each innovation indicator. The rating limits for the three-point scale were defined based on the median value for the cities in relation to each other. Thereafter, this value was increased or decreased by 50% to arrive at the upper and lower limits, respectively. These limits are marked on the charts.

In the next section, the three factors are presented in the following order: patent applications in high-tech and ICT, workforce in high-tech and venture capital invested in start-ups in the digital sector

Patent applications in high-tech and ICT

The number of patent applications and the population for each city are shown below:

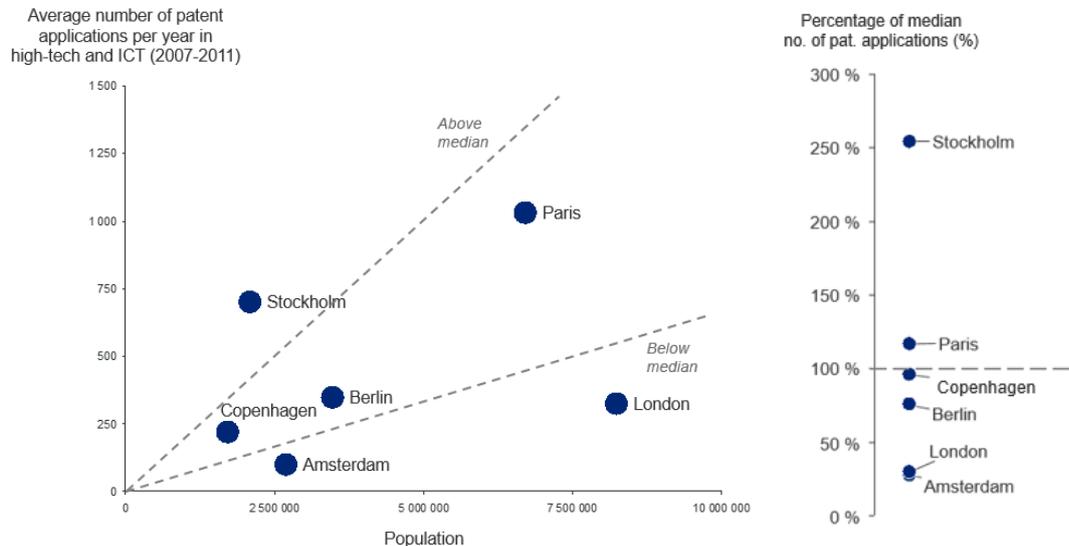


Figure 5. Chart showing number of patent applications in high-tech and ICT and population.²⁹

The chart indicates that Stockholm is performing well above the median with regard to patent applications. Stockholm, which is the second-smallest city in terms of population, generates more patents than all other cities except Paris. In terms of number of patent applications per capita, Stockholm has the highest value, with about 330 patent applications per million inhabitants. This corresponds to more than twice the value for the next city in the ranking, Paris, which has 150 patent applications per million inhabitants. London, the largest city in terms of population, generates only 40 patent applications per million inhabitants, corresponding to 12% or less than one-eighth of the same value for Stockholm. Amsterdam's performance is also comparatively low, with about 33 patent applications per

²⁹ Source: Eurostat, PATSTAT. Data from the last five years are available as complete statistics.

million inhabitants. Copenhagen and Berlin are at similar levels, with about 100-120 patent applications per million inhabitants.

The chart shows the rating limits that correspond to 50% above or below the median value for all cities, which were used as the basis for the table below:

Number of patent applications in high-tech and ICT per capita					
Amsterdam	Berlin	Copenhagen	London	Paris	Stockholm
Below	Median	Median	Below	Median	Above

Table 1: Number of patent applications in high-tech and ICT per capita.

Workforce in the high-tech sector

The number of employees in the high-tech sector and the population of each city are presented below:

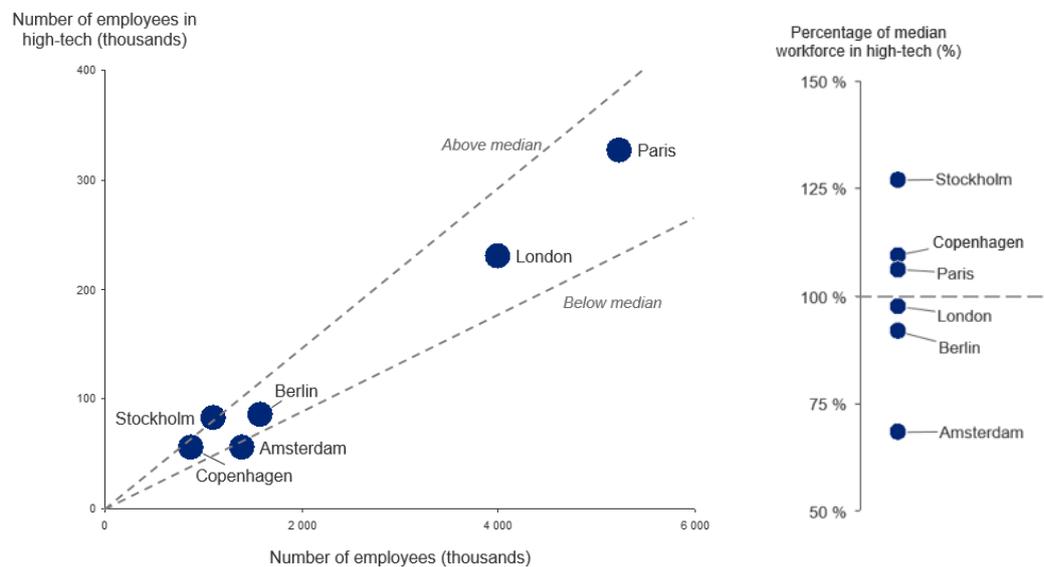


Figure 6. Chart showing number of employees in the high-tech sector and the population of each city.³⁰

As for patent applications, Stockholm also ranks highest for the percentage of the workforce in the high-tech sector relative to the other cities. Because the difference in the percentage of high-tech employees was not as clear as for patent applications, the rating limits were defined as a 25% difference from the median value instead of 50%. The chart shows that most cities are at similar levels, while Stockholm stands out with a higher percentage of the workforce in high-tech, while Amsterdam stands out with a lower percentage of high-tech employees. Stockholm's percentage is about 188% of that for Amsterdam (7.5 and 5.0 percent of the total workforce, respectively).³¹

³⁰ Source: Eurostat.

³¹ Note that in this chart, Paris has been defined according to its NUTS 2 definition (Île-de-France), due to the lack of more detailed data at the NUTS 3 level.

The results above can be summarised in the table below:

Percentage of workforce in the high-tech sector					
Amsterdam	Berlin	Copenhagen	London	Paris	Stockholm
Below	Median	Median	Median	Median	Above

Table 2. Percentage of workforce in the high-tech sector.

Venture capital invested in start-ups in the digital sector

The volume of venture capital invested in start-ups in the digital sector in all cities and the GDP of each city are presented below:

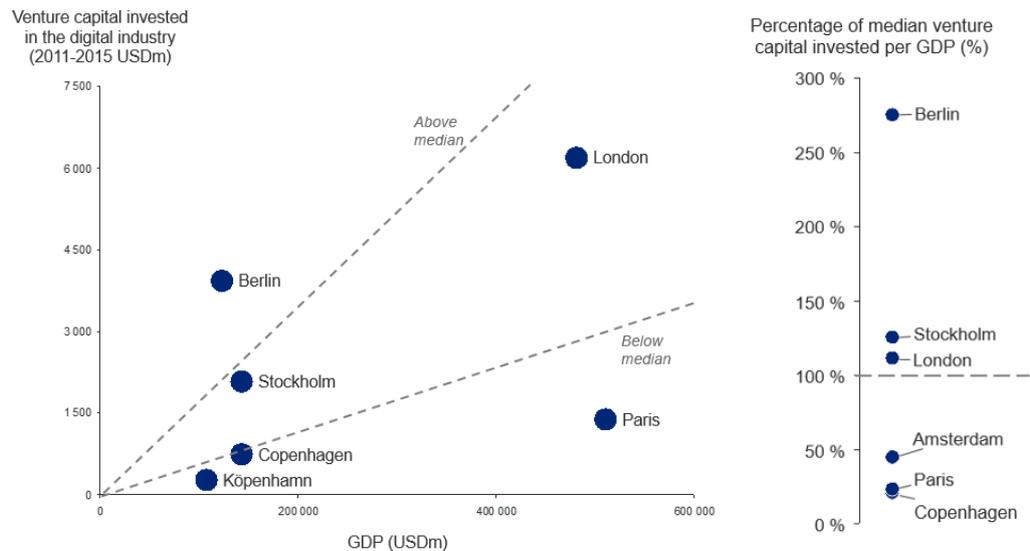


Figure 7. Chart showing the volume of venture capital invested in start-ups in the digital sector and GDP per city.³²

Berlin is the outlier with a value of almost \$32,000 in venture capital invested per \$1 million in GDP. This is a full 220% of the corresponding value for Stockholm, which is second on the list. Stockholm and London both have a corresponding value of \$12-15,000. The gap to the following city, Amsterdam, is relatively wide, with a value slightly above \$5,000. Copenhagen and Paris both end up at the bottom of the list with about \$2,500 in venture capital invested per \$1 million in GDP, equal to only around 8% of that generated by Berlin.

A more detailed account of why Berlin differs from the other cities in the study is provided in the conclusions section and in Appendix IV. It should, however, be noted that while Berlin attracts substantial venture capital, other cities, including Stockholm, may be more successful at leveraging capital into successful exits.³³ If, for example, one looks at the number of “unicorns” per city, one sees that Stockholm ranks much higher than Berlin.

The results above can be summarised in the table below:

Venture capital invested in startups in the digital sector/GDP					
Amsterdam	Berlin	Copenhagen	London	Paris	Stockholm
Below	Above	Below	Median	Below	Median

Table 3: Venture capital invested in start-ups in the digital sector/GDP.

³² Source: CB Insights.

³³ Creandum (2015): “Nordic Tech is on fire – almost 10% of global BUSD exits over past 10 years”.

Fibre infrastructure

The chart illustrating coverage of FTTH/B connections in the studied cities is shown below:

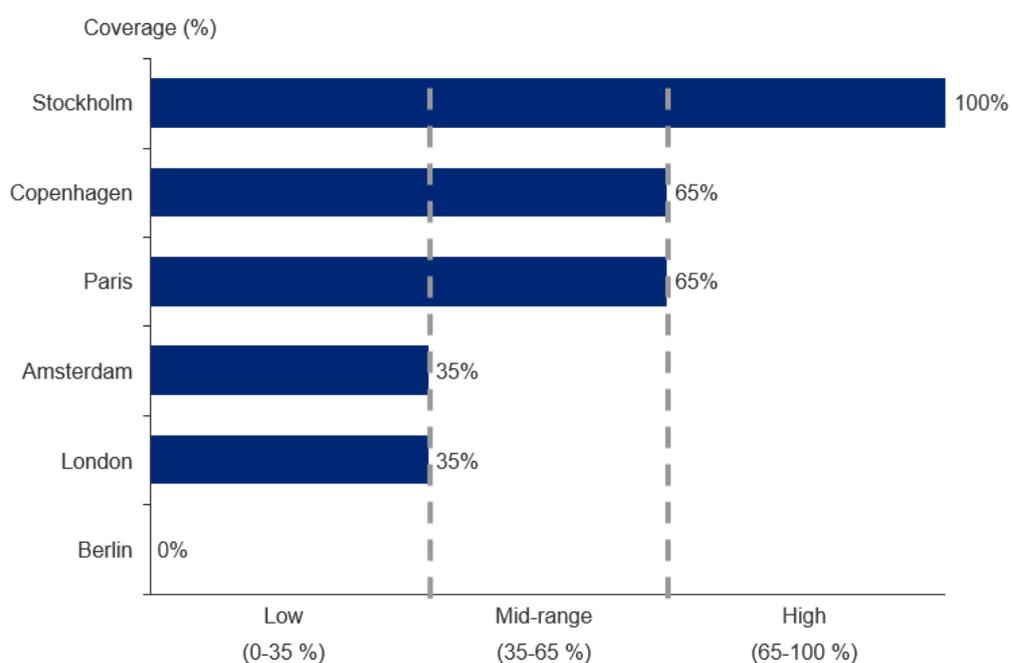


Figure 8. Chart showing degree of coverage in the studied cities.³⁴

Stockholm has the highest fibre coverage at close to 100%. It is followed, in descending order, by Copenhagen, Paris, Amsterdam and London. Coverage is lowest in Berlin where FTTH/B is virtually unavailable.

The results above can be summarised in the table below:

FTTH/B coverage					
Amsterdam	Berlin	Copenhagen	London	Paris	Stockholm
Median	Below	Median	Median	Median	Above

Table 4: FTTH/B coverage.

³⁴ Source: IHS Global and VVA (2015): *Broadband coverage in Europe 2014, a study for the European Commission*.

Patent applications in high-tech and ICT and infrastructure parameters

Aimed at studying the relationship between innovation and fibre infrastructure, the two are compared in the following section. The number of patent applications is presented first, followed by the percentage of the workforce in high-tech and finally the volume of venture capital invested compared with fibre coverage in each city.

The number of patent applications in high-tech and ICT per million inhabitants in relation to coverage:

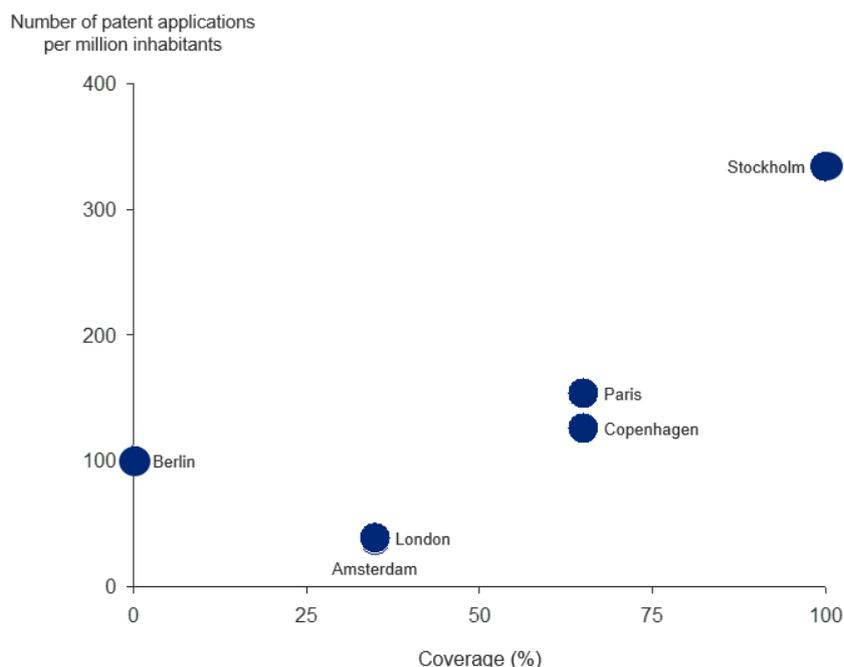


Figure 9. Chart showing number of patent applications in high-tech and ICT and population.

Figure 9 shows that Stockholm has both a very high number of patent applications per capita and an expansive fibre infrastructure. Paris and Copenhagen have relatively lower numbers of patent applications as well as less expansive infrastructures. The correlation is likewise shown in London, Amsterdam and Berlin, where the infrastructures are less expansive and the number of patent applications per capita is lower. The chart supports the hypothesis that there is a relationship between innovation and fibre infrastructure.

Percentage of the workforce in high-tech and infrastructure parameters

The percentage of the workforce in high-tech per capita is presented below in relation to coverage in the studied cities:

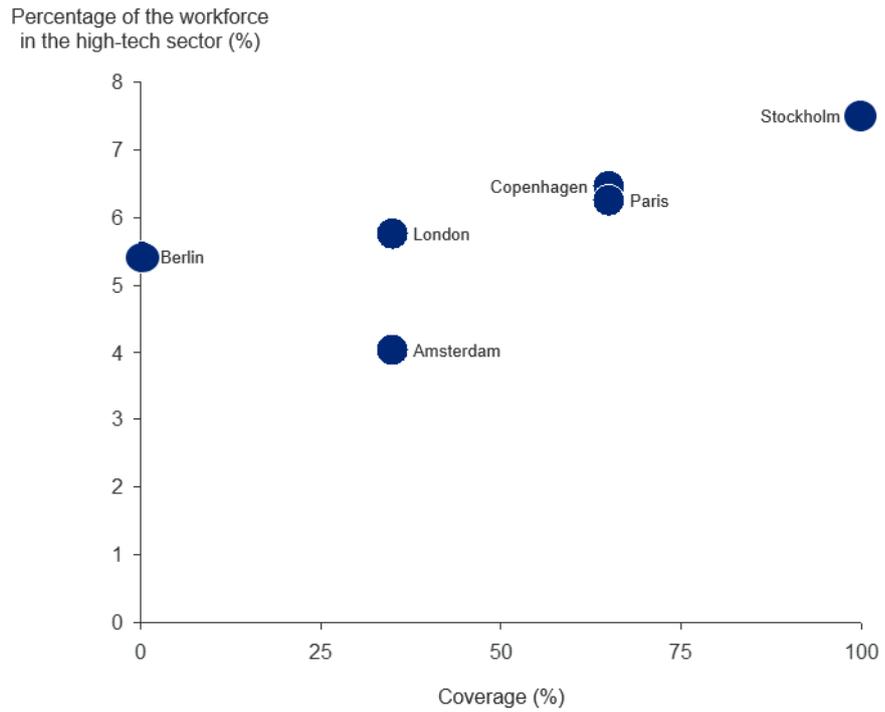


Figure 10. Chart showing the percentage of the workforce in high-tech in relation to coverage.

Figure 10 shows a correlation between coverage and the percentage of the total workforce in the high-tech sector. Stockholm, which has good coverage, also ranks highest for the percentage of the workforce in high-tech. The chart also shows that Berlin, which lacks fibre coverage, ranks lower for the percentage of the workforce in high-tech.

Venture capital invested in start-ups in the digital sector and infrastructure parameters

The volume of venture capital invested in start-ups in the digital sector divided by GDP in relation to the studied cities is presented below:

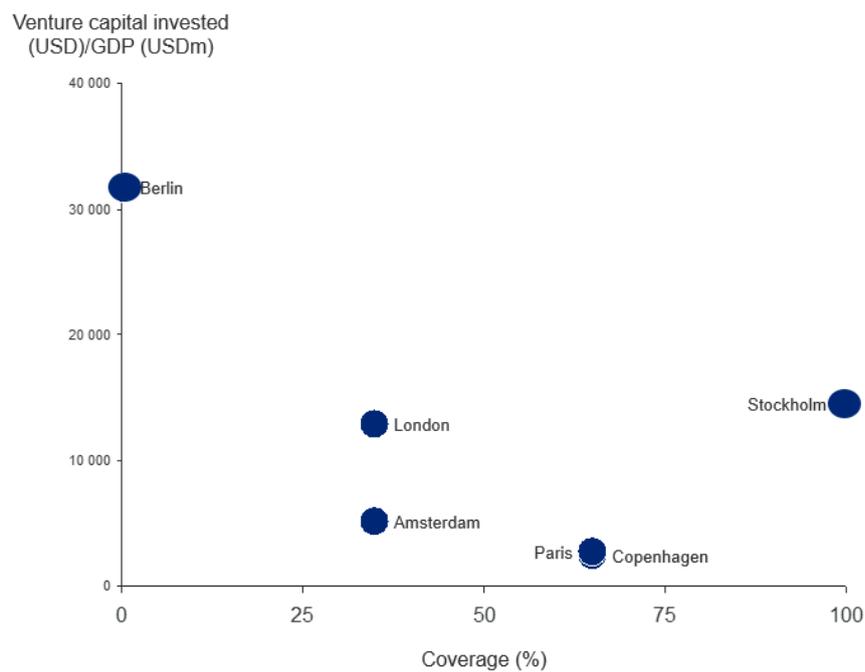


Figure 11. Chart showing the volume of venture capital invested in start-ups in the digital sector in relation to coverage.

Figure 11 shows that Berlin, despite its very small percentage of fibre infrastructure, is ranked highly for venture capital invested. The relationship between innovation measured in venture capital invested and fibre infrastructure is thus not as distinct as for the other two innovation indicators. After Berlin, Stockholm has the highest volume of venture capital invested in the digital sector in relation to GDP.

Conclusions and recommendations

The case studies of six European capitals, wherein the result of selected innovation indicators and fibre coverage were analysed, show that there is a definite relationship between innovation in high-tech and the ICT industry and the fibre infrastructure of a city.

A chart is presented below that shows the combined value of the innovation indicators compared to fibre coverage in the studied cities:

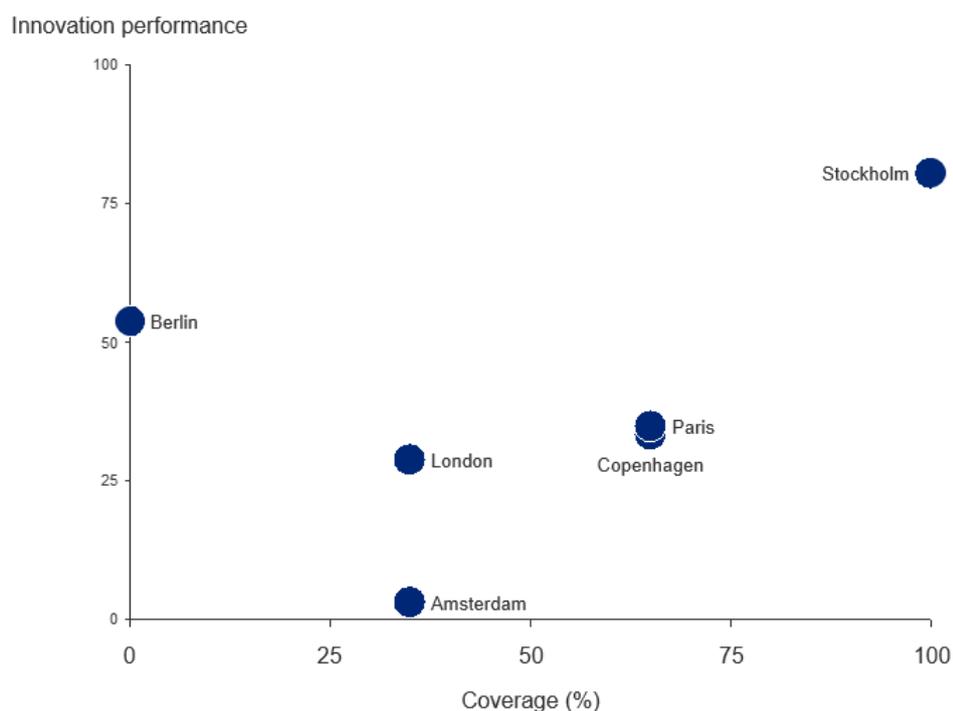


Figure 12. Chart showing the combined value of the innovation indicators and fibre coverage.³⁵

All cities, except Berlin, demonstrate a correlation between fibre infrastructure coverage and innovation performance. Stockholm is placed very highly on both the innovation axis and the fibre coverage axis on the chart. London, Paris and Copenhagen all have significantly lower innovation performance along with lower fibre infrastructure coverage than Stockholm. Amsterdam has the lowest innovation performance as well as a relatively low level of fibre infrastructure.

Berlin stands out primarily due to its high value for the venture capital indicator, which was based on a number of interacting and partially unique factors that are difficult to replicate in other cities. For example, a few very high-profile start-up successes in Berlin have created innovative “ripples on the water”, capturing the interest of global capital markets and fostering local and incentivising policy advantages for the region. Germany also began working with in-depth collaboration strategies for digitalisation earlier than other comparable countries, which has generated synergies among sectors, research, public institutions and

³⁵ The combined value is calculated as an unweighted “average” of all innovation indicators. Each indicator was recalculated to an index of 1-100, where 1 was the lowest and 100 the highest value that any city achieved. The combined values shown in the chart above were then defined as the median of all index values for the innovation indicators.

capital markets. This has also led to strategic and concrete measures to drive the financing of a world-leading cluster.

Berlin's large and mature domestic market is also characterised primarily by firms that are driving the digitalisation or e-commercialisation of existing industries (such as car sharing, online retail, etc.), rather than firms whose online services are their only source of revenue (such as game developers). Relatively modest broadband speeds are good enough for the former type of firm but demands are considerably higher for the latter type. For these firms, access to a good fibre infrastructure has been assessed as the most future-proof alternative, which means that in the future Berlin is probably going to have to consider how the increasing demands for broadband infrastructure from the aforementioned firms can be satisfied. A more detailed analysis of the inflow of venture capital into Berlin is provided in Appendix IV.³⁶

The following table summarises the results of the studied cities with regard to the innovation indicators and fibre coverage:

	Patent applications	Workforce in high-tech	Venture capital invested	Coverage
Stockholm	Above	Above	Median	Above
Berlin	Median	Median	Above	Below
London	Below	Median	Median	Median
Copenhagen	Median	Median	Below	Median
Paris	Median	Median	Below	Median
Amsterdam	Below	Below	Below	Median

Table 5: Table showing the overall picture of innovation indicators and infrastructure parameters. The cities have been ranked based on their results for each of the three indicators.

In summary, the results of this study, based on the innovation indicators and cities examined, show a confirmed positive correlation between fibre infrastructure coverage and the innovation climate of a city. Stockholm's well-developed fibre infrastructure puts the city at the top of the league table. Berlin is second, largely due to its very strong results for the indicator of venture capital invested. The other cities follow thereafter, in descending order and with a clear correlation between innovation and fibre infrastructure.

As innovation performance in high-tech and the ICT industry is playing an increasingly important role for innovation in both traditional service markets and mature industrial markets, investing in an expansive fibre infrastructure is a key concern for cities and regions intent on being at the forefront of innovation.

Because the size of a city and its market is probably also significant to its innovation performance, there is also reason to comment on Stockholm's position in relation to the larger cities in the study. Even though London and Paris are much larger than Stockholm, they rank lower with regard to innovation performance. It is therefore reasonable to assume that a good fibre infrastructure can compensate for size and access to a larger market and

³⁶ United Minds (2016): *Berlins innovationsförmåga – fördjupad nyansering av marknadsfaktorer*.

that investments in fibre infrastructure are thus even more important for smaller cities with access to limited local markets.

Yet another area in which the fibre infrastructure will have strong impact on future growth and innovation is the introduction of “Internet of Things”, 5G solutions and “smart cities.” Explosive growth has been predicted for all three of these areas, which will require very good underlying fibre infrastructure to fully meet the technical requirements and prerequisites, thus providing even clearer reason to invest in an expansive fibre infrastructure.

Finally, this study shows a clear need for further work and studies that shed light on the correlation between innovation and investments in fibre infrastructure and their impact on European economic growth and development.

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Appendix II - Acronyms

DOCSIS	Data Over Cable Service Interface Specification
DAE	Digital Agenda for Europe
EPC	European Patent Convention
EU	European Union
FTTB	Fibre to the Building
FTTC	Fibre to the Curb
FTTH	Fibre to the Home
FTTN	Fibre to the Node
FTTP	Fibre to the Premise
FTTX	Generic term for fibre configurations, referring to e.g. FTTP, FTTB, FTTH etc.
GbE	Gigabit Ethernet
GBPS	Gigabits per second
GPON	Gigabit Passive Optical Networks
ICT	Information & communications technology
IPC	International Patent Classification
IU	Innovation Union
MBPS	Megabits per second
NACE	Statistical Classification of Economic Activities in the European Community
NGA	Next Generation Access
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organisation for Economic Co-operation and Development
PCT	Patent Cooperation Treaty
PTS	Swedish Postal and Telecommunications regulator
VDSL	Very high data rate Digital Subscriber Line

Appendix III – Definitions and classification systems

Region definitions - NUTS

The cities included in this study were defined according to the regions in the following table. Information on GDP, population, etc., was thus taken from the information about these regions. The regions are defined according to the EU regional classification system, “Nomenclature of Territorial Units for Statistics” (NUTS).

The regions were selected to increase comparability among the cities and so that the assessment would be as equivalent as possible for all cities, despite differences in size, population density, area, etc. For Paris, the city was defined in most cases as an aggregate of four NUTS 3 regions (often referred to as a group as “Petite Couronne”) to create greater comparability.

City	Corresponding NUTS region	NUTS level
Amsterdam	Noord-Holland	2
Berlin	Berlin	1/2/3
Copenhagen	Hovedstaden	2
London	London	1
Paris	Petite Couronne: Paris, Hauts-de-Seine, Seine-Saint-Denis and Val-de-Marne	3 (4 regions)
	Île-de-France	2
Stockholm	Stockholm	2/3

Patent classification - IPC

Patent applications analysed in this study were made up of patent applications in the high-tech and ICT sub-classes of EPC patents and Euro-PCT patents. EPC patents refer to patent applications filed directly with the European Patent Office (EPO) under the European Patent Convention (EPC). Euro-PCT patents refer to patent applications filed under the international Patent Cooperation Treaty (PCT) with the EPO as the receiving patent office.

High-tech and ICT were defined based on Eurostat definitions of patent classifications and technology areas, which are in turn based on the International Patent Classification (IPC) system. For the purposes of this study, the definition of high-tech was constituted of the sub-groups “computer and automated business equipment” and “communication technology” within the Eurostat definition. The definition of ICT applied in this study corresponded to the Eurostat definition of ICT.

Please refer to information from Eurostat for a more detailed breakdown of patent classifications: http://ec.europa.eu/eurostat/cache/metadata/Annexes/pat_esms_an4.pdf.

Workforce in the high-tech sector – NACE Rev. 2

The definition of the workforce in the high-tech sector aligns with the Eurostat definition of “high-tech knowledge-intensive services” based on the Statistical Classification of Economic Activities in the European Community, Rev. 2 (abbreviated NACE, based on the French

name *Nomenclature statistique des activités économiques dans la Communauté européenne*). The activities covered by this definition include telecommunications services, computer and programming services, information sharing services and scientific research and development.

For a more detailed breakdown of industrial sectors, please see http://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an4.pdf.

Venture capital – Industry definitions from CB Insights

The digital sector for venture capital in this study was defined according to the definition of industry groups applied by the data source (CB Insights), as below:

Industry group	Sub-groups
Internet	<ul style="list-style-type: none">• eCommerce• Internet software & services
Mobile & Telecommunications	<ul style="list-style-type: none">• Mobile commerce• Mobile software & services• Telecom devices & equipment• Telecom services
Software (non-internet/mobile)	n/a

In this study, the digital sector corresponds to the combination of CB Insights' industry groups Internet, Mobile & Telecommunications and Software (non-internet/mobile).

Appendix IV – The innovation capability of Berlin – elaboration on market factors.

Memorandum: The innovation capability of Berlin

Harald Cavalli-Björkman
Cen Rolfsson

2016-04-11

Background & Mission

Stokab has previously given Deloitte the mission to outline the relationship between cities' or regions' broadband infrastructure and their capacity to innovate within high-tech, ICT and digital sectors. Preliminary results from this report show interesting and clear correlations, but also certain deviations worth further consideration. One such deviation is the high presence of venture capital in Berlin's high-tech sector, despite the low level of digital infrastructure development. In order to shed some light on the reasons behind the successes of the high-tech sector in Berlin, Stokab has given United Minds the task to further investigate the characteristics of Berlin's venture capital market, with respect to the high-tech sector and the broadband infrastructure – so as to further nuance the analysis presented by Deloitte.

This Memorandum:

This document includes:

- Elaboration of the problem definition for the analysis, with focus on methodology used and the importance of distinguishing between relationships and causation
- Analysis of relationships between local innovation development, venture capital inflow and fibre infrastructure level

Problem definition

At first glance, Berlin's high capacity to innovate within the high-tech sector, despite having a relatively underdeveloped fibre infrastructure, may seem contradictory to the pattern found in other cities. However, the strength of the venture capital market in Berlin is an important dimension to add in the analysis and may explain, at least partially, Berlin's success in high-tech innovation.

High-tech investments are largely directed to e-commerce and internet start-ups. However, it should be noted that causation and relationships between venture capital flows, industrial development, and growth of geographical regions are extremely complex. Hence, maintaining exact, linear and rational relationships between industry and financial market developments may sometimes lead to misleading oversimplifications. It is important to give room to other important characteristics found in Berlin, such as low interest rates, global capital flows, presence of prominent influencers, culture, etc.

To account for this, one should observe the developments in Berlin as a *phenomenon* – i.e. an overarching development connected to multiple circumstances and/or actors – rather than to a specific set of event. Causal conclusions ought to be largely avoided. Was it the local university that created the few super entrepreneurs that became drivers of Berlin's start-up scene? Were the entrepreneurs responsible for the market growth or was it rather created by a market gap? Did access to venture capital motivate the entrepreneurial initiatives? etc.

A comprehensive review of venture capital reports, market analyses, public reports, articles and other data bases unveils a picture of a progress built upon a large number of synergies and dedicated initiatives, while it also uncovers the importance of certain individuals and policies, as well as an array of seemingly random circumstances. This memorandum attempts to uncover some of the major factors and correlations that have made it possible for Berlin to become a major place for high-tech innovation, despite having a relatively underdeveloped fibre infrastructure as compared to other major European cities..

Summarized Analysis

In essence, the relatively high levels of investments in Berlin's innovation intensive digital economy over the last five years can be explained partially by an innovation wave and

partially by a speculation peak related to a mere few actors and major investments. This explains, to a large extent, the particularly high capital investments found in Berlin. However, this could also be seen as an emerging trend in line with overall global venture capital flows towards certain digital clusters, caused by a number of factors. The most prevalent causes of Berlin's venture capital growth are:

- **A limited number of global high-profile start-up success stories which have created an e-commerce focused innovation cluster – now recognised by global customer and venture capital markets**
- **Successfully developed local and national policies, which have created synergies between industry through effective development strategies – with fruitful relationships between public support functions and private investment solutions**
- **The implicit promise of forthcoming investments into necessary digital infrastructure, in order to spur future growth**

Berlin's digital economy has experienced increasing interest from both capital markets and decision makers since even before the financial crisis in 2008. However, the largest investment volumes within the internet field (the categories *software services* and *e-commerce* in the Deloitte's report) have accrued since 2013 with some particularly big quarterly surges during 2013-14³⁷. Keeping in mind that the analysis is centered around a city economy, and particular business sectors within it, specific investments may also have significant effects on the statistical outcome of total investment figures etc. for the city.

Rocket Internet and the e-Commerce Boom

One single individual, Oliver Samwer, is arguably a large part of the explanation to Berlin's boom as a tech hub, as well as its thriving venture capital market. In 2007, after having founded and sold *Alando* (a digital market place that was sold to *eBay*³⁸), as well as the cell phone service company *Jamba!* (the *Crazy Frog* ringtones, sold to *Verisign* 2004³⁹), Oliver Samwer and his two brothers started *Rocket Internet*, an internet industrializer also referred to as a "start-up creator company". *Rocket Internet* has since come to dominate Berlin's tech scene while attracting substantial national and international venture capital flows to the region. The company stands behind some of the largest European unicorns in recent years, such as *Foodpanda*, *Jabong.com*, *Lazada Group*, *HelloFresh* and *Zalando*⁴⁰. *Rocket Internet's* own 2014 Initial Public Offering became a record deal which attracted great interest, and the company has since been valued to over €8 billion. *Rocket Internet* has significantly helped accelerating venture capital investments to Berlin, both as a result of the company's own business dealings and by driving awareness towards Berlin among global capital markets. Three of Germany's five largest receivers of venture capital (with respect to aggregated amounts up until 2015) have direct ties to *Rocket Internet*, either as founders, co-founders, or investors. Among them, the largest European tech start-up investment round of all times, which occurred when parts of the Berlin based e-food delivery company *Delivery Hero* was acquired by *Rocket Internet* for €500 million⁴¹ (an investment which in itself largely explains the significant venture capital increase in the Berlin statistics in 2014⁴²). As of September 2015, *Rocket Internet* has invested more than €1.2 billion in the business. *Rocket Internet* has also been called Rocket Business School, since several employees have left the company in order to fund their own Berlin start-ups. Furthermore, the company is considered a key player in attracting international interest and tech related venture capital to Berlin,

³⁷ CB Insights VC data base www.cbinsights.com

³⁸ www.wsj.com/articles/SB930088782376234268

³⁹ www.networkworld.com/article/2333353/network-security/verisign-acquires-wireless-services-provider-jamba.html

⁴⁰ www.rocket-internet.com/about

⁴¹ EY (2016). Venture Capital and Start-ups in Germany 2015.

⁴² CB Insights VC Data base

mainly through its high profile business ideas and marketing abilities. The firm even founded its own PR agency in 2015⁴³.

Rocket Internet's achievements, along with the related successes of a handful of other companies and individuals, has resulted in a wave of creative initiatives with digital disruption at their core. These companies tend to have strong marketing profiles and have attracted huge interest on global tech-, innovation- and venture capital markets. This, in turn, has nurtured a local venture capital market attracting new talent and spurring growth of new companies, services and tech deals⁴⁴. These factors have enabled a broader public infrastructure for investments, and these investments have been further backed by state guarantees, incentives and subsidies as well as innovative financial solutions and cooperation between VC firms, PE firms and investment banks. An analysis conducted by EY states that Germany's largest digital start-ups (e.g. *Delivery Hero*) have been particularly successful in attracting global capital. This can be related to the 100 per cent increase in venture capital investments for the 30 largest receivers (in the digital industry and pre-exit/IPO) between 2014 and 2015, as well as to the increasing number of German institutional funds (+19 institutes 2015) and available institutional investment capital (+€2.5 billion 2015)⁴⁵⁴⁶. See also section 2.4.

Regional and national synergies

It should be noted that Berlin's start-up scene is characterized by actors driving the digitalization and e-commercialization of existing industries (e.g. car sharing, online retail) rather than by online companies that solely provide online services (e.g. e-Game developers). It has been heavily debated whether Berlin, with its digital successes, should be described as the "Silicon Alley" for the online sector or as a wider "industrial cluster with a digital toolbox"⁴⁷. This distinction is particularly relevant when considering Berlin's creative talent pool as well as the synergies between the analysed sector and related industries. Eight of the ten companies which have received the most venture capital in Berlin up until September 2015 offer services related to the digitalisation of traditional industries (e.g. food delivery services, financial marketplaces, online furniture stores)⁴⁸. Furthermore, technically these companies can access global markets given their technologies and business models. These combined factors make it arguable that Berlin's receivers of venture capital are rather insensitive to *local* digital infrastructure. Hence, the city could be described as a creative marketplace with digital characteristics rather than a digital market cluster.

Public initiatives, strategies and support

Germany shows similar GDP per capita development over the last few years (2010-14) as other investigated countries in Deloitte's report, however, on a regional level it can be noted that Stockholm and Copenhagen stand out, both having total growth of over five per cent over the period. Amsterdam conversely displays a GDP decline of five per cent over the period, while other cities' GDP per capita neither grew nor declined significantly⁴⁹.

However, when looking at venture capital investments in relation to GDP between 2009-13, it can be noted that countries such as Sweden and Finland significantly outperform e.g.

⁴³ www.holmesreport.com/latest/article/german-startup-giant-rocket-internet-spins-off-pr-agency

⁴⁴ EY (2016). Venture Capital and Start-ups in Germany 2015.

⁴⁵ Ibid. s.8.

⁴⁶ www.euractiv.com/section/innovation-industry/news/berlin-outranks-london-in-start-up-investment/

⁴⁷ ⁴⁷ Berlin Senate Department for Economics, Technology and Research, & Berlin Partner for Business and Technology (2013).

⁴⁸ [www.ey.com/Publication/vwLUAssets/ey-venture-capital-and-start-ups-in-germany-2015/\\$FILE/ey-venture-capital-and-start-ups-in-germany-2015.pdf](http://www.ey.com/Publication/vwLUAssets/ey-venture-capital-and-start-ups-in-germany-2015/$FILE/ey-venture-capital-and-start-ups-in-germany-2015.pdf)

⁴⁹ Eurostat – PPS per capita NUTS 2 or 1 where applicable ec.europa.eu/eurostat

Germany, the Netherlands and France⁵⁰. The German government has since taken essential strategic measures to subsidize and stimulate venture capital inflows to Germany and to Berlin, in order to catch up with other states. This can partially explain the high current capital inflow into Berlin's venture capital market. Noteworthy actions are:

- The INVEST program *INVEST– Zuschuss für Wagniskapital*, subsidises angel capital investments in start-ups by 20 per cent – up to €250 000 per investor and year⁵¹, and up to €1 million per company and year⁵². The program has administered over €100 million in German venture capital investments during the first 18 month since May 2013, and the government has signaled intentions of doubling the current ceiling⁵³.
- The launch of several programs related to financing, guarantees and measures for small- and medium sized enterprises, tech- and innovation companies and start-ups. One example is *High-Tech Gründerfonds II*, a national fund for venture capital (consisting of €288 million)⁵⁴, which is financed by the industry, banks and the government in cooperation. The fund has resources connected to the EU platform COSME, which provides guarantees and secures capital access for these companies⁵⁵. Other examples are the *Central Innovation Programme (ZIM)*, which subsidizes employments and *Leading-Edge Clusters*, a subsidizing initiative consisting of €40 million until 2020⁵⁶.
- The German government together with the investment bank KfW and the European investment fund EIF launched in March 2016 two additional funds with €725 million in new capital, which was supposed to be used to stimulate innovative companies as well as small- and medium enterprises⁵⁷.

Germany and Berlin have managed to introduce several strategic initiatives which in turn have been recognized as success drivers for the region's technological and industrial development. Berlin has a large array of available office space, with price levels corresponding to roughly half of Stockholm levels⁵⁸. Office spaces where traditional venture capital strategies can be combined with incubator- and accelerator models. More specifically, start-ups, investors and private equity firms can share office spaces and create lower risk models based on incremental planning, close cooperation and active networking, which altogether reduces risk and enhances control for investors. This has been recognized as measures increasing attractiveness and inflow of both venture capital and talent into the city. Furthermore, Berlin has a ten per cent non-native co-workers in the tech industry, something seen globally as a sign of strength^{59 60}.

Germany was the first European country to implement a comprehensive innovation- and digitalization strategy for its manufacturing- and research industry, and the platform *Industrie 4.0*⁶¹ has been considered a school book example for other countries trying to digitalize and integrate business sectors and research. This *Industrie 4.0* platform has since expanded to include also strategies and financing for also other industries. Examples are the *New High-*

⁵⁰ www.e-fi.de/fileadmin/Inhaltskapitel_EN_2015/2015_A5.pdf

⁵¹ www.e-fi.de/fileadmin/Inhaltskapitel_EN_2015/2015_A5.pdf

⁵² www.bmwi.de/DE/Themen/Mittelstand/Mittelstandsfinanzierung/invest.html

⁵³ www.exist.de/DE/Netzwerk/Kooperationspartner/Invest/inhalt.html

⁵⁴ [www.ey.com/Publication/vwLUAssets/ey-venture-capital-and-start-ups-in-germany-2015/\\$FILE/ey-venture-capital-and-start-ups-in-germany-2015.pdf](http://www.ey.com/Publication/vwLUAssets/ey-venture-capital-and-start-ups-in-germany-2015/$FILE/ey-venture-capital-and-start-ups-in-germany-2015.pdf)

⁵⁵ ec.europa.eu/growth/smes/cosme/

⁵⁶ industrie4.0.gtai.de/INDUSTRIE40/Navigation/EN/Topics/Why-germany/why-germany-policy,t=leadingedge-cluster-competition,did=1190764.html

⁵⁷ www.eif.org/what_we_do/equity/news/2016/bmwi_presentation_en.pdf

⁵⁸ Calculation based on Cushman & Wakefield's index www.cushmanwakefield.com and www.statista.com/statistics/431672/commercial-property-prime-rents-europe/

⁵⁹ [www.ey.com/Publication/vwLUAssets/ey-venture-capital-and-start-ups-in-germany-2015/\\$FILE/ey-venture-capital-and-start-ups-in-germany-2015.pdf](http://www.ey.com/Publication/vwLUAssets/ey-venture-capital-and-start-ups-in-germany-2015/$FILE/ey-venture-capital-and-start-ups-in-germany-2015.pdf)

⁶⁰ Berlin Senate Department for Economics, Technology and Research, & Berlin *Partner for Business and Technology* (2013).

⁶¹ industrie4.0.gtai.de/INDUSTRIE40/Navigation/EN/Topics/industrie-4-0.html

Tech Strategy and the *Leading-Edge Cluster Competition*, signalling long term policy initiatives to increase security and trust in German venture capital markets⁶². In 2014, the German government constituted a digital development agenda, incorporating also digital infrastructure initiatives through the so called *Digital Agenda 2018*. This particular initiative is based on a combination of incentives, strategies and methods to expand digital networks. The aim is to be able to guarantee fixed and wireless net access to a minimum level of 50Mbps on a national level by the year 2018⁶³.

Berlin is unique in comparison to other cities and regions investigated in Deloitte's report, with a very high innovation capacity, despite having a comparably undeveloped fibre infrastructure. The reason for this appears to derive from a particularly high concentration of venture capital investments. This circumstance is in turn driven by a number of interconnected and partly unique factors that are difficult to replicate in other places.

Several factors contribute to the high concentration of venture capital. One such factor is commercial success stories based on the emergence of a cluster centered around digital market segments which are comparably insensitive to fibre infrastructure, such as retail services for global consumer markets (where potential global consumer markets minimize the dependence upon local infrastructure). Notable is also that prominent entrepreneurs behind Berlin development successes have managed to spur further innovation while also capturing the interest of global capital markets as well as policy makers, where the latter has brought incentivizing policy advantages to the region and the industry.

Furthermore, Germany introduced collaborative strategies for the digitalization process prior to comparable countries, and has since then been working actively with enforcing them. This has spurred successful synergies between industries, research facilities, public institutions and capital markets, and triggered strategic as well as concrete measures to spur and drive the financing of a world leading cluster. Additionally, it should be noted that the government recently introduced measures aiming to secure the expansion of Berlin's digital infrastructure – which is broadly considered to be a critical step in the city's future development.

**Harald Cavalli-Björkman
Cen Rolfsson**

⁶² industrie4.0.gtai.de/INDUSTRIE40/Navigation/EN/Topics/Why-germany/why-germany-policy,t=the-new-hightech-strategy.did=1160434.html

⁶³ www.bmwi.de/English/Redaktion/Pdf/digital-agenda-2014-2017,property=pdf,bereich=bmwi2012,sprache=en,rwb=true.pdf

Appendix V – Survey: The impact of the fibre infrastructure

Results of email/telephone survey

Selected firms were asked to answer the following survey via the web or telephone interview. The survey was conducted in order to provide a picture of how SMEs are affected by access to fibre infrastructure. All firms contacted responded, but two chose to provide statements rather than answer the survey.

How important is business/service development to your business? (Responses ranked from 1–4)

To increasing growth/revenues?
To developing new business?

How important has fibre been to your business/service development? (Responses ranked from 1–4)

Can you provide an example of how access to fibre-based broadband has affected your business? (In your own words)

How has access to fibre... (Answers ranked from 1–4, with option to provide examples)

...affected your opportunities to reach new markets and/or customers?
...made new products or services possible or improved existing products/services?
...enabled improved support or ancillary services?
...affected your opportunities to reach larger national/European/global markets?
...affected your competitive advantages compared to firms that do not have access to fibre?
...affected your business compared to if you had only had access to ADSL (copper-based broadband)?

How important has fibre been to your internal operations?

(For example, enabled faster, more efficient communication? More collaboration among offices?)

URL to survey page: <http://goo.gl/forms/W3fdf1QI72>

Survey responses

The firms that chose to answer the survey were:

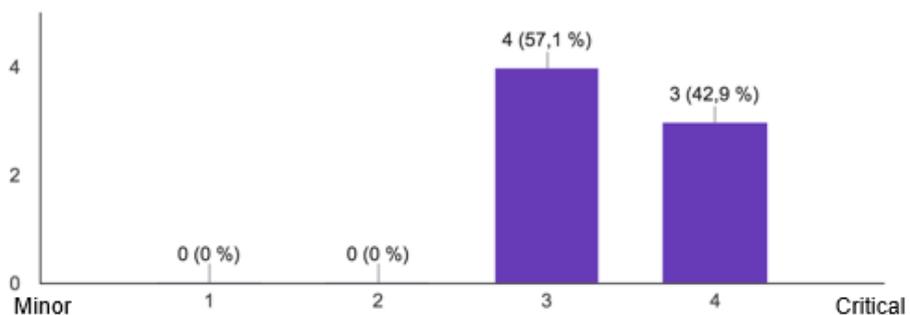
- Anderson & Jourdan: corporate communications agency
- Block Stockholm: rental of office space to communications professionals
- Bumble Labs: Wi-Fi networks and visitor flow measurements
- Fructus: sales of CAD/CAM software in the Nordic region with focus on control of CNC machines.
- Nordnet Bank: Nordic bank focused on savings
- Sequitur: Daily activities for people with Asperger's

- Skovik: software vendor that automates travel expense accounts for businesses

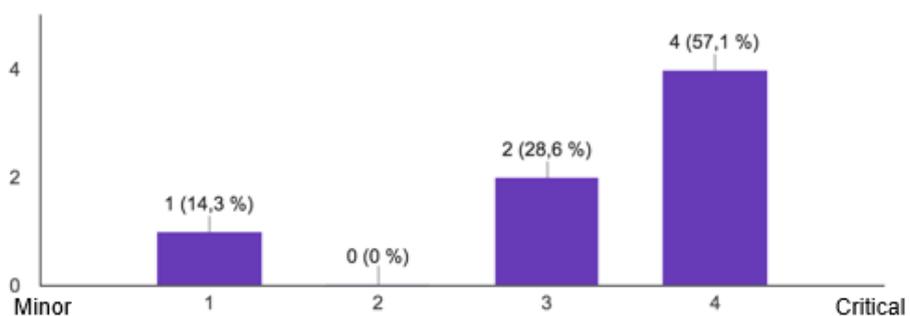
The following responses are accessible [in this linked Excel spreadsheet](#).

How important is business/service development to your business...

To increasing growth/revenues? (7 responses)

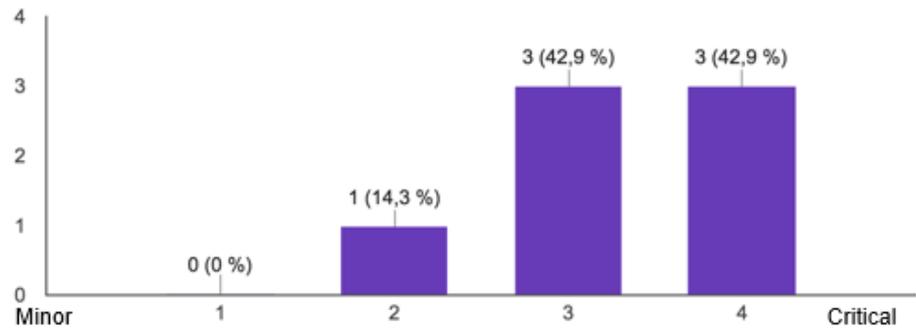


To developing new business? (7 responses)



How important has fibre been to your business/service development?

(7 responses)

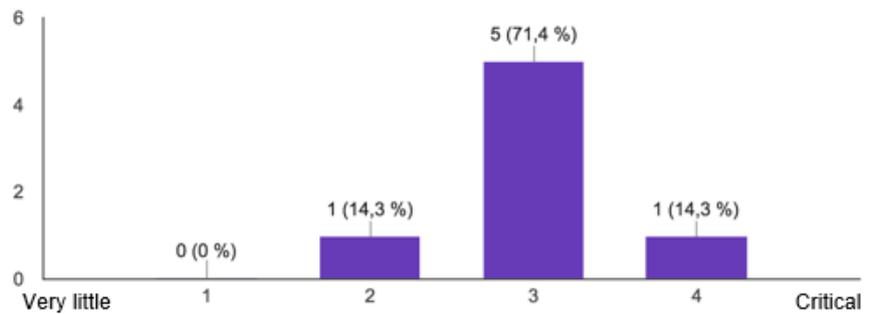


Can you provide an example of how access to fibre-based broadband has affected your business?

- Access to fibre makes external communications easier and provides fast access to servers and other systems (located in an external data centre). (Skovik)
- More flexible workplace, less time getting to and from meetings, faster delivery of digital material. (Andersson & Jourdan)
- No one would locate their enterprise in our premises if we did not have fast, effective and stable fibre, because it is critical to their business. (Block Stockholm)
- Nowadays, we can run online training programmes without a hitch. But when we only had an ADSL connection, the aggravation was constant. The shortcomings of the ADSL connection caused huge problems with transmissions and broke up speech. All of our communications suffered from the same shortcomings because the ADSL connection simply did not cut the mustard. Back then, we were even forced to distribute software updates and the like from servers other than our own. Our own ADSL connection was simply not good enough. Today, thanks to the capacity of the fibre connection, we have what we need to run our own servers in our own premises. (Fructus)

How has access to fibre...

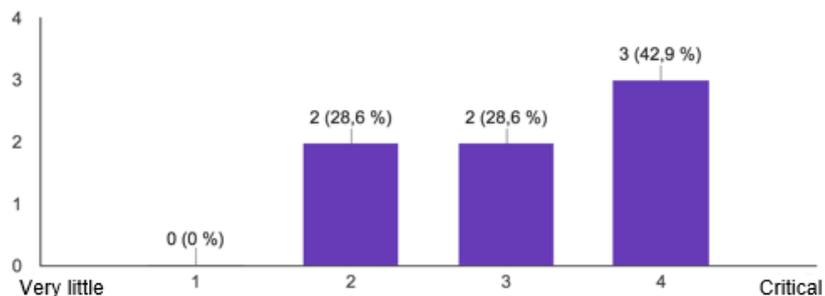
...affected your opportunities to reach new markets and/or customers?
(7 responses)



Please give an example...

- We have many customers and suppliers abroad. Distance is no longer measured only in kilometres; it is also measured in milliseconds [internet packet speed]. (Skovik)
- Everyone here works creatively to create corporate communications. Full access to digital channels is what makes it possible for us to display our work and thus reach new and old clients. (Block Stockholm)
- We can make more innovative services. (Sequitur)

...made new products or services possible or improved existing products/services?
(7 responses)

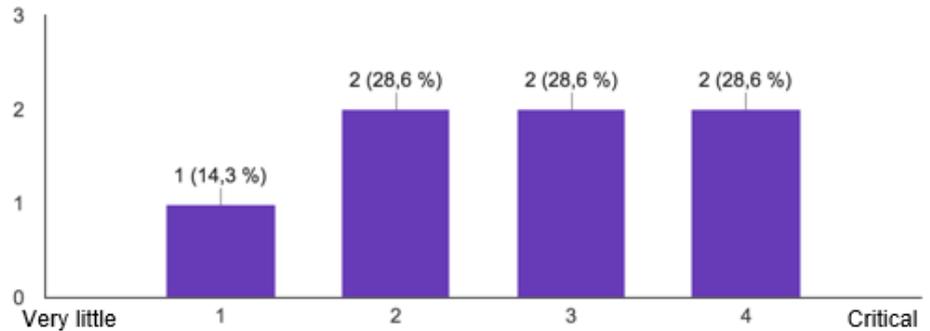


Please give an example...

- New channels for improving communication are constantly being developed, and especially through digital channels. We are continuously improving our efforts to find new and creative solutions for our clients. For example, superb new opportunities like distributing video in newsletters and our clients' other net-based services is now possible, thanks to fibre. (Block Stockholm)

- Game development. (Sequitur)

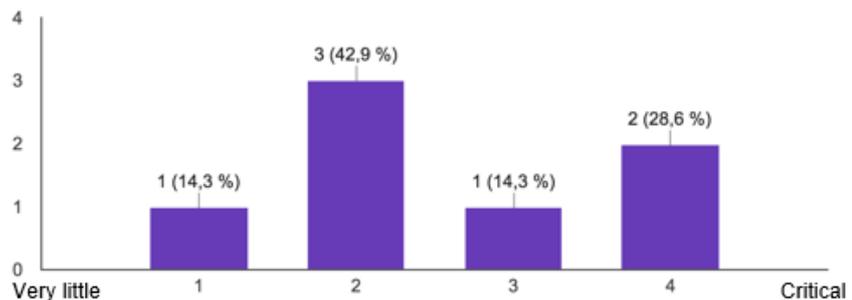
...enabled improved support or ancillary services? (7 responses)



Please give an example...

- Those of us who manage websites and the like for other customers in particular simply must have a fast connection to perform updates and corrections. (Block Stockholm)
- Our customers have benefited from a substantial improvement in online service. (Fructus)

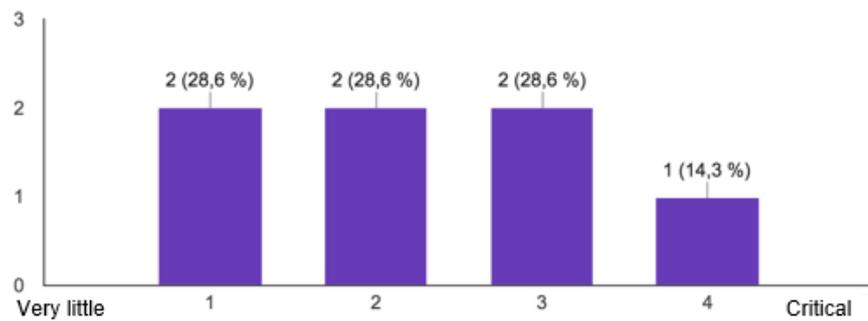
...affected your opportunities to reach larger national/European/global markets? (7 responses)



Please give an example...

- We have customers abroad and globally outsourced data centres. Fibre provides low latency and fast access to the rest of the world. (Skovik)
- We have clients all over the world, we distribute our communications services all over the world, and we use partners and suppliers who might do the original layout or print our products all over the world. And the main way we reach all off them is through good network connectivity and powerful broadband. (Block Stockholm)

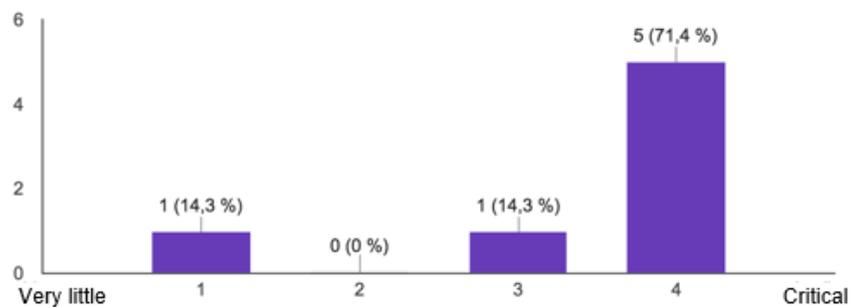
...affected your competitive advantages compared to firms that do not have access to fibre?
(7 responses)



Please give an example...

- We have no competitors. (Bumbee Labs)
- Firms that lack access to fibre are missing an important dimension to their opportunities to be seen and to enhance customer relationships.

...affected your business compared to if you had only had access to ADSL (copper-based broadband)?
(7 responses)

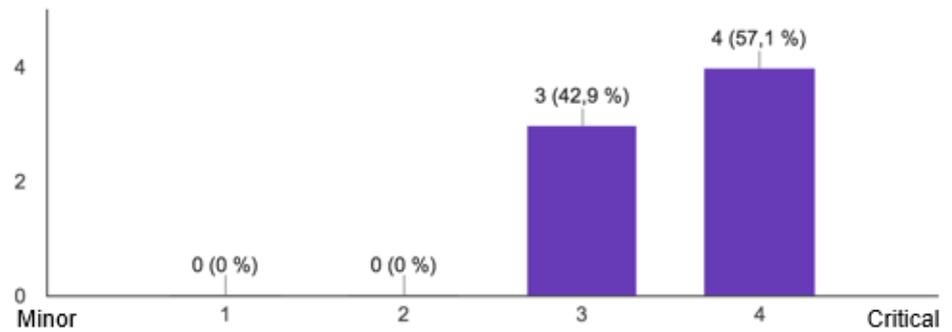


Please give an example...

- ADSL would have been a handicap. (Skovik)
- Our data quantity is so small and really doesn't require the speeds available in the fibre network, so I would have to say that we would manage with fast ADSL without losing any competitive advantage. Otherwise, we mainly work wirelessly, which means we cannot fully utilise the capacity of fibre anyway. (Anderson & Jourdan)
- We worked for the first five or six years (out of our 15 years in business) with ADSL, but every time one of the individual creatives here with us experiences slowdowns in the network, we come one step closer to losing a client. (Block Stockholm)
- More of us can work, more securely. (Sequitur)

How important has fibre been to your internal operations?

(7 responses)



Please give an example...

- Essentially all internal communication is digital via various online services. Internal communication would simply not work without a fast and stable connection. (Skovik)
- Very critical. We are a small agency network and we all live in different places. One in Ängelholm, one in Stockholm and one in Mariehamn. The ability to have a shared server and backup for all material is important. We also use Skype/Facetime to communicate with each other. We have made it an internal requirement that we should not have to be dependent upon the head office to do our jobs, which means all three of us have fibre/ADSL at home and our own backup stations to complement the backup in the head office. Naturally, that involves added costs for the company, but on the other hand improves the quality of our lives quite a bit, and as long as our clients do not feel they are getting poorer service, we are happy with that arrangement. (Anderson & Jourdan)
- Our internal communications among 45 entrepreneurs and individuals occur mainly via forums on the net. A fast, easy connection makes it easy and natural to use these to communicate internally. For example, we can quickly reach everyone and say "Heads up: Information meeting in five minutes" and much more. (Block Stockholm)
- Today, we can offer every employee the option to work from home to an extent that was not possible with ADSL. We currently have offices in several locations in Stockholm and manage internal communications with the help of fibre. Without access to fibre, we would have been forced to travel between the various offices, which would have been impossible considering the substandard traffic situation in Stockholm. (Fructus)

Other responses/quotations

Some firms chose not to answer the survey, but still wanted to provide the following additional quotations:

Klarna, the leading payment services provider in Europe:

Klarna will only be able to achieve its goal of becoming the world leader in payments with the secure, efficient and fast data communication provided by fibre connections. It is critical to us that our communications can occur with the highest possible reliability and speed. Without access to a powerful fibre infrastructure in the form of a fine-mesh network, the powerful growth we are after would be impossible. Nor would we enjoy the international competitiveness we have today. (Erik Engellau-Nilsson)

Webhallen, one of the leading online retailers of multimedia and hardware in Sweden:

Webhallen is dependent upon the fast, stable connection that fibre delivers better than anything else. Not only for connecting all our stores, but our server hall as well. Growth in our customer base is also dependent upon how many of them are reached by a good connection, which works the best when the fibre reaches as close to the customer as possible. (Marcus Hambræus)