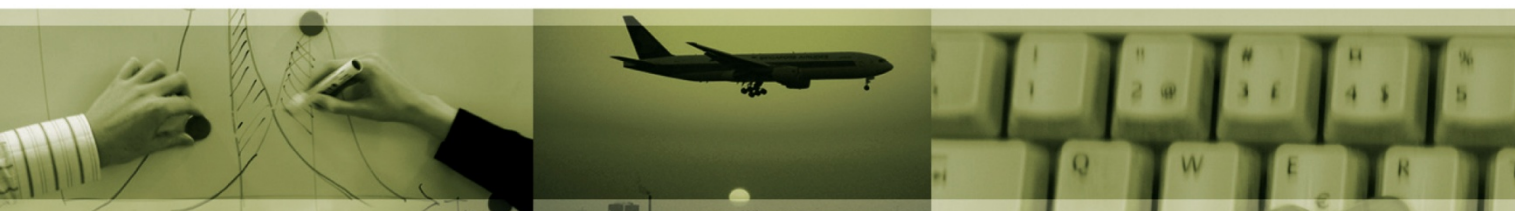

THE SOCIO-ECONOMIC VALUE OF DIGITAL INFRA- STRUCTURES

16 APRIL 2010

INFORMED DECISIONS



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PREFACE

Copenhagen Economics was requested by the Danish Energy Association to evaluate the socio-economic advantages that arise from an improved digital infrastructure in the form of different types of high-speed networks. The task encompassed a description and quantification of the effects on innovation, productivity, working hours, employment, the public sector and the environment/climate.

The result of this work will be partially available as a report (this report) and as a presentation at a hearing at Christiansborg, where Denmark as a high-speed society will be discussed. This hearing is to be held on 16 April 2010 and is arranged by the Danish Energy Association.

This report has been compiled in March 2010 by Senior Economist Svend Torp Jespersen and Economist Eske Stig Hansen. A partner in Copenhagen Economics, Martin Hvidt Thelle, was responsible for Copenhagen Economics' quality assurance of this work. Morten Baadsgaard Trolle, Christian Berg and Thomas Woldiderich, all from the Danish Energy Association, have followed the work and contributed with a large amount of background material.

RÉSUMÉ

Quicker and improved possibilities for electronic communication are an important source of growth, now and in the future. This has been determined by the majority of investigations that have shed light on the significance of electronic communication for a society. This is also the conclusion of this report.

Faster electronic communication speeds are important, because they improve productivity. Especially in knowledge-based services, faster communication speeds increase productivity as larger amounts of information can be gathered with better quality than was previously possible. This forms the basis for greater production of improved knowledge. At the same time, productivity will increase because an improved digital infrastructure, to a greater degree, allows for working from home as well as the holding of high-quality video conferences, for example with business contacts. This saves commuting time which can be used for more productive tasks. A third reason why productivity will increase is that an improved digital infrastructure creates possibilities for new types of use, for example programs or network services, and these will contribute in raising the value creation capability of a society.

1.1. VISION OF THE HIGH-SPEED COMMITTEE

At a global level, Denmark is currently that country which has the 16th fastest Internet access. This is measured by the average broadband speed. The High-Speed Committee wants to change this and has formulated a vision implying that the average network speed in 2013 will be 8 times faster than in 2008. If the High-Speed Committee's vision as regards communication speed was applicable today, then Denmark would be in third position in an international comparison of network communication speeds. The High-Speed Committee's vision is also one of the most ambitious visions that we are familiar with, namely those announced regarding speeds for 2013.

Table 1 Speed on the Internet, international comparison

2008			Prior to 2020		
Position 2008	Country	Average speed on the net, Mbps	Position (2008)	Country	Average speed on the net, Mbps
1	Japan	64	1 ↑	South Korea	1000
2	South Korea	50	2 ↑	Singapore	1000
3	Finland	22	3	Japan	1000
4	France	18	4 ↓	Finland	100
5	Sweden	17	5	Sweden	92
16	Denmark	5	12 ↑	Denmark	42

Note: In the long term, the average speed on the net is calculated as an average value of the goals that have been announced for various parts of the population. For example, in the long term the average speed in Denmark is calculated from the High-Speed Committee's vision. That is 80 percent must have access to 50 Mbps and 20 percent must have access to a minimum of 10 Mbps. The Finnish goal is based upon access to a back-bone and not net access. This is because all Finns must have a maximum of 2 kilometers to a minimum 100 Mbps Internet (fiber or cable TV net).

Source: ITIF Broadband Rankings, High-Speed Committee (2009), Norwegian government (2009), Ministry of Economic Development (2008), http://www.computerworld.dk/art/55520/gordon-brown-lover-100-mbit-internet-til-alle-briter?a=fp_1&i=0.

For the slightly longer term - 2010 - the High-Speed Committee's vision is currently not nearly as ambitious as the target seen in some other countries that Denmark normally compares itself with. Sweden, USA, and some other countries have already planned improvement of their digital infrastructure in the slightly longer term that vastly exceeds the vision of the High-Speed Committee.

Denmark has great potential to exploit higher speeds on the net, because we are amongst the most e-ready populations in the world and have been so for many years, as documented, amongst others, by the World Economic Forum (2010).¹

1.2. EVALUATION OF GAINS TO SOCIETY

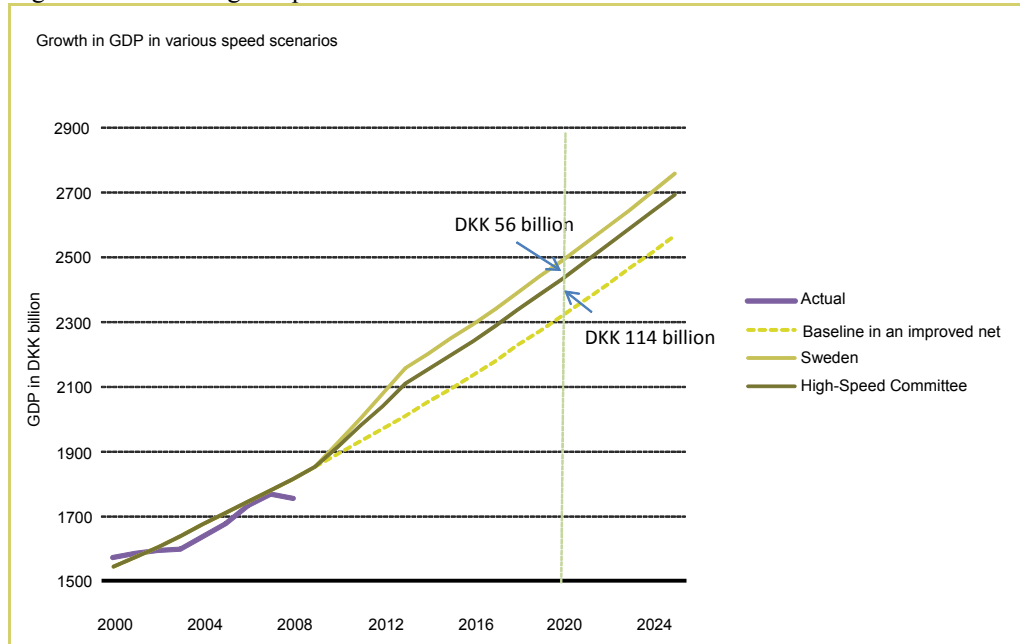
We have evaluated the socio-economic advantages that Denmark will achieve by acquiring higher broadband speeds. We have done this by creating two scenarios for the development of higher speeds up to 2013. In the first scenario, network speeds increase to comply with the vision of the High-Speed Committee, namely 8 times the speed of 2008. In the second scenario, network speeds are increased so that by 2013 Denmark achieves speeds matching those targeted by Sweden for 2020, which is 18 times that compared with 2008.

¹ Evaluation of e-readiness has as its starting point a number of conditions, including amongst which is the number of telephone lines per inhabitant, number of secure Internet servers, electricity production, percentage of population with an education in natural sciences or technology, quality of research institutes, percentage of the population with a tertiary education, education expenses, access to digital content and speed on the available broadband.

We have evaluated that if Denmark meets the vision of the High-Speed Committee, then this will contribute approximately 5 percent extra to the Gross Domestic Product (GDP) in 2020, equivalent to approximately DKK 114 billion per year. On the other hand, if in the long term Denmark achieves the same speed as Sweden, then this will contribute approximately 7 percent to the Gross Domestic Product, equivalent to approximately DKK 170 billion per year. In Figure 1 below we have illustrated the meaning of the increased speeds in various scenarios.

As a basis for our estimation we have chosen as a starting point the experiences from other countries that we can be compared to. Earlier investigations show how much this means, for example if one more percent of the employed population have access to broadband. We use these results to state that an increase in the percentage of employed with broadband access is equivalent to an increase in the average speed on the net. From various literature sources we calculate the effect regarding the percentage of employed with broadband access to estimate the effect of higher speeds on the net.²

Figure 1 Effect of higher speeds on GDP



Source: Copenhagen Economics.

² We thereby also focus our calculations on increases in download speeds, which have increased vastly as a result of the shift to DSL technologies. If the increase in upload speeds becomes greater than the historical value, then this supports the idea that the effects on productivity can be greater.

Our evaluation is associated with a large degree of uncertainty. This is because it is difficult to evaluate the effects of high speeds on the net. This is partly because there have not been any investigations in the past that focus on the effects of speed, and partly because the increase in speed that Denmark and other countries want to achieve in the next decade do not have any precedent. In the interim we have decided to base our estimates on the experiences that have been documented, simply because it is nothing less than an objective basis.

A limited increase in speeds in the past two decades has caused significant effects on the Gross Domestic Product. As a result, it is difficult to imagine that a significant increase in net speeds can occur without significant effects on the Gross Domestic Product. For example, in 2006 the Danish IT service sector contributed DKK 24 billion to the Gross Domestic Product. This sector would not have been so large if we did not have higher speeds for electronic communication.

1.3. RECOMMENDATIONS

For Denmark to release the economic potential associated with an improved digital infrastructure, it is an advantage that private service providers are incited to offer higher speeds on the net. Investigations from other EU countries indicate that it is not always economically viable for private investors to offer high-speed networks to a large percentage of the population in countries with a relatively high level of income and high population densities. For example, Table 2 shows that private suppliers can deliver fiber net (PON or P2P) to approximately a quarter of the population in Germany. Denmark has a higher income level than that of Germany, but a lower population density. We evaluate that if it cannot be economically viable for private service providers to deliver high-speed networks to a large proportion of the population in Germany, then it is extremely doubtful whether it will be economically viable for private service providers to offer high-speed networks to a large proportion of the population in Denmark.

Table 2 Part of population (in percent) for which it can be economically viable for private companies to offer high-speed Internet

Technology	Germany	France	Sweden	Portugal	Spain	Italy
VDSL	71.5	-	18.3	39.0	67.4	100
PON	25.1	25.2	18.3	19.2	12.2	17.6
P2P	13.7	18.6	18.3	19.2	12.2	12.6
Population density (number of inhabitants per km ²)	230	111	20	115	89	197
Area in km ²	357,021	547,030	449,964	92,391	504,782	301,230
Population	82.0 mill.	64.7 mill.	9.3 mill.	10.6 mill.	46.7 mill.	60.4 mill.

Source: WIK (2008).

It is possible to work with income issues or expense issues when improving incentives for private service providers.

On the income side, the public sector can create incentives for private service providers by requesting high-speed networks to public institutions or by offering public services that exploit high-speed networks. This will give private service providers an incentive to commence the provision of a high-speed network. When this is being done to central organizations, the cost of connecting the associated local area will be more easily accommodated. On the expense side, the public sector can contribute with more effective municipal case management, the combined and simultaneous laying of infrastructure cables and the removal of enforced connections to community-shared antenna systems.

Chapter 2 | DENMARK IS LAGGING IN DIGITAL INFRA-STRUCTURE

2.1. VISION OF HIGH-SPEED COMMITTEE IN AN INTERNATIONAL PERSPECTIVE

The report – Denmark as a High-Speed Society – was released by the High-Speed Committee at the start of 2010. The report described a number of benefits that would arise when Denmark develops itself as a high-speed society, amongst which this will contribute to:

- Ensuring growth and competitive capability.
- Ensuring welfare through efficiency and quality in the public sector.
- Ensuring democracy, culture and participation for all Danes.
- Ensuring that Denmark is geared for climatic and environmental challenges.

For Denmark to develop itself as a high-speed society, the committee suggested a broad range of measures for the public sector, education, research and infrastructure. As regards infrastructure, the High-Speed Committee is of the opinion that at least 80 percent of all Danish households and businesses should have access speeds of at least 50 Mbps downstream and 10 Mbps upstream by 2013. Furthermore, the committee is of the opinion that all, or nearly all, Danish households and businesses must have broadband access with 10 Mbps downstream and 5 Mbps upstream by 2013.³

Denmark is currently lagging when compared internationally as regards broadband speeds. This can be seen in Table 2.1. Various different comparisons of broadband speeds are available, including those from the OECD, World Economic Forum and ITIF.⁴ The results of the various comparisons do differ and in some comparisons Denmark fares better than that shown below. However, we are not aware of any comparison where Denmark is at the top of the list. The highest position we have seen by Denmark is a seventh place. We use ITIF's ranking, mainly because the system takes into account that even though broadband customers offer high-speed access, consumers do not always choose to use the highest speed being offered. In Denmark, consumers and businesses often opt for lower speeds than those available, explaining why Denmark is far down in the latest ITIF list.

³ It is noted in the committee's report that a minority of three committee members did not support the 80% target for high-speed broadband access, this because the target does not cover all in society.

⁴ See OECD's comparison on the website

[http://www.oecd.org/document/54/0.3343.en_2649_34225_38690102_1_1_1_1,00.html](http://www.oecd.org/document/54/0,3343,en_2649_34225_38690102_1_1_1_1,00.html),

see the World Economic Forum's comparisons on the website

<http://www.weforum.org/documents/GITR10/index.html> and

see ITIF's comparisons on the website <http://www.itif.org/files/2008BBRrankings.pdf>.

Table 2.1 Speeds in various countries – now and in the future

2008			Longer term (2020)		
Position 2008	Country	Average speed on the net, Mbps	Position (2008)	Country	Average speed on the net, Mbps
1	Japan	64	1 ↑	South Korea	1000
2	South Korea	50	2 ↑	Singapore	1000
3	Finland	22	3	Japan	1000
4	France	18	4 ↓	Finland	100
5	Sweden	17	5	Sweden	92
6	The Netherlands	9	6 ↑	Slovenia	90
7	Portugal	8	7 ↑	Australia	90
8	Poland	8	8 ↑	USA	90
9	Norway	8	9 ↑	New Zealand	81
10	Canada	8	10 ↓	Japan	64
11	Austria	7	11 ↓	Norway	50
12	Belgium	6	12 ↑	Denmark	42
13	Iceland	6	13 ↓	Portugal	41
14	Germany	6	14 ↑	Germany	39
15	USA	5	15 ↓	France	18
16	Denmark	5	16 ↓	The Netherlands	9

Note: In the longer term, the average speed on the net is calculated as an average value of the goals that have been announced for various parts of the population. For example, in the longer term the average speed in Denmark is calculated from the High-Speed Committee's vision that 80 percent must have access to 50 Mbps and 20 percent must have access to a minimum of 10 Mbps. The Finnish goal is based upon access to a back-bone and not net access. This is because all Finns must have a maximum of 2 kilometers to a minimum 100 Mbps Internet (fiber or cable TV net).

Source: ITIF Broadband Rankings, High-Speed Committee (2009), Norwegian government (2009), Ministry of Economic Development (2008), http://www.computerworld.dk/art/55520/gordon-brown-lover-100-mbit-internet-til-alle-briter?a=fp_1&i=0.

If the High-Speed Committee's vision regarding faster broadband speeds was actual today, then Denmark would have the third fastest Internet access at global level – of course dependent on whether Danes choose to buy the faster speeds.

A number of other countries also have plans regarding higher broadband speeds. This is also being debated in many countries with political signals indicating high levels of ambition. In Table 2.1 we also attempted to include the other countries' targets, plans and political statements regarding long-term speeds, that being up to 2020. The other countries' announcements regarding high-speed net targets indicate that there is significantly greater potential to increase speeds than that seen in Denmark's current vision.

The table gives an indication of who will have the fastest speeds on the net in the long term, but the values need to be read with some degree of caution. Firstly, there are differences in the political status of the objectives of the various countries. Secondly, there are differences as to when the plans can be effectuated. Thirdly, some of the countries that Denmark compares itself with have not yet announced their plans. These countries could announce plans that are more ambitious than those in Denmark. Fourthly, some countries have associated various preconditions to the announced speeds. We have attempted to take these into account by calculating average speeds, but there is still a degree of uncertainty in the calculated values.

2.2. DENMARK HAS A GOOD STARTING POINT

Denmark has big potential to derive advantages by being a high-speed society. We have one of the most e-ready populations. A large percentage of the population have broadband access, generally we have a good judicial framework and the business and public sectors are equipped to receive an e-society.

The World Economic Forum has compiled a list of general conditions for Internet use and place Denmark in the top five – there is consensus on this by, amongst others, the institutions that follow this development. Table 2.2 indicates the World Economic Forum's network readiness list. The numbers show that the five most e-ready countries are the same in 2009-2010 as in 2008-2009, but there are small shifts at the top of the list where Sweden has overtaken Denmark.

Table 2.2 World Economic Forum Network Readiness Index Rankings

Country	Position 2009-2010	Position 2008-2009
Sweden	1↑	2
Singapore	2↑	4
Denmark	3↓	1
Switzerland	4↑	5
USA	5↓	3

Note: Evaluation of e-readiness has as its starting point a number of conditions, including amongst which is the number of telephone lines per inhabitant, number of secure Internet servers, electricity production, percentage of population with an education in natural sciences or technology, quality of research institutes, percentage of population with a tertiary education, education expenses, access to digital content and speed on the available broadband.

Source: World Economic Forum (2010).

In this report we focus on the socio-economic impacts of broadband speed, because it is especially in this area that Denmark is lagging internationally and here there is a need to shed light on the importance of the extra effort. The report contributes by summing the socio-economic advantages at a macro level, something that has not previously been done for Denmark.

Chapter 3 SOCIAL ADVANTAGES OF AN IMPROVED DIGITAL INFRASTRUCTURE

An improved digital infrastructure induces higher productivity because:

- Knowledge-based workers can quickly find and share knowledge and this increases their productivity.
- Knowledge can be better shared and exploited within companies and other organizations. This forms the basis for more effective business processes that increase productivity.
- Distance-working is optimized and commuting time is reduced. The reduction of commuting time implies that we can work extra hours and this benefits value creation in society.

An improved digital infrastructure also means better welfare because:

- The private and public sectors can develop new services and products that give greater welfare. This is seen, for example, in the health sector.
- The increased productivity creates competitive skills, ensures employment and forms the basis for salary development.

3.1. EFFECTS ON INNOVATION

The development of electronic communication has passed through two generations in the past 20 years. Whenever a new generation of electronic communication arrived, it introduced fundamentally new methods of communication and created new uses for leisure and business.

New uses from a business perspective have increased productivity in businesses and contributed to creating a basis for further innovation. New uses as regards leisure have created welfare for consumers.

There are various studies that include a historical analysis of what electronic communication has been used for over the past twenty years, so here we will only provide a summary. The issue is that higher speeds generate innovation.

The first generation of electronic communication was dial-up connectivity using modems, where speeds were typically 56 Kbps or 128 Kbps for ISDN. For leisure/home activities this was typically used for sending e-mails, surfing the net and e-banking. At workplaces the modem connection was mostly used for sending e-mails and for information searches on the net. This often required a large investment of time for the individual to learn how to use the applications that were built upon the old types of connectivity.

The second generation of electronic communication is built upon DSL technology (or broadband), which typically delivers speeds of 4-10 Mbps. The move from modems to broadband has allowed much greater interaction over the net and a wide range of new uses has arisen for both leisure and work. Amongst the most significant leisure activities are online gaming, streaming of music, TV and films, file sharing on the net and basic video-on-demand technology. In workplaces, electronic communication has been integrated into work processes and work processes have been changed and adapted for electronic communication. Electronic warehousing has been introduced, thereby allowing automatic ordering of goods when stock levels are depleted. In the majority of workplaces there is an exchange of documents, technical diagrams and large amounts of electronic data associated with project solutions. It has also become more common for distance working, to work whilst commuting etc.

A number of investigations document the effects of fast Internet access on various innovation indicators:

- Innovative sales
- Process innovation
- Product innovation
- Organizational innovation

Studies show that higher speeds create innovation on all fronts. For example, van Leeuwen and Farooqui (2008), where the transgression from 56 Kbps modems to DSL meant that sales arising from new services by Dutch businesses rose by 12.8 percent.

We have used the documented experiences to evaluate how much the compliance with the High-Speed Committee's vision will mean for innovation in Denmark. To do this we have examined the basis for the documented estimates and considered what the results would have been if the Danish estimates for 2008 were applied and if the increase in net speed complied with the vision of the High-Speed Committee.⁵

The result of the calculation is depicted in Table 3.1. The first column in the table shows where the results are calculated from. The table's second column shows the effect arising from people who already have electronic communication, but

⁵ The underlying calculations can be obtained from Copenhagen Economics.

now having even faster access. The third column shows the effect arising from a greater number of people having access to electronic communication. The fourth column shows how innovation has been measured in the studies, while the fifth column shows the empirical methods that have been used. The last column shows the country that has been analyzed. As an example of reading the table, Polder et al. (2009) analyzed that Dutch and British businesses with a greater percentage of employees with broadband access have a greater tendency to develop new products, processes and organizational changes when compared to businesses with a lesser percentage of employees with broadband access. When we calculate the results from Polder et al. (2009) to shed light on the effect of achieving the vision of the High-Speed Committee, we see for example that fulfillment will increase the percentage of businesses that develop new products (product innovation), with 18.8 percent, where 12.3 percent arises from increases in speed and approximately 7 percent arises from more employees opting to use broadband.

Table 3.1 Effects on indicators for innovation to satisfy the vision of the High-Speed Committee

Analysis	Effect of speed	Effect implementation	Innovation target	Method from analysis	Area and year
van Leeuwen and Farooqui (2008)	15.3 %	5.7 %	Innovative sales/employee Innovative sales percentage	Micro economics	The Netherlands, 2002-04
	3.7 %	1.4 %			
Polder et.al. (2009)	12.3 %	6.5 %	Product innovation	Micro economics	United Kingdom and the Netherlands, 2004
	5.4 %	2.9 %	Process innovation		
	9.1 %	4.8 %	Organizational innovation		

Note: Method for DK-conversion: Upward scaling of speed and dissemination according to Micus (2009) in relation to average values from the analysis (or other source with the same data). In upward scaling logarithmic scales are used.

Source: Copenhagen Economics.

As a whole, there is a range of documented experience indicating that higher speeds for electronic communication generate increased innovation.

It can furthermore be argued that greater innovation is achieved when one is in a leading position regarding network speed. The argument is, on the basis of Eeckhout and Jovanovic (2002), if a country is lagging as regards its use of information and communication technology, then it is economically viable for the country's businesses to imitate the leading businesses in other countries rather than develop their own solutions. On the other hand, if one is ahead, then you cannot imitate others and it can best pay to develop one's own solutions.

3.2. EFFECTS ON PRODUCTIVITY

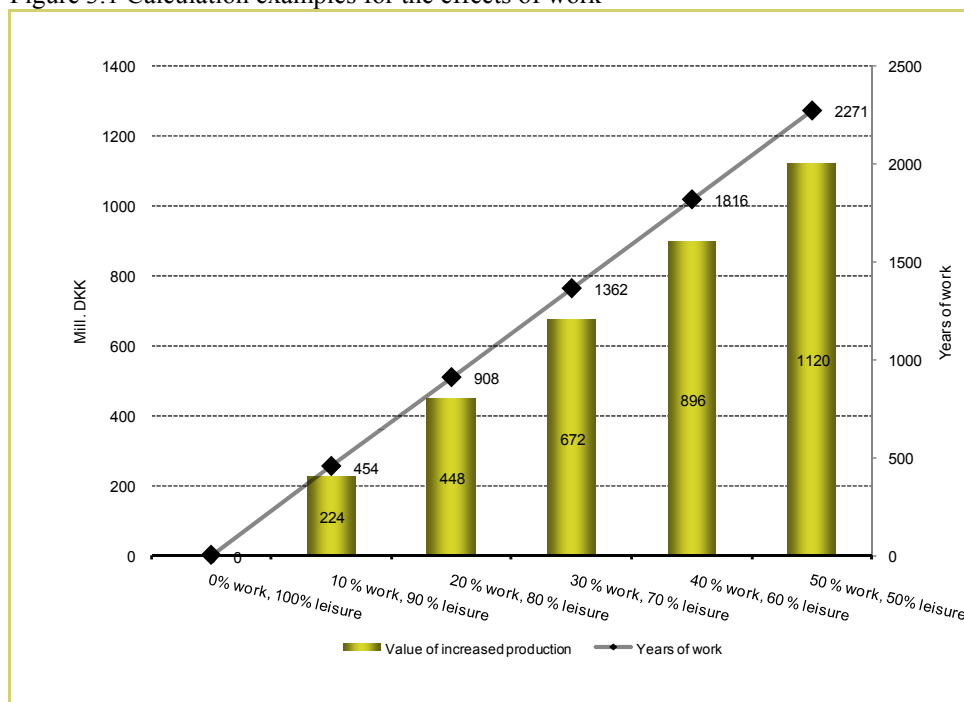
The innovation effects described previously contribute toward increasing productivity in society; this is because new valuable products and services are created. On top of this, an improved digital infrastructure can strengthen productivity through increased working time for the individual, greater productivity for knowledge workers and better organization of work activities. In this section we first provide a simple calculation to illustrate the meaning of an improved digital infrastructure for work. Following this, based upon literature, we evaluate how much an improved digital infrastructure will mean for productivity in Denmark.

An improved digital infrastructure means that it will be easier to work from home and the more stable connections allow more types of tasks to be resolved from home. Furthermore, it will be possible to deliver more services from a distance (meetings with public-sector authorities etc.). All of this means that commuting time to and from work can be saved and time for business travels can also be reduced. Part of the saved time will be converted to working hours.

An American study shows that users with high-speed connections do work two days more per month from home than those with standard broadband connections. According to Statistics Denmark, 29 percent of all those employed in Denmark do work from home. At the same time, the average daily commuting time between home and work is approximately 28 minutes. With an extra two days per month working from home, approximately 8.7 million hours could be saved on commuting time (equivalent to 4,500 years work). These could be used for work or leisure activities.

Figure 3.1 shows what the saved commuting time will mean for work being offered, this measured in years of work and for the Gross Domestic Product, depending upon how large a part of the saved commuting time is used for work. For example, if 10 percent of saved commuting is used for work, then this will increase the work being offered with 454 positions and contribute approximately DKK 200 mill. to the Gross Domestic Product.

Figure 3.1 Calculation examples for the effects of work



Note: For calculation of the effect on Gross Domestic Product an assumption is used where the increase in value per hour is DKK 264 – this being equivalent to the average hourly wage in Denmark.

Source: Copenhagen Economics.

An improved digital infrastructure creates higher productivity. This is because the digital infrastructure allows for quicker uploading and downloading of information, more information, more data-heavy information and it increases productivity in knowledge enterprises, increases working time and creates possibilities for more effective processes.

When viewing productivity increases over a period of time, there are two basic ways to evaluate the size of the growth. The method used has a big influence on the results:

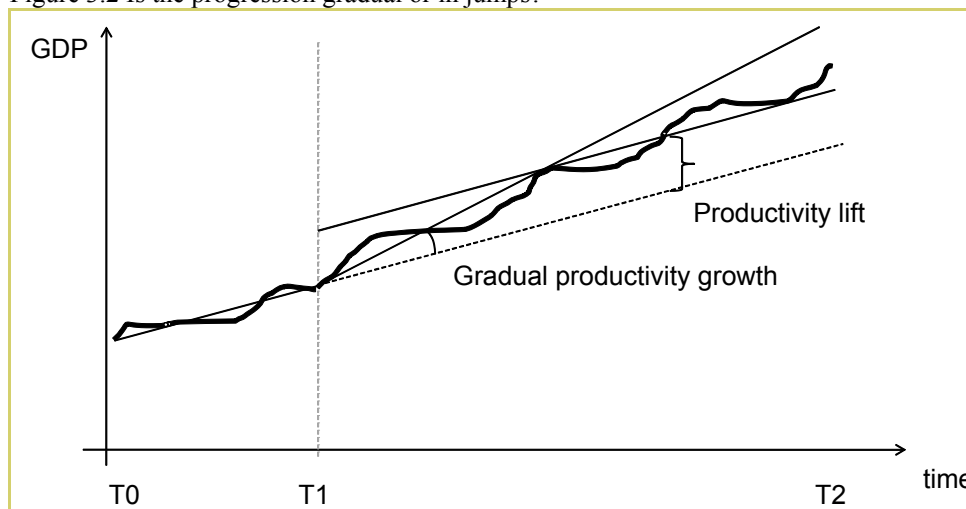
- The increase in productivity can be regarded as an increase in the level of production.
- The increase in productivity can be regarded as an increase in the rate of growth of production.

Figure 3.2 illustrates the two methods for considering an increase in productivity. From time point T1 to time point T2 the Gross Domestic Product is shown as a solid curve. When describing the development as a one-off increase in productiv-

ity, then this is equivalent to the precondition that the rate of growth is the same as before, where the average growth rate is shown by the straight line between production level points T0 and T1. When describing the development as an increase in the rate of growth, then this is equivalent to accepting that the development in the Gross Domestic Product from T1 to T2 will continue, and the line describing this development in Gross Domestic Product has a higher gradient.

The first approach gives an impression of high short-term effects, while the second approach gives an impression of significant long-term effects. We selected the first approach because it is the best basis for documentation. A number of investigations exist that analyze the effect of higher communication speeds on productivity for various countries and various scenarios. Many describe the effect as a one-off increase in productivity, whereas there are only few studies where the effect is analyzed as a higher growth rate.

Figure 3.2 Is the progression gradual or in jumps?



Source: Copenhagen Economics.

In the investigations we have seen, the effects of association are greatest where communication speed in the investigation group were highest. We do however see lesser effects per Mbps when the starting point is high. For example our analysis of these shows:

- An increase from 5 to 10 Mbps gives a gain of approximately 1.9 percent.
- An increase from 25 to 30 Mbps gives a gain of approximately 0.5 percent.

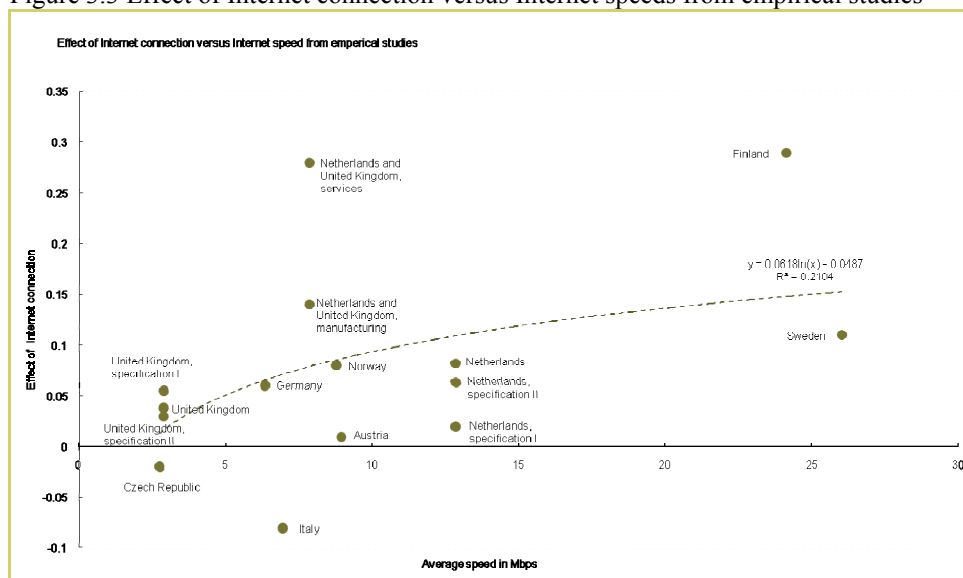
We will use this to analyze our scenarios for the development of communication speeds in Denmark. It is difficult to evaluate how an increase in communication

speeds, such as that suggested by the High-Speed Committee, will affect Danish society. This is simply because such increases in speed, and the speeds themselves, have rarely been seen before and we do not have experience with what happens when they reach such levels. On the other hand, we have experience from countries that Denmark often compares itself with. These point toward significant increases in productivity, even when communication speeds increase with low levels. With this knowledge we can determine how productivity will increase for different speed levels and we can calculate a relationship between speed and gains in production. We use this relationship to project the effect on productivity for large increases in speed.

Figure 3.3 depicts the relationship between speed and the effect on productivity. We calculated this from documented investigations, the majority of which are from Franklin and Farooqui (2008). The vertical axis depicts the productivity effect; for example a productivity effect of 0.2 results in a 20 percent increase in productivity. The horizontal axis depicts the speeds at which the productivity effect is measured. The measured productivity effect gives that effect at which all those employed have broadband access at a specific speed. The points in the figure show every documented result, and these have been transformed so they can be compared. For example, the point in the upper-right is based on Finnish business data. It shows that the productivity effect can reach up to 29 percent at a speed of 24 Mbps. This result is also available from Franklin and Farooqui (2008).

The figure also depicts that the greatest effect is realized for speed increases that have a low starting point. The graph is steep at low speeds and flattens out at higher speeds. One Mbps increase creates greater effects, for example when transgressing from ISDN to DSL, but the same Mbps increase will increase productivity to a lesser degree when the starting point is, for example, DSL.

Figure 3.3 Effect of Internet connection versus Internet speeds from empirical studies



Source: Copenhagen Economics.

We can use this relationship for scenario analyses. Differing increases in speeds create different productivity effects. The outset is the current average speed of approximately 9 Mbps (2010). We note two scenarios:

- An increase in speed matching that in the vision of the High-Speed Committee.
- An increase in speed matching that where Denmark will be equivalent to that planned for Sweden.

The method for calculating the effect is based upon the relationship from Figure 3.3. We can use the dashed line to measure the current productivity effect for Denmark, which, as stated earlier, has a current speed of approximately 9 Mbps and covers approximately 44 percent of all workers.⁶ We can deduce that Denmark could have attained an approximately 8.8 percent gain in production with 100 percent coverage, and with the actual 44 percent may have *realized* approximately 3.9 percent productivity gain. In a similar fashion we can measure the combined productivity gain, for example at a speed matching the approximately 42 Mbps vision of the High-Speed Committee. This gives a potential *accumulated* productivity gain of approximately 8 percent. The benefit as seen today must be approximately $8.0 - 3.9 = 4.1$ percent. Onto this must be added a lesser effect resulting from large distribution, this being based upon Franklin and Farooqui (2008). According to them, a generation change in technology introduces an approximately 4 percent increase in distribution, which gives a potential dis-

⁶ According to Statistic Denmark.

tribution of 48 percent in Denmark. This contributes with approximately 0.8 percent more, which gives us an accumulative productivity gain of approximately 4.9 percent.

Box 3.1 Calculation of productivity effects for speed scenarios

We have evaluated the effects of various scenarios regarding developments in net access speeds for Denmark.

We have based the evaluation of productivity effects on documented evaluations, that is how much an increase in the distribution of broadband has meant, historically speaking, on total factor productivity which is an expression for general changes in productivity for all production factors. The historical development in broadband distribution also covers workers that did not have any broadband access, or had a modem (or ISDN) connection, to now having broadband. Both these types of increases in distribution of broadband encompass higher communication speeds. We use knowledge about speeds behind all of the studies to find the effects of various speed increases. Technically speaking, this approach is termed a *meta-analysis*.

We focus on speed on the fixed network as there is a broader base of documentation to rely upon.

We work with three scenarios regarding developments in speed. The first scenario is the status quo, which means no increase in speed. The second scenario is that speed increases in accordance with the vision of the High-Speed Committee, which we have calculated to imply an increase in the average speed from the current approximately 5 Mbps to approximately 42 Mbps in 2013. The third scenario is that speed increases in accordance with the Swedish broadband strategy for 2020 with a speed of approximately 92 Mbps. We accept that an increase in speed follows an inverted exponential trend, where speed increases most in the first year, following which the rate of increase lessens.

Because we base the estimate on historical development, we also build our estimates for effect implicitly on an assumption that various historical conditions are also applicable in the future. This first requires that we can transfer effect estimates from other countries to Denmark. Secondly, it implicitly requires that the population's e-capabilities are continually improved so they match the quality on the net (this means that Danish e-capabilities and net quality must be just as good as those in other countries). Thirdly, it requires that the effect of future increases in speed per Mbps matches the historic effects, hereby also including that other conditions for exploitation of improved network quality are improved in accordance with historical development. We do not take into account that Denmark, by following the development in the scenarios, can achieve an improved relative position and be among the international leaders that create opportunities for increased innovation.

Results of the calculations are shown in Table 3.2. This indicates substantial benefits by increasing Internet access speeds in Denmark. In relation to the status quo (9 Mbps), there can be achieved GDP-effects in 2020 of between DKK 114 billion and DKK 170 billion. This is equivalent to a gain of approximately DKK 56 billion when setting goals that match Sweden, as opposed to the more moderate goals of the High-Speed Committee. When viewing the figures in 2020 it will be to ensure that the effects have been achieved.

Table 3.2 Calculated effects of speed scenarios

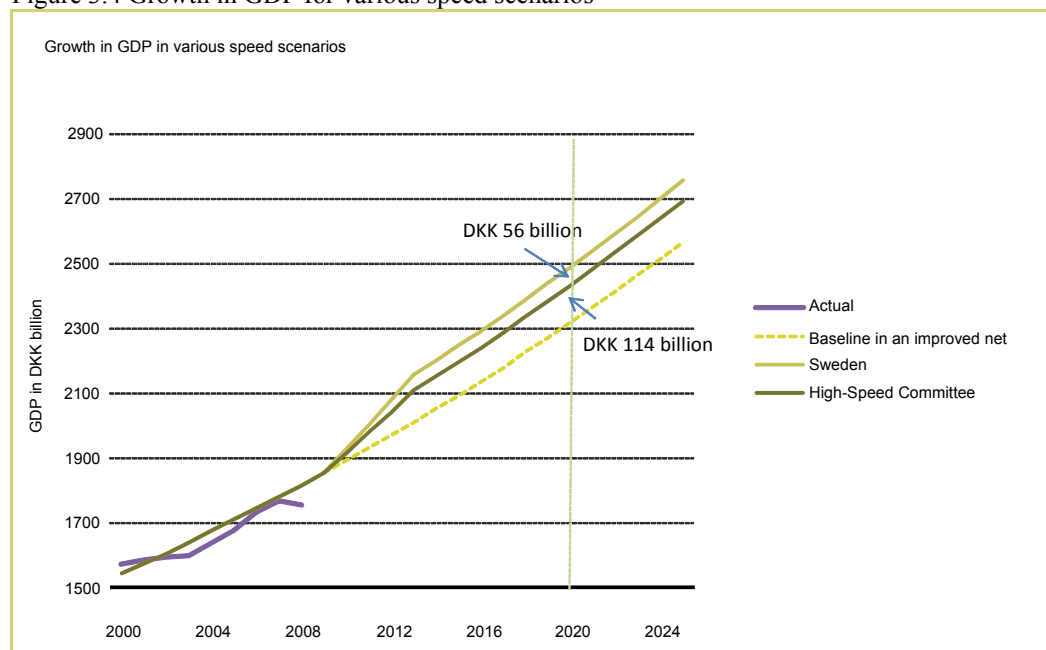
Scenario	Effect speed	Effect distribution	Combined effect	GDP effect (2020)
High-Speed Committee (42 Mbps)	4.1 %	0.8 %	4.9 %	DKK 114 billion
Sweden (92 Mbps)	6.3 %	1.0 %	7.3 %	DKK 170 billion
Status quo (9 Mbps)	0.0 %	0.0 %	0.0 %	DKK 0

Note: Based upon figures from meta-analysis.

Source: Copenhagen Economics.

The results are illustrated in Figure 3.4. This shows the development in the Gross Domestic Product up to 2027. The figure includes four curves. The first shows the actual development in Gross Domestic Product up to 2008. The next curve, the dashed line, indicates our enhancement of the Gross Domestic Product with a growth trend developed from the historic growth trend. This enhancement is preconditioned by having no development in broadband speeds above and beyond the pure trends. The third curve shows development under the precondition that we achieve the vision of the High-Speed Committee in 2013, while the fourth curve shows development under the precondition that we already in 2013 achieve the speeds that Sweden has planned for 2020. The rate of growth increases in these two scenarios for 2009-2013 because speeds increase in this period, in which we assume the digital infrastructure improves.

Figure 3.4 Growth in GDP for various speed scenarios



Source: Copenhagen Economics.

The estimated productivity effects are associated with significant uncertainties because there is no basis of experience to evaluate the large increases in speed. We therefore had to adjust experiences based on relatively limited increases in communication speeds so they also account for large increases, and this is associated with a large degree of uncertainty. On top of this, we have adjusted the documented estimates based upon the effects of broadband distribution and applied these to obtain effects on speed, which also creates uncertainty in the results.

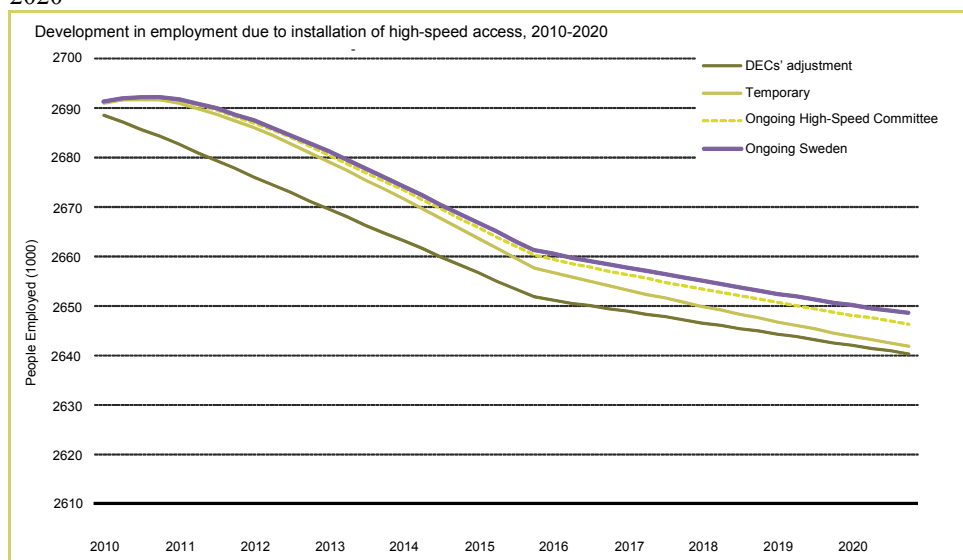
3.3. EFFECTS ON EMPLOYMENT

An improved digital infrastructure creates jobs. In the short-term there needs to be infrastructure, for example cable channels and masts, all of which create jobs in the building and construction sector. In the long term there will be product benefits as described earlier. This creates competitive advantages when compared to other countries (and also between input factors), thereby providing more jobs.

We apply a slightly different method to determine employment effects than that used to determine production effects. This is because there are fewer investigations regarding the effects of digital infrastructures on employment. We align ourselves with the employment effects calculated by Katz et al. (2009) for Germany. In that investigation input-output tables were used for the German economy. They evaluated how increased activity in the building and construction sector affected employment in the short term. They were also used to determine how high Internet speeds increased employment in, amongst others, the knowledge-based service industry.

Figure 3.5 depicts the results of our calculations for effects on employment. There are four curves. The first curve depicts the Danish Economic Councils' (DECs) prognosis for the mid-term development in employment. The next curve depicts the number of temporary jobs that will be created in the construction phase when an improved digital infrastructure is implemented. The last two curves show the number of ongoing jobs that we estimate will be created. These are, for example, in the knowledge service industry and as a result of higher productivity and innovation associated with higher speeds. We have evaluated the effects by satisfying the vision of the High-Speed Committee or by achieving the same speeds as in Sweden.

Figure 3.5 Development in employment due to installation of high-speed access, 2010-2020



Source: Copenhagen Economics.

This does not refer to hundreds of thousands of extra employment opportunities, but even a few thousand extra jobs can have a significant value to society. There is significant socio-economic value when an unemployed person moves from unemployment benefits to a permanent job. Each unemployed person that finds a job will save the public sector approximately DKK 16,000 per month in unemployment payments.⁷ On top of this, a working income is generated and a conservative estimate of DKK 18,000 per person per month can be applied, resulting in more than DKK 200,000 per person per year.

The results for employment estimation are also associated with significant uncertainty.

3.4. EFFECTS ON CO₂ EMISSIONS

Internet-based solution will be able to replace polluting transportation systems. This is applicable to:

- Video conferences as opposed to business travels
- Home/Flex work as opposed to physical attendance at a workplace

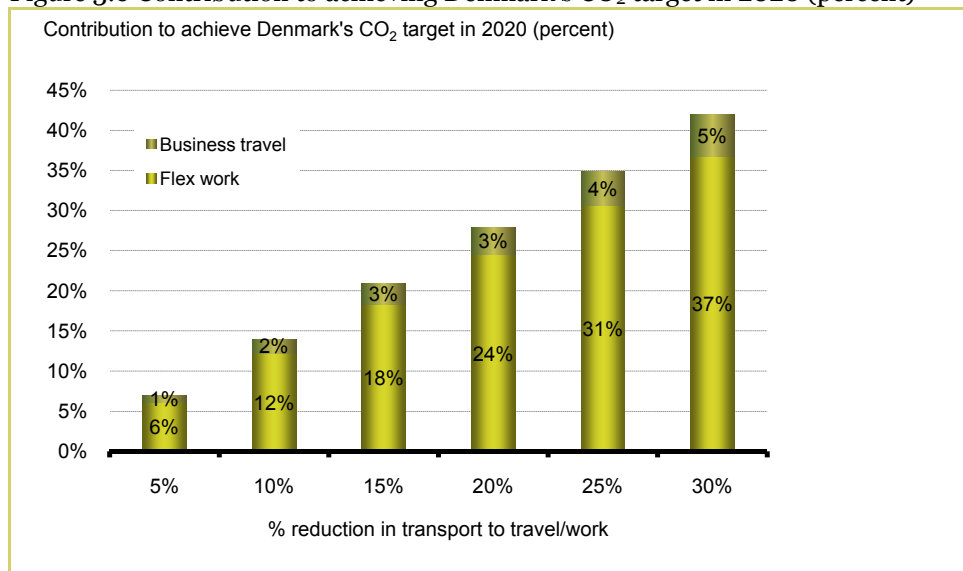
⁷ Of the DKK 16,000 only one-fifth thereof is a cost to society, because a transfer of income is not a loss of resources to society. From a social aspect, the costs arise because social resources are lost in relation to retrieving the income tax that finances such income transfers.

To a large degree, society has already begun to rework a range of services. This process can be expected to strengthen when net speeds increase.

We have performed some simple calculations to determine the effect that lower transportation needs, as a result of an improved digital infrastructure, will have on CO₂ emissions. As already known, transport is a major contributor to CO₂ emissions. In 2007, transportation was responsible for one third of the Danish CO₂ emissions. The transportation sector has an important role to play as regards satisfying the climate targets in the Kyoto agreement, to ensure 20 percent less CO₂ in 2020 when compared with 1990. Calculations are based upon similar calculations from ETNO and WWF, as in Pamlin and Szomolanyi (2008), for entire Europe.

Because we do not have a solid basis to determine the number of journeys that will be saved by an increase in Internet connection speed, we have shown a number of scenarios in Figure 3.6. For example, a 5 percent fall in transportation needs – equivalent to working one day from home per month, or by replacing every twentieth business trip with a video conference – gives 7 percent of that required to meet the Kyoto target for Denmark. Actually the effect will be a little higher than that, an American study has evaluated that a person will work from home two days per month.⁸

⁸ RVA Market Research and Consulting (2009)

Figure 3.6 Contribution to achieving Denmark's CO₂ target in 2020 (percent)

Source: Copenhagen Economics.

3.5. EFFECTS ON INNOVATION IN THE PUBLIC SECTOR

An improved digital infrastructure allows for better public services.

Our previous calculation for productivity and innovation included public services that were cheaper to produce, but not that the services were necessarily better than before. In this section we examine what this means for welfare when the public sector develops new services. Generally speaking, we have calculated what new electronic growth means for welfare in society. In the private sector, users can be charged for a new service, which counteracts the welfare benefit that the users have from the service. In the public sector there is seldom any payment for delivered services; this means we are lacking a contribution here. In the calculations we accept that the public sector is just as good as regards electronic services as the private sector (see Box 3.2).

Box 3.2 Innovation in the public sector

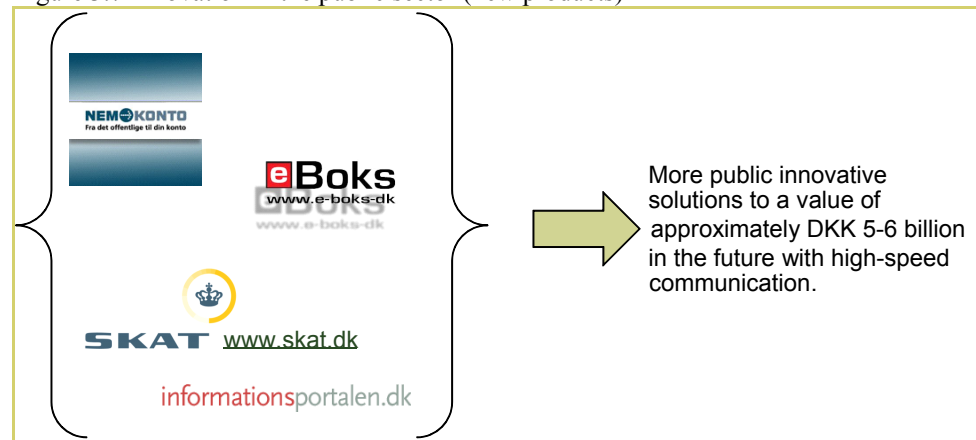
The public sector is a major part of the Danish economy. It is therefore important that the public sector also benefits from faster Internet so as to be more innovative and productive. This applies internally for the creation of services, and externally when interacting with the public. As regards interaction with the public, it is primarily the provision of services that is in focus, and in fact, the public already has examples of new services that fast Internet has allowed. For example, we can mention the website of Danish Tax and Customs Administration, Easy Account (NemKonto), E-boks, and Informationsportalen. An even faster Internet will naturally allow for more of these services.

In principal, our earlier calculations for innovation and growth also encompass the public sector. There is however a technical detail regarding macro studies. These will not accept the actual production in the public sector as their origin, only the expenses (because this is how economists define the public sector). Due to this, only productivity gains relating to processes and organization are measured (and these are reflected in the expenses), but not the added-value achieved by users of the services, for example as with the Danish Tax website. In other words, something is lacking in our calculations.

We will attempt to create a conventional formula to correct this issue. We accept that an accumulated benefit of 2% has been *measured* on productivity and that the public sector accounts for half of the economy. Our academic studies indicate that approximately $\frac{1}{8}$ of the benefit of 2% can be associated with new products (see for example Polder et al. (2009)). We can therefore calculate that approximately 0.13% is lacking - the correct total effect in this case is therefore 2.13%.

Source: Copenhagen Economics

Figure 3.7 Innovation in the public sector (new products)



Source: Copenhagen Economics.

Various investigations have indicated the advantages that can be achieved when improving the public sector; this is for services using digital solutions. The High-Speed Committee (2010) includes a range of such cases. The Danish Technological Institute (2009a,b), has as an example of such a case, looked at the advantages of using digital technology when caring for the elderly and when using broadband telemedicine, as described in Box 3.3 and Box 3.4.

Box 3.3 Case of using digital technology when caring for the elderly

In October 2009, the Danish Technological Institute (on behalf of the Danish Energy Association) analyzed the benefits to society of using digital technology when caring for the elderly.

The analysis showed that the introduction of new digital communication methods, such as interactive TV, can radically change the conditions for the elderly, nursing staff and relatives as well as provide the possibility to prioritize and focus the economic resources in that area.

An improved two-way communication via TV in a sitting room can offer increased quality of life for the elderly. This is because they can always have visual contact with nursing staff as well as receive face-to-face messages as necessary, just like when such staff visit the elderly.

As regards the prerequisites for video communication and image quality, the analysis estimates that a download speed of 13 Mbps and an upload speed of 4-5 Mbps are required. This is to ensure sufficient and stable image quality as well as capacity for two-way digital video communication and TV reception.

Besides the social benefits for the elderly, there are also significant economic benefits, even with a conservative estimate. For example, the analysis shows that expenses for elderly care can be reduced by DKK 156 million in 2009, DKK 206 million in 2020 and DKK 271 million in 2040. That is only by introducing digital communication systems for the care of the elderly (see the following Table 3.3).

Introduction of digital communication systems for the care of the elderly is estimated to reduce the number of absenteeism days taken by nursing staff by at least 20% per year.

Source: Danish Technological Institute (2009a).

The Danish Technological Institute (2009a) estimated the total gain to society as regards digital care for the elderly. The results of their calculations are shown in Table 3.3. Digital care for the elderly is estimated to provide the elderly with a better quality of life, save expenses relating to elderly care by as much as DKK 200 mill. per year and reduce staff absenteeism by as much as 20 percent.

Table 3.3 Possible annual savings by using digital care for the elderly in Danish kroner (DKK)

Possible savings/Benefits	2009	2020	2040
Savings in care expenses	DKK 155.7 mill.	DKK 206.1 mill.	DKK 271.3 mill.
Savings in elderly that do not need to live in a nursing home	DKK 51.9 mill.	DKK 68.7 mill.	DKK 90.4 mill.
Time savings in hours per week	568 hours per week		
Possible reduction in nursing staff absenteeism days following introduction of the communication technology	20%		

Source: Danish Technological Institute (2009a).

Box 3.4 Case dealing with telemedicine

Another example is the introduction of telemedicine solutions in Denmark. This can lead to large benefits for a society. This is shown in an analysis performed by the Danish Technological Institute on behalf of the Danish Energy Association.

The analysis shows that higher broadband capacity for the individual citizen is required in order to fully exploit this potential. The telemedicine-based solution demands two-way digital video communication in high resolution (image quality). It is estimated that a download speed of 13 Mbps and an upload speed of 4-5 Mbps are necessary to ensure suitable and stable image quality and capacity for both two-way digital video communication and TV reception.

A relatively conservative estimate regarding transport savings for doctors, nursing staff and interpreters could be as much as DKK 80 mill. per year. On top of this is the freeing of commuting time, which if estimated conservatively, equates to a minimum of 250 combined yearly full-time positions for doctors, nurses and interpreters.

Source: Danish Technological Institute (2009b).

Chapter 4 WHAT IS REQUIRED TO MAKE IT HAPPEN?

In the previous chapter we showed that there are large potential benefits for Denmark when having an improved digital infrastructure. We will now look at what is necessary to achieve this potential.

4.1. HOW MUCH WILL PRIVATE PARTICIPANTS CONTRIBUTE?

It is doubtful whether it is economically viable for private operators to provide a digital infrastructure. This is partly because it is expensive to lay a new infrastructure and partly because it can be difficult for the individual broadband provider to achieve the entire socio-economic benefit at higher speed. The latter is due to various conditions, amongst which is the advantage of higher speed being shared between consumers and providers and also that tax must be paid on the profit earned by providers.

As regards the Norwegian government's analysis of the advantages, expenses and need for public sector input for an improved digital infrastructure in Norway, the economic experts estimated that:

“Private solutions regarding the expansion of broadband capacity are unlikely to lead to a system that is profitable from a socio-economic point of view. Proportion of economies of scale in both consumption and production, as well as a substantial element of network externalities, will create a discrepancy between private financial gains and socio-economic benefits.” (Strøm and Vislie (2009)).

Analyses have looked at the economies of private companies that are capable of introducing digital infrastructures. In various countries it has been found that only the most densely populated high-income areas are economically viable for private companies to introduce such infrastructures:

“In high-density, high income areas, fiber rollouts could potentially yield modest positive returns...” McKinsey Telecommunications Recall no 12: The Fiber Future.

This means that even in Germany (for example), as indicated in Table 4.1, it is not economically viable from a private aspect to offer higher speeds to the entire population. The first column of the table shows a range of different technologies that can deliver higher speeds for electronic communication. The last six columns show the percentage of population where it is economically viable for private providers to service these technologies in various European countries. For example, in Germany it is only viable to deliver VDSL - a technology that can give a relatively high speed, but it not necessarily as good a future investment compared to fiber-based solutions - to 72 percent of the population.

Table 4.1 Percentage of population where it is economically viable for private companies to offer faster Internet

Technology	Germany	France	Sweden	Portugal	Spain	Italy
VDSL (combined fiber and copper)	71.5	-	18.3	39.0	67.4	100
PON (fiber)	25.1	25.2	18.3	19.2	12.2	17.6
P2P (fiber)	13.7	18.6	18.3	19.2	12.2	12.6
Population density (number of inhabitants per km ²)	230	111	20	115	89	197
Area in km ²	357,021	547,030	449,964	92,391	504,782	301,230
Population	82.0 mill.	64.7 mill.	9.3 mill.	10.6 mill.	46.7 mill.	60.4 mill.

Source: WIK-Consult (2008).

If in Germany it is not economically viable for private providers to offer high-speed nets, then it is doubtful if it is viable for providers in Denmark where there is an even lower population density and a smaller market (as listed in the Appendix of this report). It is obviously always dependent upon a concrete evaluation of each business case to determine whether it is economically viable to install high-speed networks. Furthermore, it must be noted that the private economic interest in high-speed networks will most likely improve in the future as demands increase. It is still doubtful whether private service providers will offer the solutions that create greatest social gain, as also indicated by Strøm and Vislie (2009).

In developing countries, where one starts without any infrastructure, it can better pay to install a high-speed infrastructure. This is because use of the Internet in these countries implies that earnings grow quickly.

4.2. HOW CAN THE PUBLIC SECTOR HELP?

The problem of not being economically justifiable for private providers to offer the digital infrastructure, which gives the greatest socio-economic long-term gain, is based on the fact that expected earnings for private providers is too small and expenses are too large.

The public sector can assist in two ways:

- Create a greater demand for a high-speed infrastructure and thereby increase the earnings for the private participants by establishing the infrastructure.
- Minimize expenses by establishing the infrastructure.

The High-Speed Committee has suggested that the public sector, to a greater degree, should offer services that build upon a high-speed infrastructure, for exam-

ple video conferencing as opposed to physical meetings. When the public sector offers services that are built upon high-speed communication, then it implies that the public must have access to high-speed networks and this creates a basis and demand for high-speed networks, which strengthens the income base for private providers. There also arises a range of applications that are valuable to the public and which causes them to request high-speed networks and thereby further strengthen the income base.

There are already a number of examples where the public have readily accepted solutions that require high-speed communication (see Box 4.1 for examples).

Box 4.1 Case with video conferencing in Guldborgsund municipal area

Guldborgsund Municipality in Nykøbing Falster will use video conferencing to provide visual contact with municipal staff to its citizens at home. The municipality has 6 service centers with 55 members of staff spread across the entire municipal area. It receives 50,000 – 60,000 requests per year.

Besides providing its citizens with greater flexibility when contacting the municipality, it also provides access to services at times that best suits the individual citizen. Ultimately it implies improvements in service and releases municipal resources so they can be used for other municipal tasks.

The municipality has determined that the potential lies with the citizens' questions regarding housing payments, new health insurance identification cards and new passports. If only a third of these can be managed by video conferencing, then the municipality believes that there is a lot to save from a financial aspect.

Source: Computerworld (2009).

The High-Speed Committee has pointed to a number of initiatives that can reduce service providers' expenses when establishing high-speed infrastructures. Lower-costs will advance the providers' interest to develop the high-speed infrastructure:

- Municipal management of applications regarding excavations, placing of masts and technical installation cabinets can be more efficient. Municipalities can, to a greater degree, relate to a provider's expenses regarding establishment of a high-speed infrastructure when they have demands for laying of cables, technical installation cabinets etc. in the local area. Long delays in managing cases and special demands regarding placement and architectural compliance often incur slower and more expensive implementation of high-speed infrastructures.
- The road authorities in municipalities do not cover private shared roads in rural areas. Excavations for high-speed infrastructure in these areas depend upon the necessary authorization from each property owner. This can delay the process and prove expensive for the provider.
- Municipalities should, to a greater degree, coordinate the excavations between tele-operators and other service providers. This will reduce the pro-

vider's excavation costs and create a better economy for development of the high-speed infrastructure.

- Obligatory connection to community antenna systems (cable-TV net) can be scrapped to ensure an optimal framework for new providers of high-speed infrastructures. Conditions for connection can be found in municipal local plans, housing servitudes and property owner associations, and these protect the local area from competition. This protection creates a competitive imbalance in the market and makes it costly for providers to establish a high-speed infrastructure, because they cannot optimize their expansion based upon demographic and geographic conditions.


















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APPENDIX – OVERVIEW OF DEMOGRAPHIC CONDITIONS

		Inhabitants/km ²	Area in km ²	Population
	USA	31/km ² (no. 180)	9,826,675 km ² (no. 4)	308,147,000 (no. 3)
	South Korea	491.7/km ² (no. 12)	98,480 km ² (no. 108)	48,640,671 (no. 24)
	Estonia	29.5/km ² (no. 144)	45,226 km ² (no. 131)	1,332,893 (no. 148)
	Finland	16/km ² (no. 190)	337,030 km ² (no. 65)	5,289,128 (no. 111)
	Sweden	20.0/km ² (no. 155)	449,964 km ² (no. 54)	9,325,429 (no. 85)
	Australia	2.6/km ² (no. 232)	7,617,930 km ² (no. 6)	22,194,945 (no. 51)
	Japan	337.4/km ² (no. 18)	377,835 km ² (no. 62)	127,463,611 (no. 10)
	Germany	230/km ² (no. 36)	357,021 km ² (no. 63)	82,060,000 (no. 14)
	Norway	12.5/km ² (no. 211)	385,252 km ² (no. 61)	4,850,440 (no. 115)
	Portugal	114.7/km ² (no. 66)	92,391 km ² (no. 110)	10,599,095 (no. 76)
	Slovenia	99.2/km ² (no. 77)	20,273 km ² (no. 151)	2,011,070 (no. 143)
	New Zealand	14.8/km ² (no. 164)	268,680 km ² (no. 75)	4,035,461 (no. 121)
	Denmark	126.1/km ² (no. 62)	43,098 km ² (no. 132)	5,534,738 (no. 108)
	United Kingdom	243.3/km ² (no. 33)	244,820 km ² (no. 77)	60,441,457 (no. 22)
	Singapore	6,814/km ² (no. 3)	710.2 km ² (no. 187)	4,987,600 (no. 115)
	Malaysia	72.6/km ² (no. 97)	329,750 km ² (no. 65)	23,953,136 (no. 46)
	Ireland	60.3/km ² (no. 139)	70,273 km ² (no. 117)	4,339,000 (no. 121)

Note: Figures in parentheses are actual international placement.

Source: Wikipedia, CIA Factbook.