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Development of High-speed Networks and the Role of Municipal Networks

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Working Party on Communication Infrastructures and Services Policy

DEVELOPMENT OF HIGH SPEED NETWORKS AND THE ROLE OF MUNICIPAL NETWORKS

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FOREWORD

This report was presented to the Working Party on Communication, Infrastructures and Services Policy (CISP) in June 2015 and the CISP agreed to recommend it for declassification to the Committee on Digital Economy Policy (CDEP). The CDEP approved the report in October 2015.

The lead author of the report was Mr. Bengt G Mölleryd, who prepared the document during a secondment at the OECD Secretariat, and finalised it after returning to the Swedish Post and Telecom Authority (PTS). Marco Forzati and Crister Mattsson, Acreo Swedish ICT contributed the case study and econometric analysis of Sweden. Contributing to the report from the Secretariat were Hajime Oiso, Rudolf van der Berg and Sam Paltridge, as well as Timothy Destefano who contributed with the analysis of firm level productivity in the United Kingdom.

TABLE OF CONTENTS

MAIN POINTS

All OECD countries recognise the benefits that stem from high speed broadband networks and have made tremendous progress in recent years in fostering their deployment. Nonetheless, many challenges remain in terms of how to enhance and expand these networks to meet the growing demands of an increasingly digital economy and society. Although private investments have been the overwhelming source of finance for high speed networks in OECD countries, municipal networks have been used in a number of OECD countries to fill gaps or provide substantial areas of service in a region, city or smaller town and surrounding locations. This report examines some of the experience with these municipal broadband networks in selected OECD countries. Municipal networks are defined here as high speed networks that have been fully or partially facilitated, built, operated or financed by local governments, public bodies, utilities, organisations, or co-operatives that have some type of public involvement. The models and experience of these networks have varied from being highly successful to not meeting expectations. In some cases, they have provided welcome competition by offering an alternative infrastructure and have opened the market for retail Internet service providers by separating the basic infrastructure from services. In other cases, they have enabled the use of shared infrastructure. Some have built on a long tradition of municipalities providing services from entities owned by them, such as the provision of utility services like energy, water, gas, or cable television. Some have involved public private partnerships, others have been privatised following initial public ownership and some are community driven.

An important factor underlying the deployment of municipal networks is that local government authorities or utilities regard them as a way to provide and improve public and social services, as well as essential infrastructure for commerce. Sometimes this is because they believe there is unmet demand and in others they feel they can build on their existing responsibilities, for example to improve health care, education or utility services, and more broadly to facilitate more cost efficient digital communication as well as promote economic and social growth in their cities and towns. Proponents say municipal networks provide users with access to high capacity broadband services, which give them more choices, contribute to competition, and result in lower prices, for consumers, business and the public sector. Some critics say they may sometimes compete unfairly with the private sector providers or become a local monopoly for infrastructure.

Given the large undertaking to deploy high speed broadband networks, a combination of both private and public capital is sometimes required, particularly where commercial players assess there is insufficient demand for them to invest. However, it is not always the case that local municipalities, or utilities have access to the necessary capital to invest in broadband networks or have the right conditions and capabilities. That being said, in cases where capital has been available and networks have been deployed, experience generally indicates that municipal networks stimulate further investments. Sometimes this is in the form of retail ISPs, which leverage the underlying network infrastructure, or of mobile providers taking advantage of a municipal network's fibre as backhaul. In other cases, there is evidence of private players increasing investment driven by the competition provided by municipal networks in areas that would have otherwise had insufficient competition from a single incumbent operator. A further important point is that experience shows that people, such as in rural towns, are often prepared to get involved and contribute with voluntary work or their resources, such as machinery, in order to establish networks. This occurs when communities or co-operatives contribute time and money, if no other solutions are available. The examples of municipal networks in OECD countries examined here show that in the right circumstances they have a role to play in the development of new broadband networks in order to cope with the continuously growing demand for higher capacity and in meeting policy objectives.

This report gives further support for the notion that broadband speed matters and that high speed broadband networks generate positive benefits, contribute to economic growth, as well as to making firms more productive, based on an analysis of broadband, ICT and firm productivity in the United Kingdom and an econometric analysis of high speed broadband networks in Sweden. There is also some indications that broadband networks can substitute for some types of transport and that they contribute to the creation of employment opportunities. Given the increased number of elderly in OECD countries it is also possible to use high speed networks to provide more cost efficient home care services, and when these networks are in place they can potentially make a substantial contribution to lowering costs.

BROADBAND AS A VEHICLE FOR ECONOMIC GROWTH AND INNOVATION IN SELECTED COUNTRIES

Experience with municipal networks

All OECD countries recognise the benefits that stem from high speed broadband networks and have made tremendous progress in recent years in fostering their deployment. Nonetheless, many challenges remain in terms of how to enhance and expand these networks to meet the growing demands of an increasingly digital economy and society. Although private investment has been the overwhelming source of finance for high speed networks in OECD countries municipal, networks have been used in a number of places to fill gaps or provide substantial areas of service in a region, city or smaller town and surrounding locations. This report defines municipal networks as high-speed networks that have been fully or partially facilitated, financed, built, operated, by local governments, public bodies such as utilities or other organisations, co-operatives that have some type of public involvement. It could also be accomplished through a public private partnership with a local or regional focus, or networks that are privately owned but which have been divested by municipalities, or networks that have been established in communities through initiatives made by individuals or co-operatives. The models and experience of these networks have varied from being highly successful to others that have not met expectations. In some they have provided welcome competition, by providing an alternative infrastructure and opened the market for Internet Service Providers (ISPs) by separating the basic infrastructure from services and in others enabled the use of shared infrastructure. Some have built on a long tradition of municipals providing services from entities owned by them, such as the provision of utility services such as energy, water, gas, or cable television. Some involve public private partnerships, others have been privatised following initial public ownership and some are community driven.

This report examines the experience of municipal networks in a number of countries.[1] It uses Sweden as the anchor country for this analysis given its successful use of municipal networks, but also includes case studies from Australia, Denmark, Japan, the Netherlands, New Zealand, United Kingdom, and the United States. The report also looks at some of the demonstrable social and economic benefits, which can be correlated to the development of high speed networks, and the effects of information communication technologies (ICT) and more specifically broadband networks on firm performance. Finally, it sets out some of the lessons learned for policy makers and other stakeholders.

The transition to a digital economy, the increased use of online public services and the growing significance of economic and social interaction over the Internet have made access to broadband networks critical for any location. For towns, cities and regions, this has spurred demand for broadband connectivity, and a continuously growing requirement for increased capacity. In September 2014, this fact was

underlined by the Chair of the United States Federal Communications Commission (FCC), when he said that the combination of more advanced applications, which require higher bandwidth, and the number of simultaneous users in Internet-connected households could easily reach up to six or more devices. He noted, "It's not hard to overwhelm 10 Mbps of bandwidth".[2] While entertainment has been one of the primary drivers, the FCC Chair said other applications were right behind: "For instance, if we are to tackle healthcare costs, high speed broadband video for remote examination, diagnosis and even surgery is important. If our students are to get a 21st Century education, high-speed broadband in the classroom is essential. And, increasingly, that high-speed will be in both directions."[3] Subsequently, the FCC concluded, in its 2015 Broadband Progress report, that in order to reflect an advanced telecommunication capability, actual download speeds of at least 25 Mbit/s and actual upload speeds of at least 3 Mbit/s were required. By comparison, the previous benchmark the FCC set in 2010 was 4 Mbit/s and 1 Mbit/s respectively.[4]

While all stakeholders are increasingly aware of the decisive role broadband plays, there is still an ever present question of what proportion of scarce resources should be allocated against other demands on those resources and the returns that can be expected. A key element of this question is the future demand for increased capacity relative to economic and social gains, but it is not always the case that the benefits of the investments will accrue to the local authority or the bodies that have deployed the networks. For this reason, this report highlights two case studies in relation to the use of high speed networks in Sweden and the early phase of national roll out of broadband in the United Kingdom, which has enabled a counterfactual analysis, comparing areas that had broadband with areas that did not have broadband. The experience in Sweden demonstrates that there is a possible correlation between deployment of fibre networks and decreased driving, that high speed broadband networks to some extent could substitute physical transport by cars by avoiding driving to get information, goods or services that can be obtained or ordered online, and that high speed networks could have a positive effect on employment. Meanwhile, the evidence from the United Kingdom indicates that there were differences in the returns to ICT investment due to differences in Internet speeds, and that greater ICT intensity is positively related to firm level productivity, and that there could be support for a causal relationship between ICT and productivity.

A growing body of research has shown that access to advanced broadband infrastructure has a positive effect on economic and social development, that it contributes to economic growth, creates opportunities for jobs and stimulates innovation (Box 1).[5] Consequently, issues regarding high speed broadband networks are of immense importance to policy makers, at central as well as regional levels.[6] Altogether, this raises questions on how to ensure the availability and access to high-speed broadband networks to all communities irrespective of their size and location, particularly in relation to the required investment and necessity for effective competitive choice (Box 7).

Broadband investment

The combination of growing demand, the willingness to pay for access at competitive prices and the emergence of an App-economy has driven broadband growth. This has laid the foundation for extensive private network investment. That being said, given that high speed networks require substantial investment, sometimes not met by the market, policy makers want to know what measures should be taken to ensure that all communities can be connected and what evidence is available to support the use of public funding or public involvement in deploying broadband infrastructure to augment private investment.

Consequently, most countries have developed "national broadband plans and digital agendas" with ambitious deployment targets for high speed networks, underscoring that electronic communication is critical for innovation and long-term competitiveness. These plans vary widely in OECD countries depending on factors such as inherited networks (e.g. if a cable network is widely available to provide competition to telecommunication networks), geography and population density, as well as the historical

role played by public and private provision of services at a national, regional or local level. This in turn leads to an assessment of who will invest and build networks and what approaches may stimulate action to meet these objectives.

For many OECD countries, competitive markets have delivered services that meet the needs of business and consumers. In those locations policy approaches have varied including infrastructure competition across different platforms (e.g. telecommunication versus cable) or through the use of regulatory tools such as unbundling to leverage existing facilities and to create an environment to attract market entry. It has, in some cases, consisted of schemes for public-private partnerships or specific incentives for network deployment. For other regions or locations, for whatever reason, the market may not have met the requirements of policy makers, business and consumers. For this reason, various levels of public authorities or utilities have taken action; from subsidising existing players to extend or enhance broadband coverage to, in some cases, re-entering the market often through regional and local initiatives by deploying high speed networks. This has, for some, been driven by a conviction that municipal networks represent a basic infrastructure for their communities, similar to other public utilities provided by local authorities in some locations, to support economic and social requirements, and that these networks should be provided on an open access basis to all service providers to ensure competitive choices in order to promote economic and social development. This implies that it has facilitated the development of new high speed networks, and opened the market for more competition. For those that are open, it has been a way to facilitate competition among service providers on equal terms.

While OECD countries are at different stages of development, depending on inherited infrastructure, population density and so forth, they are all witnessing deeper deployment of fibre networks to the premises or in the "last mile", in part because the technology is widely regarded as being "future proof". Moreover, fibre is critical to support greater use of wireless networks by connecting base station sites with backbone networks and to make existing local loop facilities, such as cable networks, more effective in meeting current requirements for digital services. It is for these reasons that most municipal networks are based on fibre rather than on other technologies, though this report also considers the use of complementary technologies leveraging these or other networks (e.g. municipal Wi-Fi) (Box 3 and 5).

Fibre investments and how to ensure competitive choices

As noted, the private sector is ramping up investment in deploying fibre networks in all countries when driven by competition and increased demand, whether as backbone networks to support their wireless businesses or to improve direct fixed access to their customers. Altogether, private investment has been the overwhelming source of finance for high speed networks in OECD countries. Public authorities in the OECD area have acted in various degrees to compliment these investments from national broadband schemes in countries such as Australia and New Zealand, to, in other countries, subsidies from governments to fill gaps in rural and remote areas where private financing had not been attracted based on an assessment of likely returns. Municipal authorities or utilities have played a key role in these developments by either initiating their own networks or attracting new entrants, such as Google's fibre projects in a growing number of cities in the United States. These developments show that such entry drives incumbents to increase their own investment as well as improving the quality and competitiveness of their services. In the United States, major providers such as AT&T and Comcast have announced new fibre projects to business and residents including in cities with municipal networks, such as Austin and Chattanooga.[7]

In Europe, incumbents are also rolling out fibre when driven by competition and responding to the increasing demand. To a greater extent than the United States, though, this is likely to increase as fixed or mobile players are taking the decision that they need to enter each other's markets if they have not already done so. Examples include BT purchasing a mobile company in the United Kingdom and Vodafone

purchasing cable companies in a number of European countries or partnering with existing utility companies. This raises the question of whether large cable companies in the United States will also seek to enter the wireless market, beyond their extensive Wi-Fi strategies, to match the full range of services offered by players such as AT&T and Verizon.

In Europe, Orange provides an example of a company that is an incumbent in France and a new entrant in many other markets for both fixed and wireless services. In April 2015, Orange announced that it aimed to provide 100% fibre deployment in nine French cities by the end of 2016.[8] The company said it plans to deploy fibre in 3600 communities by 2022, covering all of France's large and medium-sized cities, or nearly 60% of French households. The company added that for the remaining 40%, Orange is open to partnerships with local authorities to offer improved broadband using various technologies. In less dense areas where Orange is not planning to deploy its own FTTH network in the medium term, the company is hoping to develop a co-operative approach with local authorities including agreements with France's Auvergne and Brittany regions. The company says it is also open to collaboration with public-led projects, such as those in Laval (Mayenne) and Palaiseau.[9]

In both France and Spain competition is driving incumbents and new entrants to step up their investment in new infrastructure. A core part of the strategy is partnerships with local authorities or other players to share costs. Additionally in France, the regulatory framework for FTTH deployments outside very dense areas requires a wholesale offer. This offering enables the pooling of networks outside very dense areas, allowing end users to choose their service provider. It is open to all operators. Free (the Iliad Group), SFR and Bouygues Telecom make use of this offer from, for example, Orange.

In Spain where Orange is a new entrant the company announced in June 2012 that it would invest in fibre networks to reach around 1.5 million homes located in the main cities. Here the company is partnering with Vodafone Spain, to jointly invest almost USD 1300 million to roll out FTTH in the country. The objective is to connect three million homes, commercial premises and offices by 2015, increasing to six million by 2017, in over 50 cities in the Iberian Peninsula. Orange says agreement is also open to other operators. In September 2014, Orange said it had come to an agreement to buy Jazztel to compete with Spain's leader Telefonica and Vodafone.[10] Vodafone bought national cable operator Ono several months before Orange moved for Jazztel. In Spain the number of FTTH connections doubled between September 2013 and September 2014.[11] While Telefonica has the largest share of such connections, companies such as Orange are rolling out FTTH to increase competitive pressure.[12]

In Ireland, Vodafone has partnered with energy utility the Electricity Supply Board (ESB) to deploy fibre access network to 500 000 homes and businesses in 50 regional towns over the next three years using the utility's existing infrastructure.[13] Concurrently, Eircom is deploying fibre access network to initially 3000 homes in Cavan, with a further 15 towns targeted for a launch in the second half of 2015, followed by an expansion to 66 Irish towns in the coming years.[14] In 2012, the Irish Government announced a national broadband plan, with a target to provide broadband Internet of at least 30 Mbit/s to all citizens, and aims to reach 900 000 households with fibre. This is estimated to cost between USD 1030 and USD 2575 per family, meaning that the total investment could be up to USD 1280 million, but the sum has not yet been disclosed due to the state aid and tender process.[15]

Box 1. Effect of broadband on local economies – What works

In the United Kingdom, in October 2013, the What Works Centre for Local Economic Growth (WWG) was established to analyse policies that are most effective in supporting and increasing local economic growth.[16] It aims to provide evidence-based research for local decision makers for economic development and in 2015 published a review of studies on broadband. Based on a large sample of research the centre made a number of observations and conclusions on the causal effects of broadband on local economies.[17] The report highlighted the following findings:

- Broadband is a 'general purpose technology' that is likely to have social and environmental influences as well as economic effects. There is support to the claim that an increase in broadband penetration has a positive effect on GDP growth.
- Broadband has a positive effect on local economies, but the effects are likely to vary across types of firms, workers and areas, and may not be large in the aggregate. It may depend on complementary investments made by firms, such as training workers, reorganizing sales strategies or supply chains, and could also depend on in-migration, with an influx of new people as existing households may not be the biggest beneficiaries.
- Extending broadband to an area can affect firm productivity, number of businesses, and local labour market outcomes such as employment, income and wages. These effects, however, are not always positive, not necessarily large, and may depend on complementary investments made by firms, adoption by users, and work organisation.
- Broadband has different economic effects in different types of places, and it tends to be larger in urban areas compared to rural areas as broadband and ICT enable production complementarities, which are commonly available in urban areas.

The role of municipal networks

In Europe, the policy on fixed network regulation has, according to Cave (2014), switched from primarily concentrating on institutional unbundling with the 'ladder of investment" theory during the era of copper, to the promotion of investment in fibre.[18] Some have argued that there has been a lack of investment in next generation networks (NGA) in Europe, though the experience has differed across countries.[19] Moreover, while Japan and Korea are standouts in terms of the percentage of fibre connections for overall broadband in the OECD area, the next 14 countries are all European.[20] Notably, Sweden has the highest proportion of fibre connections outside Asia among OECD countries given the role municipal networks have played, underlying again the importance of competition to incumbent players in stimulating investment. Nonetheless, the examples of France, Ireland and Spain demonstrate that fibre developments are moving apace in countries with a lower proportion of FTTH in their broadband mix (Box 6). In addition, the strategy of a company such as Orange demonstrates that the private sector will look for municipal partners in areas where they do not see an immediate business case. In Germany, municipal networks, so called Stadtwerke, have been deployed in a number of cities, as for example in Bochum, Hamburg, Munich and Norderstedt.[21] Italy has strived to enhance co-ordinated action between central and local government in order to promote the development of high speed networks (Box 7). In Brazil, the city government of Rio is planning a state-wide public network covering 92 municipalities, expanding from the current network which connects public institutions, and schools in Rio.[22] In Costa Rica, a number of activities are being undertaken to promote broadband development (Box 4). Colombia has also consistently worked to promote broadband development (Box 9). Altogether, municipal networks are present in a number of countries, but represent a minor part of their overall broadband markets.

Cave and Martin (2010) have noted that following liberalisation and privatisation some believed that the telecommunication sector no longer needed to be reliant on public finances as the sector was prosperous and could fend for itself with direct access to capital markets (Box 2). In many ways, this is true especially given that, in earlier times, state owned monopolies were also a source of general revenue for governments instead of that capital being available for reinvestment in networks. The main challenge for operators came to be more that service competition reduced monopoly rents but did not necessarily

provide a driver for next generation network investment, absent of infrastructure competition. Countries that did not have competitive pressure from developments building on historical cable networks, the entry of municipal networks or the entry of a new player did not necessarily have an appropriate driver to prompt a dominant incumbent to invest in new infrastructure. That is why some national, regional or local governments have taken the decision to commit public investment either to provide a source of competitive pressure or because they believe the market will not deliver broadband infrastructure in a timely manner and to the extent necessary. Consequently, Cave and Martin (2010), underscore that some form of public funding may be necessary and appropriate in the absence of the market taking the lead.[23]

Municipal networks are one option to meet goals with the use of broadband in the absence of sufficient competition or when policies are pursued for reasons of equity that prevail upon weighing the (high) cost of rolling out infrastructure against assessed demand. In order to examine municipal networks this report addresses the following issues by drawing out evidence from selected case studies:

- What is the extent and role of municipal networks on broadband markets? What network technology do they use? Do municipal networks have an effect on other players in infrastructure markets and how these markets are organised?
- What business models do municipal networks use? How do they affect competition in services/application markets?
- How do the applied business models for municipal networks affect the availability and prices for communication services?[24]
- What are some observed social and economic effects associated with high speed networks/municipal networks?
- What lessons could be drawn from municipal networks for broadband policies?

In order to distinguish between different roles and functions in the sector, the report differentiates between physical infrastructure providers (PIP), which own and maintain the passive infrastructure; network providers (NP), which operate and typically own the active equipment; and service providers (SP), which deliver digital services.[25] The separation between the different layers identifies the roles that are required to provide retail services. The division between the basic infrastructure and services is also reinforced by the transition to all IP-networks, which facilitates a separation of the transport layer from the application layer, constituting a fundamental shift from the telephony network logic where the intelligence was an integrated part of the network to an IP-network logic where the intelligence is placed in devices at the edges.

Box 2. A view from academia

Gomez-Barroso and Feijo (2010) say that the discussion about the involvement and intervention of the public sector to the market is an attempt to redefine the relationship between the free operation of markets and public intervention in economic activity, and their relationship to each other in the telecommunication sector.[26] Regardless of the specific path followed by a country's telecommunication market, they say, governments are reappearing as influential players in the field by promoting or developing broadband expansion plans. Gómez-Barroso and Feijóo suggest that an acceptable justification for government intervention is a market condition, revealing that markets are not fully competitive.

Noam (2010) points out that the current phase of the communications market is characterised by scale economies, network effects, concentrated markets, with a growing significance of infrastructure and investments and therefore will lead to a larger role for the state.[27] In order to accomplish network upgrades, Noam underscores that various measures are required, such as for example, common-carrier-like access rules for content and applications, unbundling of network elements and wholesale; infrastructure sharing, break-up of networks into wholesale infrastructure and retail services, re-creation of government ownership, tax incentives and subsidies to rural areas and access to ducts, poles, and public rights of way, and a co-ordination of civil works construction.[28]

Both Gomez-Barroso and Feijo (2010) and Noam (2010) take the position that the public sector has an important role to play in the transition to high capacity broadband. Li (2012) made a critical study of the NBN project in Australia and questioned if the aim was to bring commercial returns on government investment by serving the country as a utility. Li argues the challenge would be to examine if it could be achieved in one undertaking; and if so, what the appropriate implementation measures would be but that, in any case, these issues should have been done before the commencement of the project.[29] Davidson and Santorelli (2014) evaluates the efficacy of Government-owned broadband networks and highlight that failed and failing GONs offer much needed perspective about the complexities and challenges associated with building and deploying advanced communications networks.[30] Troulos and Maglaris (2011) examine the literature about public sector in broadband development and highlight that among determinant factors are low demand an fairly important concern for municipal projects in both rural and urban settings, like for example Amsterdam's Citynet which experienced low penetration rates (less than 10%) after several years of operation. Moreover, Troulos and Maglaris underscores that motivation among the citizens is essential to succeed with the municipal network.[31]

State aid: the case of Europe

Although the treaty of the European Union has a general prohibition on state aid, as it could distort competition, undermine the internal market and potentially crowd out private investment, the legal framework allows for a number of policy objectives that make state aid compatible with the internal market. These can include, for example, deployment of high speed broadband networks in rural areas, investments by public actors on market terms, and for services of general economic interest. [32] The European Commission takes the position that state aid and structural funds can be used in areas that are not fully served by private investment in order to reach the targets of the Digital Agenda 2020.[33]

The European Commission distinguishes between three levels of coverage depending upon the potential availability of high capacity broadband networks. Areas that do not have any broadband coverage are defined as white, while areas where one broadband network is available are classified as grey, and areas with at least two broadband networks are categorised as black. A location such as a town could be labelled as white, and thereby compatible with state aid, provided that no market player intends to invest at that location within the following three years. In order to accomplish the geographical differentiation according to the European Union framework, member states have to survey the market in conjunction with a broadband coverage analysis, which should then be subject to public consultation.

The European Commission has cleared numerous cases involving state aid for the deployment of high speed networks in locations that are classified as white areas.[34] Examples include a broadband programme in the United Kingdom, which is briefly described later in this report, and in Portugal. In 2008, Portugal

published a digital agenda aiming to promote investments in Next Generation Networks (NGA) in rural areas.[35] After a public consultation the government identified targeted white areas, divided into five regions, and set the goal to reach 50% NGA coverage by 2013. The government conducted a public tender in order to select operators that would be prepared to build, operate and maintain fibre networks in these regions with the support of USD 147 million in state aid in combination with private investment.[36] The operators were recommended to use existing infrastructures from municipalities, utilities as well as the incumbent in order to reduce the deployment cost. The networks covering mainland of Portugal (North, Center and South) were completed in December 2013. The network covering Azores Islands was completed in 2014 and the one related to Madeira Islands has not yet started its implementation. All networks must guarantee open, equal and non-discriminatory wholesale access.

In the European Union, if a state, region, or municipality invests, directly or indirectly, for the disposal of an undertaking it is not necessarily regarded as state aid. This is because it could be eligible as an investment that is done under the so called Market Economy Investor Principle (MEIP), which has to be demonstrated thoroughly and comprehensively beforehand, either by means of a significant participation of private investors or the existence of a sound business plan showing an adequate return on investment, an example of this is the municipal network in Amsterdam, described in the case of the Netherlands (Annex I).[37] Investments in municipal networks can also be eligible as a service of general economic interest (SGEI).[38] An example of a SGEI is the scheme that the department of Hauts-de-Seine in France set up in 2005-2006. The deployment was supported by public funding of USD 82 million, in combination with the licensee also contributing with financing.[39] The concession holder is obliged to provide wholesale services, such as dark fibre, under objective and non-discriminatory conditions, and refrain from providing end consumer services.[40] The European Commission approved the project. The decision was appealed by a number of operators, subsequently rejected by the Court of Justice of the European Union (CJEU).[41]

Deployments of municipal networks in areas that previously did not have broadband networks, which benefit from state aid, are commonly obliged to provide wholesale access to interested service providers that could market their services to end customers for at least seven years.[42] This could be followed by decisions made by National Regulatory Authorities on obligations, depending upon how the regulatory framework with significant market power (SMP) is applied.[43]

Elsewhere in the OECD area

The United States is exploring whether there are steps that can be taken to empower localities to pursue creative, community-specific solutions to broadband deployment. The United States Congress appropriated funds for programmes that provide grants and loans for the construction and upgrade of broadband infrastructure. The Broadband Technology Opportunities Programme, administered by the National Telecommunications and Information Administration (Department of Commerce) benefited from such funds. It awarded competitive grants to public and private sector entities in 2009 and 2010 focusing on building middle mile infrastructure. It was also the case for, the Broadband Initiatives Programme, administered by the Rural Utilities Service (Department of Agriculture), which awarded grants and loans to public and private sector entities in 2010 for targeted last-mile infrastructure. This has facilitated the successful entry of a number of municipal broadband projects.[44]

Australia and New Zealand have both implemented extensive publicly financed broadband programmes, described in the country case studies later in this document (Annex I), and provide examples of policy makers choosing different approaches of involvement in the expansion of broadband networks, as did Singapore. Although the National Broadband Network (NBN) in Australia is not a municipal network the interest here is to explore how it interacts with municipals. This is because this report includes looking at the interaction of municipal networks with public and private networks.

Selected examples of the use of municipal networks

This report presents examples of regional high speed networks in eight OECD countries, though here placed in a national context, exhibiting different types of municipal networks, taking various approaches, and involving a range of actors and organisations (Annex I). Their analysis shows that there are noticeable effects on social and economic developments in all these locations.

In order to examine the characteristics of the cases, this report uses the framework presented in the European Commission's broadband guide, which makes a distinction between passive infrastructure (ducts, cables, premises) and active equipment components used to implement the technology (routers and switches, control and management servers). Together these components establish a platform on which services can be delivered.[45] The framework consists of four constructs, where the first, the infrastructure type, concerns the type of network technology used; the second, the investment model, shows the role municipality/utility plays for the investment, implementation, operation, ownership and management of a municipal network; the third, the business model, displays the network model used, whether open access or vertically integrated; and the fourth, the finance tools, show the financing model used.

The type of network technology that is used in municipal networks varies. Although fibre based networks are commonly used in municipal fixed networks, such as fibre to the building (FTTB), or fibre to the home (FTTH), other options are also available, including fibre to the node (VDSL), or cable networks with Hybrid Fibre Coax (HFC). A further distinction for fibre networks is, whether it is a passive optical network (PON), where a fibre connects several end users, or a point-to-point network, with a unique fibre connection to every end customer.

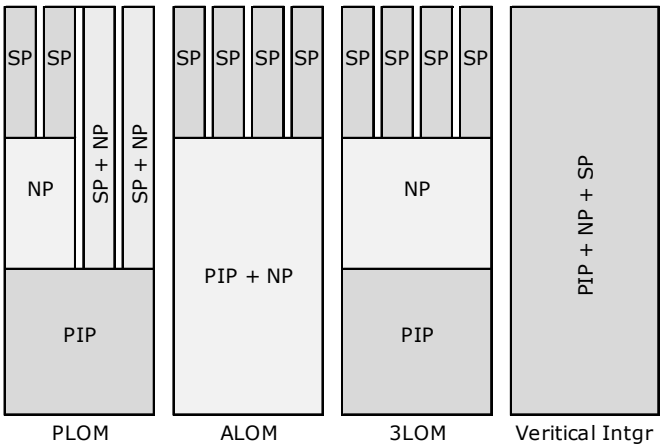
There is a wide range of possible investment models for the deployment of municipal networks. They can, by way of example, be direct investment in a publicly-run high speed network or a public private partnership, or indirect investments in a privately-run high speed network through public outsourcing or a concession agreement. Community investment is another option where local residents, businesses and municipality subsidise a network through gap funding. It could also be private design built and operated, where a municipality or state funds a company or organisation to operate a network.

The business model sets the roles for the involved players in a municipal network and the broadband guide suggests there are three such roles. A physical infrastructure provider (PIP) owns and maintains the passive infrastructure; a network provider (NP) operates and commonly owns the active equipment; and a service provider (SP) delivers digital services. In addition, applications can be provided 'over the top'. The degree of network openness depends on the prevailing business model. If a player fulfils all the roles it becomes a vertically integrated operator, while if the roles are performed by different entities it facilitates an open network, potentially available to all interested parties on non-discriminatory conditions (Figure 1). There are a number of possible combinations, where the most commonly used are:[46]

- Passive-layer open model (PLOM): an entity builds and operates the passive infrastructure, which is available to all market actors under fair and non-discriminatory conditions.
- Active-layer open model (ALOM): an entity deploys and operates the passive and active layer, placing active equipment in all access nodes and builds an open, operator neutral network over which all service providers can deliver their services to end users. [47]
- Vertically integrated model (Vertical Intgr): the operator combines all the three roles: physical infrastructure provider (PIP), network provider (NP) and service provider (SP).
- Three-layer open model (3LOM): the roles of physical infrastructure provider (PIP), network provider (NP) and service provider (SP) are separated. The municipality provides the physical

infrastructure, but the network provider role could be assigned to one company that provides open, operator neutral network over which all service providers can provide their services.

Figure 1. Three models for open access for municipal networks and a vertical integrated model



Source: Based on European Commission Guide to High-Speed Broadband Investment and Forzati. M., and C. Mattsson (2015)[48]

The key characteristics of the different cases can be categorised in a framework (Table 1). This includes information about the involved municipalities and companies, type of infrastructure and the type of investment and business models used.

Table 1. Country cases with municipal fixed networks

Country	Short characteristics	Municipality, companies	Infrastructure type	Investment model	Business model
Australia	Public private company, local networks	Australian Capital Territory TransACT	VDSL2, FTTN, FTTB, HFC	Direct investment	ALOM
Denmark	Utility deploys a municipal network	Vejen, SydEnergi	FTTH/FTTB	Direct investment	VI
Japan	Community led deployment of a municipal network	Kamiyama	FTTH	Direct investment	VI
Netherlands	Municipality driven development of networks	Local infrastructure	FTTH/FTTB	Direct investment, indirect	PLOM
New Zealand	Utility deploys a municipal network	Northland, Northpower Fibre	FTTH	Direct investment, indirect	ALOM
Sweden	Municipality deploys municipal network	Stockholm, Stokab Hudiksvall, Fiberstaden	FTTH/FTTB	Direct investment	PLOM ALOM 3LOM
United Kingdom	Municipality outsourced network, and state aid	Peterboroug, CityFibre	FTTN, VDSL2, FTTH/FTTB	Indirect, operator subsidy	PLOM
United States	Utility deploys a municipal network	Chattanooga, Electric Power Board	FTTH	Direct investment	VI

The driver for investment in the different cases varies from being initiatives taken by municipalities, utilities, policy makers, co-operatives, private actors, or being a push from users. A selection of different actors can be highlighted together with their motivation for investment (Table 2).

Table 2. The different cases and about the investments

Country	Information about the investments
Australia, TransACT, Australian Capital Territory (ACT)	Prior to iiNet acquiring the company it was partly owned by the main energy and water utility in the Australian Capital Territory, and had the aim to deploy high speed broadband in ACT.
Denmark, SydEnergi, Vejen	SydEnergi, a regional utility owned by a co-operative, expanded into broadband after the liberalisation of the electricity market in Denmark. This released capital funds and paved the way for the deployment of a broadband network. The investments have been financed through internal capital, and debt. The entry into the broadband market has been encouraged by an active municipality with an ambitious broadband plan.
Japan, Kamiyama	Municipal network deployed with financial support from the prefecture, and the national government. The network is said to have been instrumental in making the town more attractive.
Netherlands, Amsterdam and other localities	Public investments in a commercial city network as well as in municipality owned cable-television networks. Municipals say they are interested in broadband expansion, with an aim of making these cities more attractive and to stimulate economic growth.
New Zealand, Northpower Fibre, Northland,	The regional utility expanded into broadband and deployed a high speed network in the north region of the country financed with internal capital, debt and state aid.
Sweden, Stokab, Stockholm; Fiberstaden, Hudiksvall	Owned by the city of Stockholm with the aim to deploy an open fibre network in Stockholm, investment financed with internal capital and debt.
United Kingdom, CityFibre, Peterborough	Private investment which has been embraced by the local council, and triggered by a market opportunity to establish an open fibre network that could capitalise on growing demand from public, private and business users.
United States Electric Power Board, Chattanooga	Regional utility that expanded into broadband and financed through internal capital, debt and state subsidy for a smart grid network.

While there is, for the most part, a reliance on private investment to develop broadband networks in OECD countries, public investment is occurring where this has not met objectives. Both Australia and New Zealand, by way of examples, decided to alter their policies and provide support for the deployment of high speed broadband networks. If public intervention has taken place, with state aid, there is commonly an obligation for these networks to provide open access. This is also the case for some of the municipal networks covered in this report. TransACT, Australia, was obliged to provide a reference offer for a wholesale interconnection service and supply it to access seekers on reasonable request. Northpower Fibre, New Zealand, is obliged to provide wholesale access and is restricted from providing retail services. Stokab, Sweden is only providing dark fibre to Internet Service Providers, mobile network operators and other interested parties. The telecommunication law in the Netherlands has no restrictions on municipalities to invest in public electronic communication networks given that these networks would not be feasible without the involvement of municipalities. Following the enactment into law of the United States Telecommunications Act of 1996, the Chattanooga owned agency made the decision to begin providing communication services.

In order to facilitate access to existing infrastructure, like ducts, conduits, and in-house wiring, the European Commission has published a directive which should be transposed into national law before the end of 2016. The directive makes it mandatory, given certain conditions, for utilities, transport, and operators to provide access to ducts and other passive infrastructure which could be used for deployment of high speed networks.[49] The aim is to enhance co-ordination between construction projects, improving

information sharing in order to facilitate more cost efficient deployment of high speed broadband networks. Moreover, all new buildings, and those undergoing major renovations after 2016 should be equipped with in house wiring.

Experience shows that some municipal networks have been very successful and others less so, while meeting different challenges. Some of the key factors in selected projects can be highlighted (Table 3). Municipal networks are by far from being always financially successful, irrespective of whatever other benefits they bring to a community via improved broadband. Prior to its sale, for example, the commercial future of TransACT, Australia, was said by some to be under a cloud. An important consideration is that commercial and technological changes occur following the entry of a new municipal broadband network, including the responses from other players, which can lead to more competition. In the case of TransACT, the new owners took the decision to cease building its own infrastructure and rely more on the incumbent's wholesale ADSL product.

Table 3. Selected case experience with municipal networks

Case from Countries in this report	Challenges such as overbuilding existing private sector networks and sustainability	Selected factors such as role of local champions, lead users	Outcome
Australia	To expand an open access network based on collaboration with a number of Internet Service Providers.	Instrumental in expanding broadband networks in the ACT with the support of an existing utility.	Faced increasing competition from the incumbent and was subsequently acquired by a competitive ISP.
Denmark	Initially slow demand for high speed broadband services, but this increased over time in accordance with the deployment of the network and development of more effective sales, marketing and distribution.	Established a solid presence in the region, capitalised on a regional broadband agenda, contributed to local and regional development.	Has become a significant player in the broadband market, contributing to increased availability of broadband and facilitated for the municipality Vejen to reach digital agenda targets.
Japan	To facilitate deployment of high speed broadband networks in an area where private operators had been reluctant to invest.	Fruitful collaboration between the public and private sector in combination with additional initiatives made by the municipality led to a positive development.	The high speed network has offset population decline and is said to have revitalised the city of Kamiyama.
Netherlands	Initially difficult to find service providers to operate the housing corporations' open networks and to build up demand.	Through a combination of demand aggregation, up-front payment from customers for (part) of their connection, municipal financial guarantees, provincial subsidies and other measures the broadband networks have grown.	Facilitated infrastructure investments. Consolidation of the market has enabled KPN to strengthen its position.
New Zealand	To facilitate a deployment of high speed networks in the northern region of the country, where the market had been reluctant to invest.	Accomplished an open network that facilitated a dynamic ISP retail market.	Increased availability of high speed broadband services, successful private public partnership.
Sweden	Early deployment of a basic fibre infrastructure network that developed over time. Challenges in the management of the responsibility areas, such as in fault management and first line support, between the service providers and	Open network provides access to dark fibre, facilitating ISPs, mobile operators to invest and provide end customer services.	Extensive availability of high speed broadband networks with a dynamic ISP market.

	network providers.		
United Kingdom	The regional broadband plan was more ambitious than the national plan.	Fruitful collaboration between the municipality and a small operator that capitalised on the demand for high speed broadband services.	Competing infrastructure, improved availability of high speed broadband services.
United States	Deploy broadband network and services, complement existing power services, interact with customers, and become an ISP.	Instrumental in making advanced telecommunication services available to business and residential customers.	Expanded coverage of high speed broadband network, supporting positive developments in Chattanooga.

This report describes a number of examples of municipal networks with involvement of the public sector, including municipalities, utilities, co-operatives, as well as private companies, providing advanced broadband services to end customers, businesses and the public sector. Although conditions, circumstances and outcomes vary between the different cases it is possible to make some generalizations of the effects and lessons learned, such as by way of examples that:

- Municipal networks have in a range of ways contributed to the development of cities and regions by expanding the availability of advanced telecommunication services.

- The public sector can be a lead user of high speed networks and thereby facilitate delivery of improved broadband services, to locations such as schools and medical centres.

- Local and regional broadband strategies and plans can play a significant role in promoting the development and availability of advanced communications services.

- Public initiatives and investment can complement private investment, and collaboration between the public and private sector can be fruitful.

- Open networks can facilitate a dynamic ISP retail market but can involve monopoly power in the provision of infrastructure.

- Substantial risks are involved in the deployment of high speed networks which require that the appropriate competence are in place, with organisational as well as financial capabilities in order to manage complex broadband infrastructure projects.

The establishment of municipal networks is dependent upon a number of national and local circumstances, and they are often seen by public authorities as an extension of their role in providing other utility infrastructures for their residents and local businesses. Successful municipal networks can provide users with access to high capacity broadband services, provide users with more choices, contribute to competition and lower prices for consumers. Indeed, as might be expected, municipal networks with more ISPs frequently provide lower retail prices for users. The way municipal networks are structured varies across different countries, and for those that strive to establish open networks where retail ISPs can compete on equal terms, it is one way to establish a competitive market for services.

BROADBAND, ICT AND FIRM PRODUCTIVITY IN THE UNITED KINGDOM

ICT relates to firm productivity

A key question asked by authorities, at any level of government, when asked for support for broadband infrastructure through public funding is the expected benefits. For municipal authorities this question is specific to their location in the sense that they wish to know what will be the likely effects on attracting new business activities with the attendant jobs and opportunities they will bring.

In the last three decades empirical research has provided substantial evidence that a positive relationship exists between information technology (IT) and productivity. Empirical evidence, for example, suggests that Information Communication Technologies (ICT) leads to reduced production time, increased innovation and specialisation, improved accuracy, and has enabled firms to replicate processes faster and lead to increased productivity dispersion.[50] This has meant some types of jobs, that employ certain types of skills, have benefitted and others have experienced declining demand. Likewise, some businesses organised in particular ways, which utilise these new technologies, have thrived whereas others have reduced their activities as a consequence of changing demand or have exited the market.

The question remains, however, as to whether enhanced management, education and entrepreneurial ability, are the drivers of change and ICT plays only a passive role, or if ICTs enable firms to do things that they did not originally anticipate or were constrained from undertaking due to an insufficient access to broadband, including attracting individuals and firms able to leverage its benefits. Isolating the effect of ICT from other influences can be achieved through a variety of methods, which collectively could be seen as the equivalent of randomly allocating ICT technologies to firms and seeing what happens compared to those who were not given the technologies. For this document an empirical analysis was undertaken to look at the effects on firms with and without access to broadband.

By exploiting a particular situation where ICT was randomly allocated to firms in the United Kingdom, the work described here examines the extent to which a causal relationship exists between ICT and firm productivity. This analysis uses the roll-out of ADSL broadband across the United Kingdom at the turn of the 21st century as an instrument for ICT intensity. During this time period, the main options for Internet access for the majority of locations in the United Kingdom were narrowband (dial-up) and the first wider availability of ADSL broadband.[51]

The key differences between the two technologies, under consideration here, was their speeds to connect to the Internet. At the time, ADSL provided connection speeds up to 8 Mbit/s whereas dial-up offered speeds up to 64 Kbit/s. Both technologies utilise the public switched telecommunication network, where firms and households are connected to a predetermined technology exchange, which acts as a hub between the fibre optics spine and users. Given the large number of telecommunication exchanges in the United Kingdom (5 630) and the limited supply of BT engineers, ADSL was not rolled out simultaneously. Therefore, businesses in certain areas had access to a superior communication technology earlier than firms elsewhere, making it possible to examine their performance in relation to firms without broadband.

The results, documented here, demonstrate that across firms in the United Kingdom there were differences in the returns to ICT investment due to the substantial differences in Internet speeds. The results from this work suggest that greater ICT intensity is positively related to firm level productivity. In

addition, an instrument variable approach provides preliminary evidence of a causal relationship between ICT and productivity. ADSL enablement is associated with greater ICT intensity of firms, which positively and significantly impacts labour productivity. These results represent the first steps to understanding how ICT has shaped the performance and behaviours of United Kingdom firms. More detailed explanation regarding the data used, the empirical strategy employed and the results obtained are available (Annex II).

Summing up the ICT and productivity analysis

This analysis provides some empirical evidence regarding a causal relationship between ICT and labour productivity. The work relies on standard OLS and an instrument variable approach, using the rollout of ADSL broadband an instrument for ICT intensity. The OLS results are consistent with empirical predictions of a positive and significant relationship between IT and productivity. For the IV estimation, ADSL enablement leads to an increase in ICT intensity, which positively and significantly influences firm productivity. The results therefore suggest that the availability of ADSL broadband incentivises IT upgrading thereby increasing productivity.

The empirical strategy and instrument appears to be theoretically robust given the characteristics of the technology and the nature of the enablement. The instrument is also statistically robust with strong first stage results, exhibiting the expected positive sign and F statistics above or at the threshold of the cut-off, suggesting that the instrument is adequately strong. However, given that this analysis only employs one instrument it is not possible to test for the possible endogeneity of the instruments.. However, these results provide preliminary evidence regarding the complementary effects of broadband and ICT adding a piece of insight of the significance of ICT and broadband for economic growth.

IMPLICATIONS OF BROADBAND FOR A LOCAL ECONOMY AND THE ENVIRONMENT: AN ECONOMETRIC ANALYSIS FOR SWEDEN

High speed broadband and fibre networks

This section presents econometric work on the effects of fibre networks in the 290 municipalities in Sweden. The aim is to quantify the effectiveness of increased broadband penetration and analyse socio-economic effects of fibre networks in these municipalities. Municipality initiatives in Sweden have been particularly numerous and ambitious in the deployment of high speed broadband networks, and are in general seen as a major driver for investment in broadband networks, especially in rural areas, where existing infrastructure is of poorer quality and where the interest of commercial operators to deploy high speed broadband networks is generally low. There are different alternatives for the upgrade of telecommunication networks to deliver high speed broadband services (e.g. above 25 Mbps): upgrade of existing copper access lines (typically twisted pairs telephone cables, or television coaxial cables), the deployment of next generation radio networks (WIMAX or 4G/LTE), or the deployment of new wired infrastructure – typically optical fibre cables – to the end user. The latter solution is referred to as fibre-to-the-home (FTTH) when the fibre reaches single households, and fibre-to-the-building (FTTB) when the fibre reaches, by way of example, a multi-dwelling building basement or ground floor, to which broadband traffic is handed over to the property network (typically a CAT5/6 copper network owned by the property), altogether referred to as fibre networks here. Although the deployment of new infrastructure requires substantial investments, most municipalities in Sweden chose to deploy fibre networks. This is because it is

widely considered as future proof. The physical properties of optical fibre allow symmetric speeds and transmission rates that are several orders of magnitude in advance of other options.

Effects of fibre networks

A large number of published studies analyse the effects of broadband in general. Broadband is linked to increased GDP and growth in, for example, Fornefeld *et al.* (2008) and Koutroumpis (2009)[52]; while Van Ark *et al.* link broadband to productivity.[53] The relationship between broadband and employment is, for example, analysed in Katz *et al*. (2009) and Majumdar (2008)[54]; while the relation between broadband and international trade is addressed by Forzati and Larsen (2008)[55]. A conclusion that is possible to draw from these studies is that the effectiveness of broadband investments depends on IT maturity, and countries that invest in more than just infrastructure, such as education, benefit more from broadband compared to those who invest less in supporting infrastructure.

There is an ongoing debate among scholars and policy makers, for example in Kenny and Kenny (2011), Gruber *et al*. (2014), Rohman and Bohlin (2012), Teppayayon and Bohlin (2011), regarding the merits of high speed networks and whether the benefits claimed for fibre infrastructure can be achieved by other forms of network elements for the final access connections (e.g. existing copper local loops or wireless technologies) to business and residential premises.[56] While most generally believe that deploying fibre closer to these premises is beneficial, there are differences over timing and whether the benefits outweigh the costs. As a result, there is a great deal of interest in the question of whether it is possible to identify specific economic and social effects of fibre access networks.

Three examples of studies that have investigated the effects of fibre networks are Ovum (2009), Ida and Horiguchi (2008), and Felton (2010), but they primarily use qualitative approaches.[57] Given that there is a scarcity of econometric studies that analyse the economic and social effects of fibre access networks, the work here endeavours to further inform this issue. The few econometric studies on the effects of fibre access networks is not surprising given that they have only recently started to be widely deployed and there has been limited availability of data. However, Sweden is an exception with a high availability of fibre networks, a large and rapidly growing user base, as well as available economic and social indicators together with data at national and municipal levels. This report looks for the most part at the effects of fibre broadband networks and reaches no conclusions on whether any of those benefits are exclusively attainable with fibre networks and not with other types of broadband infrastructure.

Analysis and results

The regression analysis of the 290 municipalities has been based on data for a 3-year period from 2010 to 2012, due to the availability of consistent statistical data. In total, 870 sample data sets have been used in the regression analysis. In addition to fibre penetration, other parameters were included as control variables, while other parameters were examined in the regression, but showed no statistical correlation with the socio-economic variables under examination e.g. tax rate, average yearly income per person, population age distribution, share of foreigners and immigrants. Some of these factors are indeed correlated with employment (defined as the ratio of number of people in gainful employment to total population), for example, and population evolution. This means their potential impact may be captured by those factors (and indeed, removing a significant control variable sometimes leads to another variable reducing its significance). The work here also controlled for potential multicollinearity among the independent variables by regressing each independent variable against each other (see Annex III).

The analysis shows that the presence of fibre networks is positively correlated with a number of socio-economic factors, which indicates that, when controlling for the relevant variables, a 10% higher fibre penetration is correlated with:

- Reduced car use of 135 km per year and inhabitant (250 km for highly urbanised municipalities)
- 1.1% higher employment (1.7% for highly urbanised municipalities)
- Increased business creation by one additional company per 12000 inhabitants per year

Effects of fibre networks on car use (average driving distance per inhabitant per year

One of the frequently mentioned benefits of fibre based broadband is that the high quality of the connections allows for a number of operations to be done remotely, hence reducing the need for physical transport. Online shopping is one example, but the service that is expected to have a more far reaching effect is teleworking. This work aims at assessing whether and to what degree this effect has materialised. The work here ran regression analysis across the 290 municipalities over the 3-year period and controlled for a number of parameters. Several variables have been tested, and it was found that three variables are statistically significant (for the two-tailed 95% confidence interval): urbanisation level (negative correlation, unsurprisingly: urban areas are better served by public transport), population evolution (growth over the past 10 years, negative correlation, and probably backward causality: driving is increasingly seen as necessary but unpleasant, hence places requiring less driving are seen as more attractive), and employment ratio (positive correlation, again unsurprisingly: people with a job typically need to drive more than people without a job). Other parameters that were considered in the regression model but were found statistically insignificant were income tax rate, average yearly income per person, population age distribution, share of foreigners and immigrants. Some of these factors are correlated with employment and population evolution so their potential effects may be captured by those factors (and indeed, removing a significant control variable sometimes leads to another variable becoming less significant). The analysis shows that on average a 10% higher fibre penetration is correlated with a lower drive distance of 135 km per year and inhabitant, given that all the other significant factors remain unchanged.

Effect of fibre networks on car use for different urbanisation levels

Of the three control variables, the urbanisation level had a very strong and statistical effect on the average driven distance: a 10% higher urbanisation level is correlated with a reduced driven distance of 417 km per year and inhabitant (Table 10). Consequently, it is reasonable to examine the effect of fibre penetration on driven distance for three separate cases, each with different urbanisation levels. The following three intervals of urbanisation levels have been used:

- Low urbanisation level: $61 \leq$ urbanisation level < 72
- Medium urbanisation level: $73 \leq$ urbanisation level < 84
- High urbanisation level: $85 \leq$ urbanisation level < 93

Low *urbanisation level:* The regression analysis showed that the fibre penetration has a smaller effect on driven distance as compared to the general average case, a 10% higher fibre penetration is correlated with a lower driven distance of 65 km per year and inhabitant, given that all the other significant factors remain unchanged (Table 11).

Medium urbanisation level: The regression analysis show that at a medium urbanisation level the influence of fibre penetration on average driven distance is insignificant. The R^2 value also dropped dramatically compared to the general case (Table 12).

High *urbanisation level*: The regression show that at a high urbanisation level the effect of fibre penetration increase dramatically: a 10% higher fibre penetration is correlated with a lower driven distance of 250 km per year and inhabitant, given that all the other significant factors remain unchanged. The R^2 value is over 0.7 indicating that at high urbanisation level the model explains a substantial share of the variation (Table 13).

The results may seem surprising; it might be expected that municipalities with a low urbanisation level have most to gain from teleworking, because distances are on average longer, and public transport is less well developed. On the other hand, highly urbanised municipalities tend to have more jobs in the service sector, which probably makes it easier to work from home a few days a week. The net effect will be a combination of the two effects: more jobs in the service sector means more commute trips which can be avoided, but lower urbanisation means that more of such saved trips are normally made by car, and over longer distance. The results of the regression analysis seem to suggest that, at present, having a high proportion of jobs in the service sector is more effective in leveraging fibre networks to reduce car usage than having long distances and poor public transport. Given that the effect of fibre availability is not measureable in municipalities with medium levels of urbanisation, this can possibly be explained by the fact that the number of jobs in the services sector is low, while public transport still represents a large share of commuting.

Effect of fibre networks on employment: average

An anticipated benefit of fibre networks is that they will increase a municipality's economic attractiveness, lead to the establishment of more companies (or the decision of existing ones to stay), and increase the efficiency of the labour market, thanks to virtual labour mobility (another effect of teleworking). All this is expected to have an effect on employment and business creation. The work here initially set out to measure the effect on employment.

The regression analysis showed that on average 10% higher fibre penetration is correlated with a 1.1% higher employment rate, given other significant factors remained unchanged (Table 14). Control variables that showed statistical significance (for the two-tailed 95% confidence interval) were urbanisation level, population evolution, income, education level and business creation. Education level is defined as the proportion of the population with a secondary education degree. Other parameters that were considered in the regression model but were found statistically insignificant were income tax rate (the differences are generally very small and tend to affect housing prices), population age distribution, share of foreigners and immigrants. Again, some of these factors are indeed correlated with other control variables, so their potential impact may be captured by those factors.

Effect of fibre networks on employment for different urbanisation levels

It is relevant to analyse whether highly urbanised municipalities benefit more than rural ones in terms of employment due to the deployment of fibre networks. Regression analysis was conducted for the three urbanisation levels and found that 10% higher fibre penetration is correlated with:

- 1.1% higher employment rate (R^2 value at 0.17, Table 15) for the low urbanisation level,
- 0.7% higher employment rate (Table 16) for the medium urbanisation level,
- 1.7% higher employment rate; moreover the model has a R^2 value of 0.57(Table 17) for the high urbanisation level.

It is notable that, even when it comes to employment, highly urbanised municipalities benefit the most from fibre broadband, which could be explained with the higher proportion, in urban areas, of jobs within the ICT and service sector, for which an excellent electronic communication infrastructure is critical.

Municipalities with low or medium level of urbanisation seem to benefit less from fibre broadband networks. It is noteworthy that, among those two groups, employment in low urbanisation (rural) municipalities is unaffected by education level (Table 16), but it nonetheless benefits more from fibre broadband than medium urbanised (semi-rural) ones. Regarding the observation on education level, a possible explanation could be that most jobs in low urbanised areas require less qualified labour. The fact that fibre broadband shows a higher effect on employment in rural municipalities may be explained by the fact that rural areas often lack alternative broadband infrastructure. In other words, higher fibre penetration in rural municipalities means higher broadband penetration, while in semi-rural municipalities it generally means better quality broadband.

Business creation (new company registrations)

There is an assumption that business creation is expected to benefit from fibre networks. The analysis here showed that a 10% higher fibre penetration is correlated with 0.08 more company registrations per 1000 inhabitants per year. In other words, one additional company registration per year per 12 000 inhabitants, when controlling for other significant factors. However, the regression analysis did not reveal different behaviours for different urbanisation levels (Table 18/19), rather urbanisation is negatively correlated with business creation, meaning that rural areas tend to have more company registrations per capita than urban areas. This may be explained by the fact that rural areas are characterised by smaller businesses than urban areas (large companies tending to cluster in larger cities).

Effectiveness of municipal initiatives in increasing fibre penetration

In analysis here, the explained variable is fibre penetration, and the explanatory variable of interest is municipal fibre network engagement. To identify a proxy for that, this work follows a two-step procedure. It starts from municipalities with a municipal fibre network. Out of those, the networks that are members of the Swedish Local Fibre Alliance (Svenska Stadsnätsföreningen, SSNf) are selected as "active". Hence, a regression parameter (an "active" flag) is defined, which takes the value of 1 for municipalities covered by an SSNF member network, and a value of 0 otherwise. In doing this, 141 out of 290 municipalities are identified, according to the latest SSNF figures (2014).

The work performs a regression analysis (details in Annex III) of the fibre penetration using municipal fibre network engagement (the "active" flag) as an explanatory variable and a number of control variables. The work conducts different regressions, testing different control variables, and control variables that show significant correlation with fibre penetration are urbanisation level, population trend (population increase over the past ten years), income per capita, and education (specifically the proportion of people with an undergraduate degree). Other factors showed correlation in some configurations, such as employment, but their effects were better captured by other factors, to which they were partly correlated. The regression results show that active municipalities, measured as those having a municipal network member of SSNF, show a higher fibre penetration level. Specifically active municipalities have a 6.1% higher fibre penetration levels as compared to other municipalities (Table 20 in Annex III).

A note on causality

Altogether, it is important to underline that the regression analysis presented in this work only proves correlation between fibre penetration and a number of socio-economic factors, and does not claim to verify the causality between increased fibre penetration and the socio-economic variables presented here. In

general, correlation could mean that (1) fibre networks cause positive socio-economic developments, but it could also be that (2) a positive socio-economic development leads to fibre network deployment. For car use, it is probable to rule this out as unlikely. For employment and business creation, backward causality cannot be safely excluded. Even so, this would indicate that new businesses see a value in fibre based broadband, which is a valuable measurement of the socio-economic benefits of fibre networks. Moreover, there could be other factors not accounted for in the model that effect both fibre penetration and the outcome variable. For all three outcome varibles (car use, employment and business creation), it could be that (3), similar public policies in a municipality lead to fibre network deployments and, independently, to positive socio-economic developments. If this is the case it could be argued that fibre developments are the result of policies that tend to lead to positive socio-economic developments in general and take that as a general indication that fibre networks seem to be part of good public policy. In conclusion, although it is challenging to verify the causality of the different correlations, this econometric analysis indicates a number of relevant, notable and important economic and social developments related to the high availability of fibre access networks.

FINDINGS

The analysis of the case studies demonstrates that in a large number of OECD countries, municipal networks play an important role in the provision of broadband access. These initiatives provide people, public organisations and businesses with access to high speed networks that may not have been otherwise provided or not in a timely manner. The authorities or bodies that developed these networks point to them facilitating opportunities for economic development for towns, cities and regions, as well as being more attractive places to live and work.

An important factor underlying the deployment of municipal networks is that public authorities regard them as a way to provide and improve public and social services for their citizens, and improve the availability of information and communication. Moreover, they also extend the ability for schools to communicate and enhance education, and more broadly enable more cost efficient internal communication. They also facilitate economic growth and development of new jobs and strengthen the competitiveness of businesses located in their towns and regions. There is also a desire to use municipal networks to provide more accessible health care services in combination with cost efficient solutions, and to safeguard access to basic infrastructure and enable development of high capacity services. Some of the municipal networks have been formed to open the market to retail ISPs to compete on equal terms and to provide competitive prices.

Although the establishment of municipal networks is dependent on a number of local and national circumstances with financial capabilities, they are often seen by public authorities as an extension of their role in providing other utility infrastructures for their residents and local businesses. Successful municipal networks can provide users with access to high capacity broadband services, provide users with more choices, contribute to competition and lower prices for consumers. Indeed, as might be expected, municipal networks with more ISPs provide lower retail prices for users. The way municipal networks are structured varies across different countries, and for those that strive to establish open networks where ISPs can compete on equal terms, it is one way to establish a competitive market for services.

Municipal networks constitute large infrastructure projects and are, therefore, associated with potential risks. Relevant competence is required as well as experience based on the efficient provision of

other utility services. At the same time, in the absence of competition any municipal network may have monopoly power over infrastructure (i.e. wholesale charges to the ISPs that provide retails services) or, if they are an integrated provider, for their direct customers.

Given the large undertaking that deployment of broadband networks represents, a combination of both private and public capital is sometimes required, particularly where commercial players have assessed that there is insufficient demand for them to invest. Experience generally indicates that municipal networks stimulate further investment. Sometimes this is in the form of retail ISPs, which leverage the underlying network infrastructure, or of mobile providers taking advantage of a municipal network's fibre as backhaul. In other cases, there is evidence of private players increasing investment driven by the competition provided by municipal networks in areas where a single incumbent operator would not have generated sufficient competition. A further important point is that experience shows that people, such as in rural towns, are often prepared to get involved and contribute with voluntary work in order to establish networks. This occurs when communities or co-operatives contribute with time and money if no other solutions are available.

The analysis gives further support to the assumption that broadband speed matters and that high speed broadband networks generate positive benefits, contribute to economic growth, as well as make firms more productive. It is also possible to argue that high speed broadband networks can substitute for some types of transport and that they contribute to the creation of employment opportunities. Given the increased share of the elderly in OECD countries it is also possible to use high speed networks to provide more cost efficient home care services. When these networks are in place they could potentially make a substantial contribution to lowering costs. However, this could be influenced by factors such as budget allocation, charges between different administrations and even tax issues.

The examples of municipal networks in OECD countries examined in the report show that, under the right circumstances, they have a role to play in the development of new broadband networks to cope with the continuously growing demand for higher capacity and in meeting policy objectives.

The technology shift to all IP-networks means that operators of the future will likely look very different from traditional telecommunication operators. The latter are currently seeing a decrease in demand for services that are priced along traditional or premium lines, as customers shift to IP based services. This means that while historical operators are facing demands to reduce costs and increase investment, the foundations of their business are fundamentally changing. In some cases, competition will drive these players to transform themselves and meet market demand. There is plenty of evidence in many OECD countries that they are making that shift. In other cases, however, municipal networks are an option to provide unmet demand and are almost inevitably going to be seen by some as providing a potential competitive advantage for businesses and residents of those locations. That being the case, policy makers need to ensure that there are no regulatory barriers to municipal networks, while at the same time ensuring that they compete fairly with the private sector, by for example making it possible for private operators to get access to existing ducts, purchase dark fibre and bid on public services.

In many OECD countries, policy makers face a number of challenges related to developing broadband across all regions and locations to ensure that all people can participate in the digital economy and meet societal objectives such as democratic participation and delivery of social services. This raises the question of the degree to which public funds should be used to fund broadband infrastructure. One advantage of municipal networks is that local communities take these decisions. Nonetheless, there are always competing demands on available resources for government at a local or national level. This means it is critical to first see if private capital can be used, driven by competition, and to examine public and private partnerships, or if motivated for additional financing from the state to support municipal initiatives. It is

also essential that if public funds are used they are leveraged to increase competitive choice for business and consumers and do not create different forms of monopoly power.

A possible approach is to combine public funds with private capital, but enforce a separation between basic infrastructure and the provisioning of services to facilitate a competitive market for services and applications. The physical infrastructure could thereby be seen as a utility, an infrastructure for society, which could be provided by municipal networks as a way to establish open networks. Nonetheless, such infrastructure would still have monopoly power and need to be regulated accordingly in the absence of sufficient competition.

Given the extensive capital required for broadband infrastructure, investing in its deployment is not without risk, and this risk has to be addressed like for any project. Policies that facilitate local and regional initiatives, under certain conditions, as one size does not fit all, are one way to support the development of broadband networks. It is clear from the investments being made by public authorities or utilities either at a national level or in locations where demand is not being met by the market, that municipal networks are viewed as one option to meet objectives. A common theme in this report is that there is a global trend – in rural as well as urban areas – for increasing demand for communication capacity. As increased capacity has a significant effect in all sectors, it is essential to prepare and develop broadband strategies and plans where municipal networks are one option to be considered.

ANNEX I: SELECTED EXAMPLES OF USE OF MUNICIPAL NETWORKS

AUSTRALIA

TransACT before and after the new NBN framework for broadband provision

Following federation, in 1901, telecommunication services became the sole responsibility of the Commonwealth Government of Australia. As a result, Australia had little experience with regional networks for the next century. During most of this time telecommunication infrastructure and services were supplied by two state owned monopolies, with respective domestic and international remits. As in many countries with areas of low population density, people living in those areas frequently constructed party lines to connect to the national network but for the most part the state-own operator built telecommunication infrastructure. In 1991, in the first steps towards full market liberalisation, a second licence was awarded to provide national and international services. The duopoly period ended in 1997 after which other players were free to enter the market. Around the turn of the century, concurrent with a growth of demand for broadband, the first independent city wide or regional broadband networks began to emerge outside state capitals.

In Canberra, one such network was TransACT, which was half owned by the government of the Australian Capital Territory (ACT). Between 2000 and 2004, TransACT deployed a Very High Bit rate Digital Subscriber Line (VDSL) network in the ACT using a fibre to the node (FTTN) architecture, passing approximately 60 000 premises.[58] It offered ADLS2+ services to the majority of the remaining premises in the ACT using Telstra Wholesale's unconditioned local loop service. In 2007, TransACT acquired hybrid fibre coaxial (HFC) networks that had been deployed in the regional Victorian cities of Mildura, Ballarat and Geelong by Neighbourhood Cable. From 2009, TransACT deployed fibre to the building (FTTB) networks to new housing developments in the ACT. TransACT's deployment was underwritten by ACTEW, the ACT's supplier of water and power.[59]

In November 2011, TransACT was acquired by iiNet, one of Australia's largest Internet service providers. In May 2013, iiNet and NBN Co reached agreement for NBN Co to acquire TransACT's fibre to the premises networks. This was a commercial matter between the parties. TransACT continues to operate under its own branding within the iiNet group. It continues to offer VDSL, HFC and ADSL2+ services on its own networks as well as retailing NBN Co services. In March 2015, TPG Telecom announced an acquisition of iiNet Ltd for USD 1.1 billion, financed through bank loans, aiming to compete on a national level using NBN infrastructure and in some cases where it has legacy network facilities.[60] The acquisition was approved, or rather not opposed, by the Australian Competition and Consumer Commission (ACCC) on August 20 2015, although ACCC was concerned that the acquisition may lessen competition in the retail fixed broadband market it would not reach the threshold of a substantial lessening of competition as required under section 50 of the Competition and Consumer Act.[61]

Establishment of the National Broadband Network Company (NBN Co)

In April 2009, NBN Co was established as a new national, wholesale-only next generation broadband platform that would operate on an open access and non-discriminatory basis to support fair and effective retail level competition. The establishment of NBN Co also addressed concerns about Telstra's dominance in the broadband market, primarily through providing a vehicle for the structural separation of Telstra by the progressive migration of its customers to the NBN. The Australian government has committed to complete the National Broadband Network, and has set a cap of USD 28.5 billion, representing USD 1 250 per capita in public equity, to ensure that all Australians have access to very fast broadband as soon as possible, realised through a combination of fixed, wireless and satellite access, all depending on factors such as population density.[62]

NBN Co is subject to the controls established in the *Public Governance, Performance and Accountability Act 2013* and operates under the existing telecommunications regulatory regime in Parts XIB and XIC of the *Competition and Consumer Act 2010* (CCA). NBN Co has not been given any statutory monopolies but once the NBN is completed, it is expected that it could wield substantial monopoly power over the provision of wholesale access. Given NBN Co's unique status, specific legislative provisions apply to it. All services that NBN Co supplies are automatically declared and as such are subject to regulation by the Australian Competition and Consumer Commission (ACCC). This reflects the view that the NBN, as a bottleneck access provider, should be subject to regulation.

To prevent NBN Co favouring particular downstream customers, its service terms and conditions must be transparent and the company must supply services on a non-discriminatory basis. Any differences between the access agreements of NBN Co's customers must be reported to the ACCC and made publicly available on the ACCC's website. The *NBN Companies Act 2011* provides that NBN Co operates as a wholesale-only provider of telecommunications services. NBN Co is limited to supplying carriers and carriage service providers. This responds to concerns about vertically-integrated operators having the ability and incentive to favour their own retail operations.[63]

Open access rules applying to superfast networks

Under Parts 7 and 8 of the *Telecommunications Act 1997*, fixed-line local access networks, or parts of such networks, that are built, upgraded, altered or extended after 1 January 2011, such that they are capable of providing a carriage service where the download transmission speed is normally more than 25 Mbit/s to residential or small business owners must be wholesale-only and operators of such networks must offer a layer 2 bitstream service on a non-discriminatory basis with a price regulation on local bitstream access service in form of a price ceiling of USD 28 per month, based on a benchmarking against NBN Co's price. From 1st January 2015, carrier licence conditions require some carriers not covered by Parts 7 and 8 and operating superfast residential fixed line broadband networks to offer wholesale services on a non-discriminatory basis. From 1st July 2015, these carriers will be required to functionally separate their wholesale and retail businesses.[64]

Under proposed new legislation, from 1 January 2017, structural separation will be the default requirement for new high-speed fixed line broadband networks, but the ACCC will be given the power to authorise functional separation of such networks, where it judges this to be in the long-term interests of consumers. 'Grandfathering' arrangements will apply to networks that were in place prior to 2011 and any networks rolled out under the interim carrier licence condition.[65]

TransACT exemptions from the open access rules

The Australian Telecommunications Act provides for the Minister for Communications to give exemptions from the requirements under Parts 7 and 8, to provide flexibility to deal with unforeseen or other circumstances. In recognition of its pre-existing business plans, in 2012, TransACT was granted exemptions in relation to several of its existing and planned networks. These exemptions are subject to the condition that TransACT publish a reference offer for a wholesale interconnection service and supply it to access seekers on reasonable request. The exemptions remain in place to 1 July 2018.[66]

NBN Technology Choice Programme

While NBN makes the selection of each technology it will apply in each area it has introduced a programme called "Technology Choice".[67] It provides an opportunity for eligible applicants, such as an individual or municipal authority, to select an alternate technology solution by paying what it assesses to be the cost of the change. There are two options available: "Area Switch" or "Individual Premises Switch".

NBN says that its charge to change technology for Area Switch can range from tens of thousands of dollars to several millions of dollars. Meanwhile it says, its charges for Individual Premises Switch can range from a few thousand dollars to tens of thousands of dollars. NBN notes the cost generally depends upon the size and complexity of the project. The new programme not only offers upgrade paths from satellite and fixed wireless but has also added more technologies to provide options of changing from the originally offered Fibre to the Node (FTTN), Fibre to the Building (FTTB) and Hybrid Fibre Coaxial (HFC) networks. NBN Co assesses every application individually so that it can provide applicants with a high level cost estimate. An initial application fee of USD 271 for individuals and USD 902 is required for the application and further fees for a detailed quote. As the programme was only launched in March 2015 there is, to date, little experience on the possibilities for municipalities or individuals to self-install upgrades or how owners of the pits, ducts and other such infrastructure would treat this possibility.[68] For its part NBN says it will charge on an incremental basis for any change under the programme. For its part NBN says it will charge on an incremental basis for any change under the programme and it does not have a statutory monopoly. A community is free to choose from one of over 200 licenced carriers to build local facilities and the government has encouraged this option in new real-estate developments.

Recent developments

In 2014, a review was undertaken of the telecommunications access regime under Part XIC of the *Competition and Consumer Act 2010* and the rules about NBN Co's operations under the *National Broadband Companies Act 2011*. Submissions to this review unanimously agreed that NBN Co should remain a wholesale-only provider. The panel undertaking the review agreed that it was appropriate for NBN Co to continue operating on a wholesale-only basis.[69] A further review resulted in NBN's focus shifting from fibre to the premises towards a multi technology mix, facilitating re-use of existing but upgraded networks, such as fibre to the node and then over copper access networks, utilising very high bitrate DSL (VDSL) and existing cable TV-networks with Hybrid Fibre Coaxial (HFC), in combination with deployment of fibre to the premises.[70] The review concluded that this approach reduced the net up front cost and that, in its summation, consumers' willingness to pay for the additional speed was not sufficient to cover the excess amount needed to deploy a fibre access network. The cost-benefit analysis was aimed at capturing the value of using high speed broadband primarily through what consumers were willing to pay as well as in that they pay for the connection in part to access online education and health services . It added that public benefits (externalities), such as in improving outcomes, or lowering the cost, of education and health services were likely to be significantly lower than private benefits.[71]

NBN and Telstra have agreed that NBN will have access to Telstra infrastructure over a 35-year period, and the agreement has stipulated an 18-month period from when NBN services are available in a region until all households and businesses are migrated from the copper and cable networks to NBN.[72] As part of the agreement Telstra receives per subscriber address amount (PSAA) payment from from NBN.[73] Telstra is one of NBN Co.'s largest customers as well as one of their biggest suppliers, not only providing copper access networks but also cable (HFC), and planning and design services to support the NBN rollout, with a contract signed during the second half of 2014.[74] Around 3% of Telstra's net income was derived from NBN during H1 FY2015, an important driver for revenue growth as well. NBN has also signed agreement with Optus acquiring their Hybrid-Fibre Coaxial network.[75]

In early 2015, there were more than 80 retail service providers that offer broadband services on the NBN's wholesale platform. This provides residential customers and businesses with a broad variety of services at competitive retail prices.

Figure 2. Market shares access technologies fixed broadband.

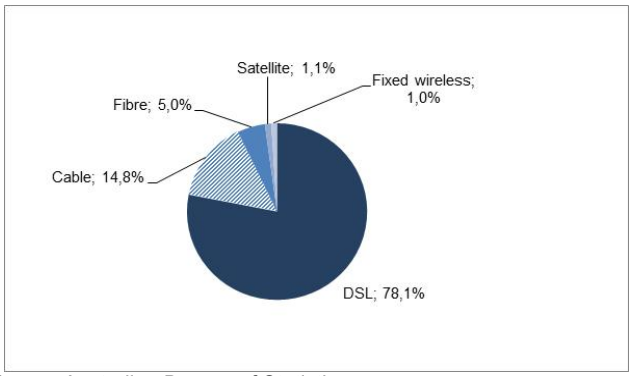
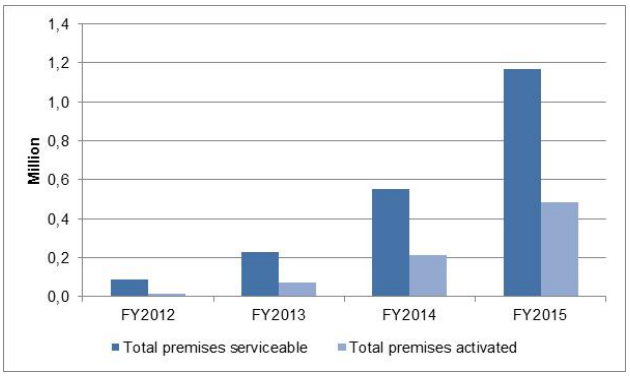


Figure 3. NBN connections



Source Australian Bureau of Statistics

The fixed broadband market in Australia has around 6.5 million subscribers (1 July 2015) and is dominated by DSL, which connects three out of four broadband subscribers. Around 5% of the fixed broadband subscriptions are connected with fibre, of them are the majority based on wholesale access from NBN Co (Figure 2). Based on NBN Co's connected homes and businesses completed by FY2015, the level of completion is 15% of the eight million premises that are planned to be connected (Figure 3).[76]

Experience shows municipal networks are by far from being always financially successful, irrespective of whatever other benefits they bring to a community via improved broadband. Prior to its sale, for example, the commercial future of TransACT was said by some to be under a cloud. An important consideration is that commercial and technological changes occur following the entry of a new municipal broadband network, including the responses from other players, which can lead to more competition. In the case of TransACT, the new owners took the decision to cease building its own infrastructure and rely more on the incumbent's wholesale ADSL product.

DENMARK

Fibre project in Vejen municipality

In Denmark, the Vejen municipality together with the local utility companies SE (previously Syd Energi) and TRE-FOR have executed a local broadband project that provides eight out of 10 households with a connection to a high speed fibre network. In 2002, three small rural municipalities in Southern Denmark set out a broadband vision aiming to connect all households with fibre networks, to create a digital region of connected municipalities.[77] The municipalities regarded broadband as a strategic issue for the region and local communities. Their vision of a connected community was based on the conviction that it is a prerequisite to establish a high capacity digital infrastructure, both fixed and mobile, in order for smaller municipalities to be attractive enough to sustain and facilitate commercial and residential development, and offset declines in the attractiveness of rural areas in the region. The assumption was that fibre networks can provide a future proof infrastructure enabling opportunities for services and applications for the public and private sector.[78]

In 2004, the small municipalities Rødding, Gram and Nørre Rangstrup and later Vojens joined forces in the region and deployed a fibre ring. This was, according to the municipalities, in response to no providers being prepared to roll-out a fibre network between central nodes in the four municipalities and that prices for leased lines were high at the time. The aim was to connect public institutions, utilise a common IT platform and thereby achieve more efficient IT processes. It was followed by the deployment of an additional fibre ring in 2006 following a reform of the municipalities in Denmark and the new Vejen Municipality was established. This initiative provided a substantial boost to broadband development in the region. Today, Vejen is an 814 km^2 rural municipality in Southern Denmark with 9 500 inhabitants in the main city and 42 600 inhabitants in the municipality.[79]

Since 2007, all public institutions within the Vejen municipality are connected to the fibre network providing connections up to 1 Gbit/s, either through the municipality owned networks or on leased dark fibre or alternatively through a leased connection via the utility company SE's network. The networks have continuously been developed, creating stable, flexible and robust communication within and between the municipalities, and also enabled the provision of Wi-Fi networks. This has facilitated the municipality Vejen to use a broad range of IT systems and applications to improve working processes, implementing interpretation over video in an integration centre and at a job centre. The network has also provided schools with significantly improved communication capabilities.[80] Moreover, Vejen is collaborating with other municipalities on platforms for telemedicine and technologies for the delivery of welfare services, such as home care.

More than eight out of ten households and businesses in Vejen have access to the fibre network. In order to fulfil the vision of fibre to all, some additional investments are still required, which according to Vejen is achievable. The two local utility companies, SE and TRE-FOR, are set to complete the roll out of fibre to all households and businesses in the region within the next couple of years.[81] Although, the initial demand was not as strong as expected it is increasing. Several companies have expanded in the rural areas and large farms use the access to the fibre network to develop and optimise production processes, potentially creating new jobs in the Vejen municipality.[82]

The utility providers

The regional Danish utility companies, commonly owned in trust by consumers in each respective region, started to roll out fibre networks around 2005. The utilities' entry into the broadband market was initiated by the liberalisation of the electricity market in Denmark in 2005, and the transfer of the airborne

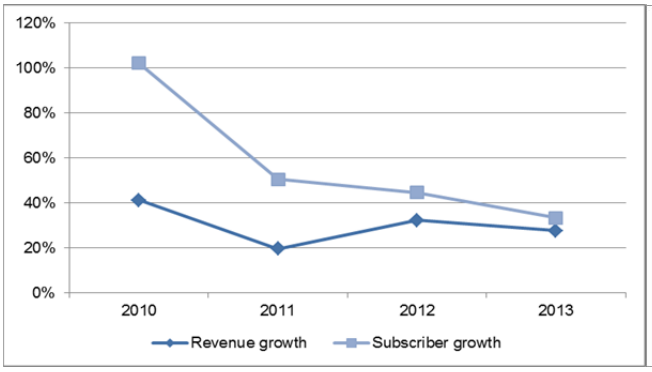
power network underground in order to avoid future disturbances, e.g. resulting from storms. As the regional utilities controlled the power networks the liberalisation required a transfer of the ownership of the grid from the regional utilities to the state owned company Energinet.dk. This facilitated competition on power distribution as all utilities could then use the state owned infrastructure. In return, the regional utilities obtained access to previously restricted capital facilitating expansion into other activities, such as energy related products and deployment of fibre networks.[83] Concurrently, there was a consolidation in the sector among the utilities.[84] The regional utilities contribute with around one fourth of the broadband investments in Denmark, and approximately 20-25% of all broadband subscriptions. SE/Stofa alone accounts for 12% of the fixed broadband market (Figure 6).[85]

The municipalities invited the local co-operative utility companies to invest and deploy fibre networks to businesses and households at an early stage as the municipalities themselves are not allowed to make investments in broadband networks for private consumers and businesses. In 2004, Sydvest Energi (now SE) made the strategic decision to expand into broadband and was followed by TRE-FOR a couple of years later.[86] SE was established after a merger between a number of local and regional utilities in 2006. It is owned in trust by 272 000 members.[87] This co-operative ownership has been important for demand and the decisions to deploy high speed broadband as customers are representatives of the owners and thus have common interests. SE has primarily worked as a vertically integrated operator, providing end user services through their own network.

The co-operation between Vejen municipality and the utility companies' facilitated a much faster deployment of fibre to almost all households and businesses in the area. For example, public institutions' demand for fibre connections have supported local citizens as potential customers in rural communities, and the co-ordination of other utility projects involving ducts, conduits and civil works have reduced the costs for rollout. Furthermore, the utility companies have upgraded the electricity supply system in the area to a smart grid by connecting all transformer units to fibre networks for survey and support, and by placing all electric cables into the ground in order to avoid potential problems from storms.

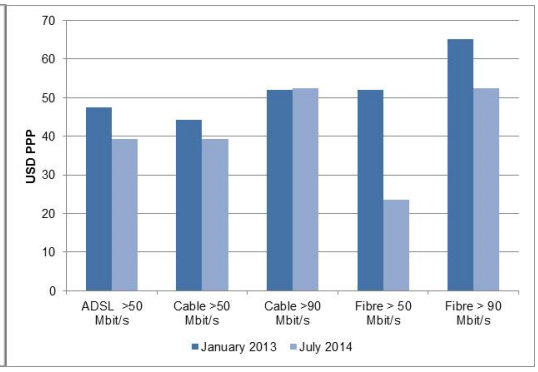
Investments in fibre networks are not without risk. SE was forced to make a substantial depreciation on USD 100 million, on its fibre network in 2009 as the asset value of the fibre network was diverging too much from the market value. This motivated SE to do an overhaul of its strategy and business plan in order to improve profitability and to prioritise the attraction of new customers, thus revising the deployment plan and market share targets. Following the financial crisis, however, the demand for high capacity broadband picked up, and the business case has improved, enabling SE to revalue the fibre network with USD 35 million (in 2011). Although the growth numbers have declined, SE still generates substantial revenue and subscriber growth (Figure 4). Notably, with the decline of prices on fibre access subscriptions, which are primarily provided by the regional utilities, it has become more attractive for consumers, who alternatively could get copper based broadband at higher or equivalent prices (Figure 5).

Figure 4. SE revenue and subscriber growth year-on-year



Source: SE annual report and OECD estimates

Figure 5. Lowest prices on fixed broadband



Source: Danish Business Authority

SE acquired the established cable-TV operator Stofa in 2013 from the Swedish private equity company Ratos for USD 338 million, adding 200 000 broadband subscribers and 375 000 cable-TV subscribers. Thus, SE expanded its geographical presence considerably, and enabled it to provide its own TV offering.[88] SE transferred all their residential broadband customers to Stofa's platform during 2013, to use Stofa as a distribution channel to these customers.[89] Consequently, it left the distribution and marketing company called Waoo! which was set up by eleven regional utilities. SE is now a significant player on the Danish broadband market providing fibre broadband and cable-TV to more than 650 000 customers under the Stofa brand, with a market share of 12.1% on fixed broadband.[90] A comparison of the prices for fixed broadband shows SE's competitiveness to the incumbent TDC, that has somewhat higher prices and who are not offering symmetrical capacity for the copper based subscriptions (Table 4).

Table 4. Prices on Danish broadband market for households USD PPP (March 2015)

	20/2 Mbit/s	40-50 Mbit/s	90-100 Mbit/s	250-300 Mbit/s	500 Mbit/s
SE/Stofa	26**	35	44	73	
Waoo!		37	52	65	131
TDC	34	39*			

* 50 Mbit/s download and 10 Mbit/s upload

** upstreams is 10 Mbit/s

Source: Company websites

The Danish broadband market

The incumbent TDC dominates the fixed broadband market with a market share of 58%[91], which is the fourth highest incumbent share in the European Union (Figure 7).[92] Slightly more than half of the fixed broadband subscriptions in Denmark are Next Generation Access (NGA) of which 40% is based on fibre, meaning that slightly more than one out of five fixed broadband subscriptions are based on fibre.[93] The absolute majority of the fibre lines are provided by regional utilities.[94] TDC is primarily focusing on providing high capacity broadband connections through its cable-TV network and copper based VDSL.[95] The growth rate of fibre-based broadband is trending upwards and during 2014 it increased with 35%. However, fibre based broadband is facing competition from VDSL as well as broadband over cable-TV (DOCSIS 3.0), which has a combined market share of 60% of all NGA subscriptions.[96]

Figure 6. Division of capital expenditures on broadband.

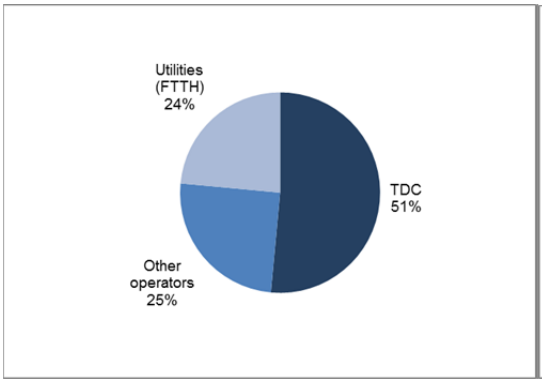
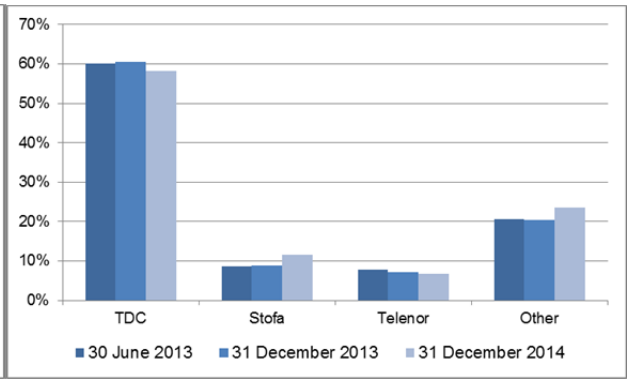


Figure 7. Market shares fixed broadband



Source: Danish Business Authority

The fibre rollout in Vejen has contributed to making the Southern Denmark region the part of the country with the highest concentration of high capacity broadband. This places the region as one of the leading fibre areas in Europe.[97] Denmark has set an ambitious broadband target aiming for all households and businesses to have access to 100 Mbit/s downstream and 30 Mbit/s upstream by 2020. This will be undertaken through a technology neutral approach and be driven forward by the market.[98] Today, the fixed broadband penetration is 41.3% subscriptions per 100 inhabitants placing Denmark second within the OECD.[99]

Box 3. Wireless municipal networks

Since they were first launched over a decade ago, public Wi-Fi zones have become an intrinsic part of the communication landscape. Municipal networks can be provided over Wi-Fi, making a building such as a library, park, campus, district or larger swath of a city a wireless access zone.[100] Although the Wi-Fi standard allows for very high bitrates the actual throughput depends on the availability of backhaul, where high capacity municipal networks can play a role. This benefits users without a cellular connection as well as potentially reducing the burden of cellular networks for traffic that may demand more capacity. Wireless municipal networks appear, in one way or the other, in most OECD countries. In Australia, for example, the City of Adelaide has partnered with the State government and an ISP (Internode) to offer free Wi-Fi throughout the central business district and surrounding parklands.[101] The network uses fibre-optic cabling provided by Internode, the Adelaide City Council and the Government of South Australia to transmit data from the Wi-Fi zones into the ISPs network.

The city of Paris and the Île-de-France region offers free Wi-Fi service to all, residents and visitors alike at over 260 public places.[102]A number of cities in Greece provide free municipal wireless networks to residents and tourists covering public locations, and parts of those cities, such as in Heraklion, Lagkadas, and Thessaloniki.[103] In Ireland, the City Council in Dublin has engaged a company to run the municipal wireless network through a concession, and the network has coverage in 12 locations, and the service is free of charge for download speeds up to 500 Kbit/s.[104] In Italy, Venice has established a wireless municipal network, which allows the city to provide services to residents, who work, study or visit Venice, while tourists have to buy the service.[105]

Oulu (Finland) has a municipal wireless network covering central parts of the city, University campus and some other key locations. The network is a private public partnership operated by the City of Oulu, the University of Oulu, and the VTT Technical Research Centre of Finland.[106] Trondheim (Norway) has a wireless municipal network, which provides communication to companies, and facilitates research and development linked to the University in Trondheim.[107] Wi-Fi is ubiquitous in public spaces in the United States. Wireless municipal networks are provided in, for example the city of Raleigh, where Albany Free net provides access at some locations through a public-private partnership.[108] Finally, the City of New York has announced a programme to replace payphones with kiosks offering Wi-Fi and the ability to make free calls within the United States as well as calls to emergency services.[109] he "LinkNYC" plan would massively expand Wi-Fi availability across all five boroughs of New York City through up to 10 000 of these Link stations and offer free charging stations for mobile devices and be supported in part by advertising.[110]

JAPAN

Kamiyama town and Tokushima prefecture

Kamiyama is a relatively small town, with around 6 000 inhabitants, located on the Shikoku island, in the southwest part of Japan, one of the least populated of the four main islands in that country. It takes around one hour by automobile to reach the town from the prefectural capital Tokushima, which in its turn is located 500 kilometres southwest of Tokyo. Kamiyama has, as most towns and villages in rural Japan, a declining population, which decreased 22% during the decade leading to march 2015, as well as an aging population, with 45% of the population over 65 years.[111]

Kamiyama has succeeded, however, to offset the falling population trend, and even recorded a net increase in 2011, excluding the effect from natural mortality. It is widely regarded that the town's engagement in bridging the digital divide and associated efforts to create jobs, with financial support from the prefecture and the national government, has been decisive for the improvement of the demographic

situation, which is exceptional in the region. Since 2005, the town has been one of the frontrunners for public deployment of optical fibre network in rural areas.

Approximately USD 9.5 million has been invested by the public sector to install 262 km of optical network to cover Kamiyama and the neighbouring village Sanagochi. The financing of the broadband network has been shared by the Ministry of Internal Affairs and Communications (30%), the prefecture (10%), and the remaining 60% has been provided by the municipalities of the town and the villages. After the completion of the network in 2005 around 85% of the households in Kamiyama subscribe to the broadband network, which provides them with 100 Mbit/s Internet, digitalised television and IP telephony for USD 19 per month. The operation of the network was awarded to a regional telecommunication operator who has signed a long-term lease contract with the municipalities, which also covers the cost for maintenance. [112,]

Besides the infrastructure deployment much more has been done to attract people and enterprises to establish themselves in the town. The local authorities and the prefecture have supported a non-profit organisation to establish a centre to assist in immigration to the town, which has helped 116 people in 65 families who moved to the town between 2008 and 2013. The city has also supported the deployment of "satellite offices", to which city based companies can dispatch part of their workforce or employ local people for better working environments. By January 2013, eleven companies had their offices in the town, dominated by ICT ventures, which could take advantage of the broadband infrastructure and available houses. An example on the experience of living and working in Kamiyama expressed by one employee of an ICT company providing cloud computing service can be cited here: "Unlike in Tokyo, I do not feel much of exhaustion here other than that of my work. The major reason is that I do not need to commute any more, as it takes only 10 seconds from the house where I am living to the workplace."[113] About three out of four of the employees have worked in this office according to the report. Moreover, spill over effects for the town have begun to emerge, such as the establishment of new cafés around the offices.[114]

In 2013, in an interview, the Mayor of Kamiyama, Mr. Masakazu Goto, underscored the importance of collaboration between public and private sectors.[115] The Mayor noted that the town's public project to deploy the fibre network was "innovative" and eventually led to the success of satellite offices. At the same time, he praised the private sector's potential to create and implement new ideas, and emphasised that the public sector should be a supporter on the back of their efforts to reactivate the local community.

Box 4. Costa Rica - Telecommunication Infrastructure and municipalities

After the liberalisation of the Costa Rican telecommunication market in 2008, a number of activities have taken place in order to promote competition and access to quality telecommunication services for the whole population: parts of the radio spectrum have been allocated to new operators; the legal and regulatory framework has been modernised[116]; and procedures have been introduced for public entities regarding installation and expansion of telecommunication infrastructure.[117]

Even though the availability of services has improved significantly, and the usage of mobile telephony and Internet have spread to large groups of society, the government has recognised that a number of challenges remain in order to reach a competitive market. The approval processes for deployment of networks is still cumbersome; there is a competence gap among municipal officials; there is no regulation for the use of rights of way (roads, railways, pipelines); there are no guidelines for how telecommunications infrastructure could be incorporated in the construction of new roads, of pipes and ducts; and there is no available national registry of telecommunications infrastructure.

The Government takes the view that further developments could benefit from a multi-stakeholder model where different perspectives are taken into consideration. The governance model, they say, needs to be flexible in order to solve upcoming challenges and to involve municipalities in order to address regional particularities. It has established a Co-ordination Commission that could address a broad set of issues that is required to develop and implement efficient processes for the installation or extension of telecommunication infrastructure, and provide technical assistance to municipalities.

The Commission consists of participants from several ministries, and the "Instituto de Fomento y Asesoría Municipal", which is the entity responsible for the promotion and improvement of municipalities.[118] The Commission has made a number of recommendations, including by way of examples amendments to legislation regarding procedures for finalising construction plans[119], conditions for building permits of telecommunication towers and developing a public policy for telecommunication infrastructure. Moreover, the Commission is developing a telecommunication infrastructure registry, which contains the country's installed infrastructure, and together with other stakeholders working on a strategy for the transformation of municipalities into digital cities.

The aim of the overall approach is to create conditions for infrastructure deployment in line with Costa Rica's needs and with the objectives set out in other national planning instruments pursued after the liberalisation of the telecommunication market. This includes ensuring compliance with the principles of universal access, affordability, efficiency, equity, sustainability, quality, more and better coverage as well as sharing infrastructure in the provision of telecommunication services.

THE NETHERLANDS

Municipalities' active within the communication sector

Historically, communication networks in the Netherlands have demonstrated a repeating theme of local, private and municipal deployments. The first telephony networks, launched in the 1880s, were private ventures under license from municipalities. Subsequently, municipalities developed their own telephone networks or when licenses expired, took over private networks. This was followed by a nationalisation of local networks, which was completed in 1928, when the PTT assumed a monopoly for all telephony.[120]

The distribution of television was predominately carried over cable networks govern by a concession system, which gave municipalities a preferential position.[121] In the 1980s, changes in the regulation allowed communal cable-TV networks to co-operate and merge enabling larger municipal and provincial utilities to strengthen their position.[122] Cable-TV networks expanded rapidly when community housing corporations were restricted to use aerial antenna's and satellite dishes.[123] The municipalities divested their

holdings in cable-TV networks to regional utilities and private investors around the turn of the century, when the concession system was phased out.[124] It initiated a consolidation of cable-TV networks resulting in a duopoly, where Ziggo, formed in 2008 through the merger of Essnet Kabelcom and Casema (previously owned by KPN), and UPC controlled 90% of all cable-TV connections, which was further reinforced when UPC took over Ziggo. In 2015, cable-TV in the Netherlands consists of up to 20 networks, of which one controls 90%, two have 4% each and the others share the remaining 2%.[125]

In the year 2000, the Ministry of Economic Affairs launched the Kenniswijk (knowledge neighbourhood) initiative in order to create an environment where advanced broadband networks and services could jointly be developed. The government provided financing of up to USD 57 million, which was granted when municipalities and private players matched the funding.[126] After a tepid beginning, due to the "dotcom crisis" and lack of interest from existing players, the Kenniswijk scheme gathered momentum when citizens in Nuenen organised a co-operative demand aggregation initiative, called OnsNet (OurNet). In the lead up all the 7 500 households in the town signed up. This inspired other cities to follow suit and within a short time 15 000 households were connected to the network.

Social housing corporations took the lead in the development of fibre to the home (FTTH) projects, driven by a conviction that access to high capacity broadband would make residences more liveable, would support eHealth applications for the elderly and promote social equality. For example, in Enschede the housing corporations deployed FTTH to 1200 households funded by two social housing corporations, Woonplaats and Domijn, through their own capital in combination with a loan from the municipality. It was followed by other social housing corporations, such as Portaal and Patio, which invested in FTTH networks. By 2006, these projects accounted for somewhere between 35 000 to 50 000 connections. As the housing corporations experienced challenges to find service providers for the open networks some housing corporations also acted as ISPs. In 2007, the ministry responsible for overseeing social housing corporations decided that the deployment of passive infrastructure could be regarded as being part of the role of running a social housing corporation, but not to manage active networks. This forced housing companies to divest several of the existing projects.[127]

Amsterdam and Appingedam

Some cities were prepared to take a more active role in the deployment of fibre networks. The experiences of Amsterdam and Appingedam are illustrative. In 2001, the authorities in Amsterdam recognised the significance of having access to excellent network infrastructure, ultimately requiring fibre to the home. It investigated whether the market was prepared to deliver a future proof infrastructure. UPC, the local cable-TV subsidiary of Liberty Global, which had acquired the municipal cable-TV network in Amsterdam in 1998[128], was convinced that there was no need for such an infrastructure. The telecommunication incumbent KPN had plans for FTTH, called Deltaplan Glas, which relied on co-operation with the cable-TV companies and therefore was also not interested in the city network.

In 2005, the city of Amsterdam together with five housing corporations and two financial investors (ING and Reggefiber (owned by the investment company Reggeborgh) agreed to invest in a fibre to the home network. This was strongly opposed by UPC, which argued that it constituted illegal state aid. The city of Amsterdam on the other hand argued that the investment was compatible with the Market Economy Investor Principle (MEIP), and should therefore not be regarded as state aid.[129] The European Commission initially questioned whether MEIP was applicable, as it did not consider that all parties invested under the same terms and conditions, which implied that the city of Amsterdam accepted to take on certain initial risks without appropriate compensation.[130] Nonetheless, the European Commission concluded, after a lengthy process, that the City of Amsterdam's investment was coherent with MEIP and should therefore not be regarded as state aid.[131] Subsequently, ING sold its shares to Reggefiber while the city and the social housing corporations sold half of their shares, which made Reggefiber the majority owner (70%).

In 2004, the city of Appingedam decided to commence a fibre-to-the home network since neither Essent Kabelcom (today Ziggo) or KPN were prepared to deploy an advanced broadband infrastructure in the city. Appingedam acted to facilitate the establishment of a foundation through a loan and a guarantee and issue a tender for the management of the active layer of the network, and then exploit the network on a wholesale basis open to all service providers. Essent Kabelcom objected on the grounds that it constituted illegal state aid as there was no market failure and appealed to the court which decided that the case had to be notified to the European Commission. The city argued that was not state aid as the project concerned the provision of "public infrastructure" open to all parties at similar conditions and the operators did not offer advanced broadband services. The European Commission disagreed and stated that the city did not provide a Service of General Economic Interest, nor did it act on terms, as would a private investor. The city, they concluded, was going to provide illegal state aid to the foundation, the operator of the network and the networks making use of wholesale access to the network. It was, they said, therefore not compatible with the common market.[132]

Following the turn of the century, many municipalities and regional organisations found that fibre connections for businesses and public institutions were often prohibitively expensive. The cause was insufficient competition as only one or two operators in most regions provided dark fibre or managed services.[133] In addition, operators used so called 'value based pricing', where the price of fibre increased if more bandwidth was used between locations, despite using the same fibre. In 2001-2002 several regions made attempts to establish regional Internet Exchange Points (IXPs), to add more supply into the region and to act as a backup to Amsterdam's Internet Exchange. However, the dotcom crash eliminated much of the market and the remaining operators were unable to invest in new locations.

In the eastern part of the Netherlands, the region then focused on bringing demand to the NDIX (Dutch-German Internet Exchange) that had been established there. This was accomplished by bundling the demand of business and public institutions and then purchasing customer owned dark fibre networks to terminate, ideally, at so-called carrier neutral data centers also known as market places. This was made easier through fibre rings that had been put in place by construction companies. The dark fibre infrastructure allowed the users/owners of the network to use their own equipment and the desired speed and then interconnect their multiple sites to each other. At the carrier-neutral market places they could then purchase services, such as IP-transit, managed VoIP, back-up and other IT services could also be bought over the platform of the Internet exchange. This model was copied for business parks, towns and villages throughout the Netherlands and Germany. Today NDIX serves 100 data centres and 45 different fibre networks.

Following the cases in Amsterdam and Appingedam the Dutch parliament discussed the involvement of municipal investments in telecommunications networks. As a result, in 2006 the parliament decided to make an amendment to the Dutch telecommunication law which forbade municipalities to invest in companies offering public electronic communication networks and services, or to have a share or influence in such companies. However, municipalities were allowed to invest in a public electronic communication network if without the support of the municipality - such a network would not be feasible. Later, however, this article in the Dutch Telecom law was altered with the Crisis and Recovery law of 2010. It was deemed unnecessary that municipalities were more restricted in their ability to invest in networks compared to other regional government entities. The government stated that as broadband networks were in particularly local networks, municipalities were best equipped to have a stimulating role in the deployment of broadband. The case of Amsterdam was mentioned as an example where the municipality had contributed with a positive push, since private investors were reluctant to invest. Consequently, the current law does not forbid municipalities to invest in broadband, but it requires that networks that municipalities invest in provide access under open and non-discriminatory conditions.[134]

Reggefiber makes a difference

Many of the fibre initiatives in the Netherlands experienced difficulties to obtain financing from capital markets. However, the Reggeborgh investment group of the Wessels family was an exception, and it controlled the largest construction company with extensive investments in real estate. The strategy of Reggefiber was to experiment with different roll out models and technologies. It settled primarily on a model that focused on smaller towns, where it would roll out a network if demand aggregation had achieved at least a 30% penetration level. It chose to deploy point-to-point networks that were open for other service providers. Municipalities would not invest in the network as such, but would co-operate, allowing Reggefiber to do the repaving instead of leaving this to the municipality at the expense of the company. Reggefiber's investments in larger cities such as Amsterdam and Almere proved that cities, and particularly multi-dwelling units, were more difficult and expensive to roll-out than expected. [135] Consequently, most cities over 100 000 inhabitants in the Netherlands have not yet seen any FTTH deployment.

At first, Reggefiber co-operated with smaller ISPs since the ISPs with nation-wide DSL networks were reluctant to invest. The smaller ISPs, however, had trouble establishing competitive offers for television. As a response Reggefiber organised a television offer through Glashart Media for all ISPs active on its network, leveraging the combined subscriber numbers in negotiations with content providers. Reggefiber also established a company named the ISP Fabriek (ISP Factory) to support ISPs in their start-up phase. The model of aggregating demand pursued by Reggefiber was replicated by others, and resulted in some successful local co-operative FTTH networks, which often used the same technology as Reggefiber networks, and with ISPs that are also active on Reggefiber's network.

In 2008, KPN acquired a stake in Reggefiber and the company became a joint venture between Reggeborgh and KPN, which gradually increased its holding. In 2011, KPN acquired all Reggefiber's Internet service providers and their 110 000 customers, and, in 2014, KPN purchased all shares in Reggefiber from Reggeborgh. That being said, Vodafone, one of the ISPs on the network, has challenged this purchase in court. Reggefiber has reached 2 million households in the Netherlands. The fibre network is regulated open access, with prices ranging from USD 13.20 to 19.30 per line per month, with a potential for up to 20% discount if the penetration rate is higher. After consolidating Reggefiber, KPN announced that it would scale down its investment in new lines and rather opt for Passive Optical Networks, which could reduce costs as it require less fibre, but it comes with a competitive concern as it is a shared infrastructure. Reggeborgh meanwhile has initiated the first FTTH projects in Germany, under the name Deutsche Glasfaser.

The success of Reggefiber stimulated Rabo Bouwfonds, through its Communications Infrastructure Fund (CIF), to enter the market as an investor by purchasing and funding fixed and wireless telecom infrastructure. It acquired CaiWay, a medium sized cable-TV company and upgraded its network to point-to-point FTTH. It also acquires and funds other cable companies that want to upgrade their fibre networks. CaiWay is the only ISP available on CIFs network. Almost all of the independent cable-TV companies in the Netherlands, with the exception of Delta which owns the cable-TV network in the province of Zeeland (4-5% of the country), are converting their cable-TV networks to point-to-point FTTH networks. The COGAS cable network is 50% owned by the COGAS gas and electricity network in the east of the Netherlands, which in turn is owned by nine municipalities and CIF. This network expects to upgrade 80 000 connections to FTTH. A similar set up exists in Harderwijk, but with the local cable-TV association. On these networks there are generally other ISPs available, besides CaiWay.

There is still one independent cable network, Kabel Noord which is owned by five northern municipalities, which never consider divesting its network, although it contemplated a potential deal with CIF. It decided to upgrade its network to Gigabit Ethernet FTTH, initially 16 740 connections in the main

city and towns with likely another 11 000 to follow. Due to the region being one of the least prosperous in the country, the municipalities saw the need for investment in infrastructure. There are in addition some smaller independent cable television associations, such as SKV Veendam with 11 000 connections, which is also investing in FTTH.

Dutch municipalities are becoming more involved in investments in FTTH networks to rural areas. This is particularly the case in areas where the main towns and villages have FTTH networks, while not the surrounding areas. Through a combination of demand aggregation, up-front payment from customers for (part) of their connection, municipal guarantees on loans, provincial subsidies, commercial loans and crowd sourced loans the funding for these connections is raised. However, such initiatives often experience challenges to find enough participants and often have to extend the sign-up period.

Concentrated market

The result is that by 2015 over 2 million Dutch households of the seven million Dutch households have access to FTTH from around 25-30 different ISPs, primarily via KPN/Reggefiber's infrastructure, but also via networks of (former) cable-TV network operators associated with CIF. In addition, there are a number of smaller FTTH networks. Almost all of these networks pursue an open and non-discriminatory access policy. Hybrid-Fibre Cable networks are provided predominantly by Ziggo to roughly 90% of the population and Delta to 4% of the population with speeds up to 200 Mbit/s. Over KPN's copper infrastructure a number of ISPs offer services using various DSL variants. KPN is using vectoring and bonded vectoring to deliver up to 200 Mbit/s to their customers. The implementation of vectoring has faced scrutiny from its competitors, as this makes unbundled local loops impossible, restricting the competitive freedom of these ISPs. KPN will continue to invest in FTTH, but likely at a slower pace and will develop its DSL offers to offer G.Fast, which could deliver up-to 1 Gbit/s over the copper network.

Figure 8. Share of broadband connections

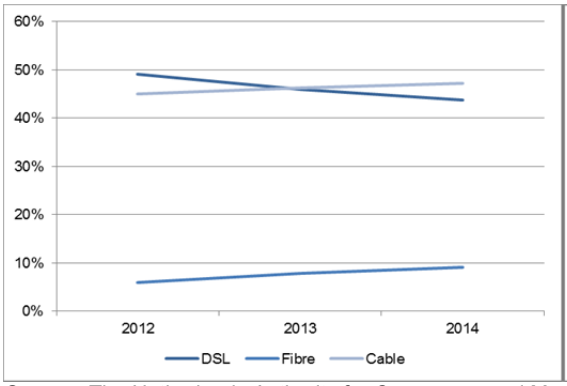
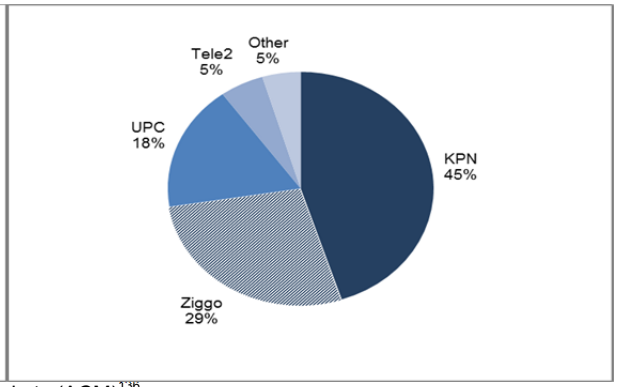


Figure 9. Retail market shares fixed broadband



Source: The Netherlands Authority for Consumers and Markets (ACM)[136]

In the Netherlands, the involvement of municipals proved critical in many areas for the development of the market for electronic communication, but the outcomes have been subject to dynamic forces, entrepreneurship, regulation and other factors. The number of fibre subscriptions per 100 inhabitants in the Netherlands was 3.5 by June 2014 while DSL and cable still dominates (Figure 8).[137] Of the fixed broadband subscribers were 9% connected with fibre by the end of September 2014, and out of 0.6 million fibre subscribers reported by ACM 86% use KPN's network, indicating a concentrated fixed broadband market (Figure 9).[138]

Box 5. Fixed wireless municipal network

A connection through a fixed wireless municipal network is carried over radio to a fixed location, such as a residence or office, which are equipped with an antenna. Countries such as Canada, Czech Republic, Slovak Republic and United States report among the highest numbers of fixed wireless networks in the OECD area.[139] Some of these networks are driven by municipalities, communities or non-profit organisations, though many are supplied by the private sector and can be used by municipalities. [140]

Utilities Kingston is a community owned operator, present in the eastern part of Ontario, Canada and provides licensed fixed wireless system with services in Napanee and Brockville.[141] In Stewart, British Colombia, Onewayout, a community run internet service provider, uses fixed wireless access points and operates in the 2.4 GHz and 900 MHz band and service is limited to line of sight or almost line of sight. The monthly price for a subscription is USD 24 with a cap on 10 GB and USD 32 for a 15 GB cap.[142] In Iowa, United States, the Coon Valley Co-operative Telephone delivers internet services to small cities like Stuart, Orient and the Diamond Head Lake area, for which it charges USD 45 per month for a subscription with a capacity up to 3 Mbit/s and USD 65 per month for a capacity up to 6 Mbit/s.[143] Community Digital Wireless (CDW), a partnership of five independent telephone companies, provides fixed wireless internet services to Fayette County and the eastern half of Bremer County, if the customers external antennas are pointed toward one of CDW's transmission towers. The cost for a 1 Mbit/s connection is USD 65 per month, and the price for a 3 Mbit/s connection is USD 148 per month.[144]

In the Czech Republic a number of voluntary, independent and non-profit associations of individuals and legal entities provide fixed wireless access to the Internet. For example Freenet Liberec, which has connections points in area Brovmovská and Pavlovice; hkfree.org community network, which has connection points in Hradec Kralove area; Association KHnet.info which has a broadband telecommunications network in Kutna Hora; and another is Unart, which provides communication to its members.[145] In Australia, the National Broadband Network (NBN) plans to provide coverage for approximately 4% of all premises in the country to fixed wireless networks to which they use spectrum in 2.3 GHz based on the LTE standard.[146] Two tiers of speed are made available for retail providers to market at 12/1 Mbit/s and 25/5 Mbit/s (i.e. 12 downstream and 1 upstream) with data caps typically being 30 GB, 300 GB and so forth.[147] By way of example an offer for 25/5 Mbit/s with a 300 GB cap is priced by Internode, a retail provider, at USD 50. An estimated coverage map is made available to potential subscribers from which retail ISPs pass requests for connections to NBN for installation of equipment for reception.[148]

NEW ZEALAND

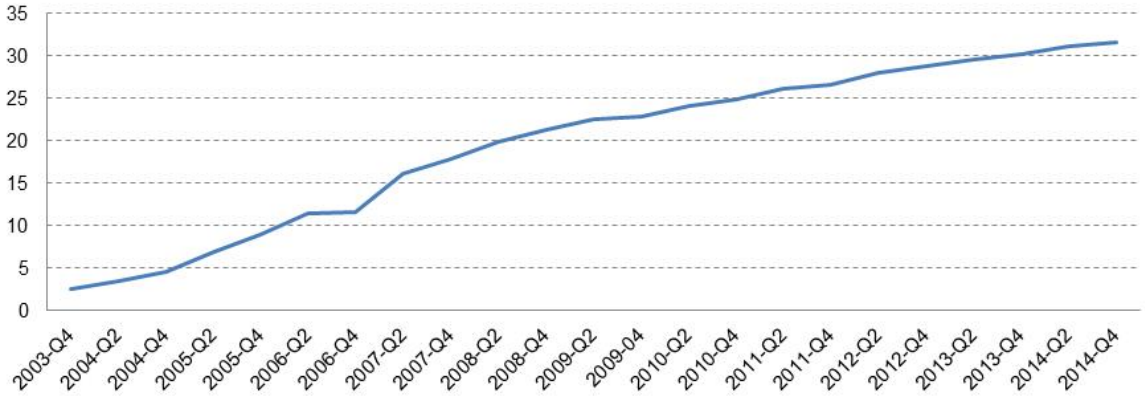
Improved competitiveness

New Zealand has made substantial strides over recent years in improving the competitiveness and availability of broadband across the country. It has done so starting from a market that had insufficient competition. Unlike some countries New Zealand did not enter the broadband era with substantial cable television coverage and unbundling was introduced much later than other OECD countries. This left a single player with substantial monopoly power, something that was reflected in low levels of broadband penetration and relatively high prices. In 2006, for example, New Zealand stood at 26th of the then 30 member countries of the OECD in terms of broadband penetration.

Since 2006 New Zealand has transformed its broadband market. The introduction of unbundling and functional separation, in that year, provided an immediate stimulus to competition and this was reflected in an acceleration of penetration (Figure 10). The new obligations were enforced using information disclosure, separate accounting of the incumbent's business operations and enhanced monitoring and supervision by the Commerce Commission. In just two years New Zealand rose from 26th to 19th among

OECD countries. The government was keen, however, to address the issue of how to stimulate further investment particularly in fibre to business and residential premises, as well as key locations such as schools and hospitals. In 2008, therefore, it announced a range of initiatives including public investment in partnership with private capital to develop fibre connectivity to 75% (later amended to 80% by 2020) of the population. In addition, the structural separation of the incumbent telecommunication operator opened the market for not only it to bid for the deployment of fibre, but also regional and municipal players in areas such as energy to participate.

Figure 10. Broadband growth in New Zealand



Source: OECD Broadband Portal

One of the successful bidders was Northpower Ltd, a utility owned in trust by consumers based in Northland.[149] This region covers the northernmost part of New Zealand where the utility subsequently built a fibre network in Whangarei. This section will highlight the experience of faster broadband in Northland, following a brief introduction to the national broadband programme.

The Ultra-fast broadband plan

In 2008, the New Zealand Government took the decision to invest USD 1.35 billion in collaboration with market players to deploy fibre networks throughout the country, aiming to reach 1.2 million residential, business, educational and health premises.[150] The country was divided into 33 candidate (urban) areas and Crown Fibre Holdings Ltd (CFH) was founded to manage the co-investment.[151] The initiative was driven by a desire to improve competitiveness and meet unmet demand for broadband throughout the country.[152] In order to promote service competition, network providers are restricted to only providing wholesale access, which is subject to price regulation, to interested Retail Service Providers.[153]

Given (2010) noted the public-private interplay in New Zealand demonstrated a shift from the previous emphasis on infrastructure competition and, largely, a reliance on private capital that had characterised the country since the initial liberalisation of the market and privatisation of Telecom New Zealand.[154] The low level of alternative network infrastructure and lack of unbundling had concentrated significant market power with one player with little competition to drive investment, including in areas without service.

Following the 2008 reforms, Crown Fibre Holding oversees the development of coverage plans, and monitors service performance.[155] The state company interacts with Territorial Local Authorities (TLAs) in conjunction with the infrastructure partners, in order to take account of local views on deployment priorities. Ahead of the selection process, the regional utilities and network operators formed an interest

group called New Zealand Regional Fibre Group aiming to obtain contracts.[156] The involvement of the electricity companies was, according to Webb *et al* (2014), critical to ensure competitive pressure on Telecom New Zealand, and instrumental in the decision to divide the broadband initiative into regional coverage areas.[157]

The broadband partners with Crown Fibre Holding are:

- Northpower Ltd, provides 1.6% of the broadband coverage,
- WEL Networks and Waipa Networks[158], covering 13.7 %,
- Enable Networks[159], covering 15.3% and
- Chorus Ltd, covering 69.4% and which is deploying its network in 24 out of the 33 broadband areas.

In 2011, Telecom Corp New Zealand completed a structural separation in order to comply with the conditions of the broadband initiative and the 2006 amendments of the Telecommunications Act. It voluntarily divested its fixed network and wholesale operation into a separate company named Chorus Ltd. The remaining part of the company, including the mobile and fixed retail operation, was re-named Spark New Zealand Ltd. Chorus maintains its national copper network and has built out fibre networks in 24 candidate areas, where it has been awarded concessions to connect over 830 000 premises, investing USD 2.45 billion, facilitated by a capital injection of USD 761 million from Crown Fiber Holding.

Northpower Fibre deploying fibre in Whangarei

In 2014, Northpower completed the deployment of a fibre network in Whangarei, serving around 80 000 people.[160] Northpower, one of the largest multi-utility contractors in New Zealand, set up Northpower Fiber in order to manage the fibre deployment after it secured the contract with Crown Fiber Holding. The latter contributed with financing, complemented by funds from Northpower Limited.[161] A contributing factor to Northpower becoming a network partner was that it had established a smaller fibre optic network in Whangarei in 2007. Here the utility had leveraged the existing electricity distribution network to provide broadband services to local businesses.[162]

In total, the Northland region has 166 000 inhabitants and covers 14 000 km^2, representing 4% of the population of New Zealand and 5% of the country's surface.[163] In Whangarei, household penetration of fixed Internet services is ~60% compared with ~75% nationally.[164] The fibre network has been deployed to more than 19 000 premises, and the penetration of the Northpower fibre network was 15% at December 2014, increasing by 1% per month, with a customer base over 3 000.[165] The capital investments done by Northpower in the fibre deployment during 2008-2014 amounts to USD 29.2 million which means that it has contributed to work and economic activity in the region.

Whangarei is the capital of the Northland region with almost half of the population.[166] The Whangarei district has around 27 000 employees working for more than 6 500 businesses, and the area generates approximately 50% of the economy in Northland.[167] The district's vision is to be vibrant, attractive and thriving while developing sustainable lifestyles based around their unique environment.[168]

Customers can choose between a wide range of competing service provided by retailers with 15 linked to on the website.[169] The services on offer for consumers have substantially improved in terms of quality, performance and prices. By way of example, a consumer spending USD 81 per month in 2010 would have expected to receive a bit cap of 20 GB, an advertised speed of 24 Mbit/s, though declining with

further distance from the exchange. By 2015, for the same amount a consumer could receive 100 Mbit/s over fibre and a 150 GB cap. Alongside the substantial reduction in price for the faster speed and increased data allowance consumer could also chose other plans that were not available in 2010 such as faster speeds (200 Mbit/s up and down to 1 000 Mbit/s in the so called Gigatown region) as well as unlimited data (Table 5).

Table 5. Price comparison fixed broadband New Zealand 2010 and 2015

	2010	2015	Change
Monthly price USD	81.24	82.09	1.0%
Monthly price USD PPP	67.73	67.35	-0.6%
Price Mbit/s USD PPP	2.82	0.67	-76.1%
Price per GB USD PPP	3.39	0.45	-86.7%
Subscription	DSL	Fibre	
Download Mbit/s	24	100	317%
Bit cap GB	20	150	650%

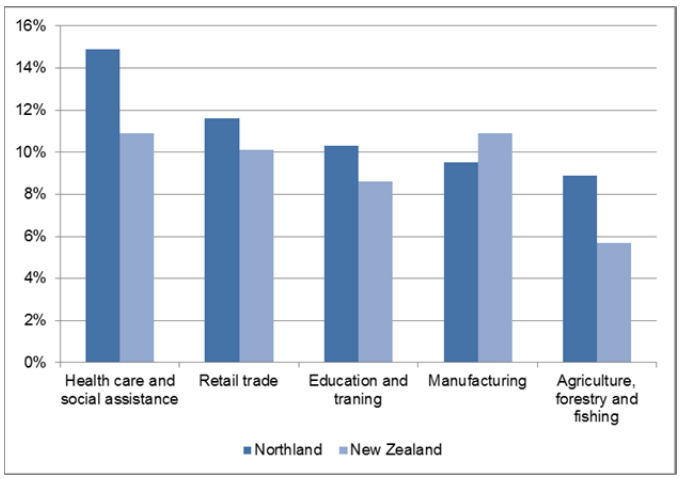
Note: The 2010 prices were for Telecom New Zealand and for February 2015 for Snap. Source: Communications Outlook 2011 and retailer websites

The experience of with ultra-fast broadband

Following the focus on increased retail competition, first through unbundling and then open networks under the government sponsored programme, together with the improved underlying infrastructure, growth in the penetration of broadband has continued to increase apace. From 2006 to 2014, New Zealand shifted from 26th to 15th for fixed broadband penetration in the OECD area. In terms of the ultra-fast broadband (UFB) programme, the national uptake figures reached 11.3% as of December 2014, more than double the December 2013 rate and more than four times what it was at the end of 2012.[170] During the three months to December 2014 the number of end users connected to UFB increased by 26% from 55 010 to 69 301. In total more than 570 000 New Zealand homes and workplaces are now able to connect to fibre.

Given the broadband network in Whangarei was completed in mid-2014 it is still too early to make any definite analysis of the effects of the broadband initiative. What can be said is that the network is aimed at creating new opportunities in a region which is below national averages in terms of income and in which there are higher levels of unemployment. In Whangarei specifically, household incomes are only 69% of the average of all towns and cities where UFB is currently being deployed.[171] The median income in Northland is USD 19 180 compared to USD 23 360 (for New Zealand, unemployment is 9.7% compared to 7.1% for New Zealand.[172] The UFB network could potentially improve the socio economic outcomes in the region. Given that health care and education are among the top three industries the improved connectivity to schools and hospitals could be beneficial, along with higher residential penetration as they interact with these and other institutions (Figure 11).

Figure 11. Top five industries in Northland



Source: Statistics New Zealand, Census 2013

The broadband network in Whangarei can have a positive effect on business through improved productivity and economic growth. This is because reliable and faster Internet connections that allow large amounts of data such as files, plans and images to be downloaded and uploaded were not available previously. It also provides more cost efficient communication with new features. Improved access to online video and television services are a further feature.[173] E-commerce allows companies to reduce production, administration and sales costs and increase revenues. Telecommuting would save people and businesses time and money, as well as reducing traffic congestion and its environmental impacts.

Implications for education and health sector

In 2014, the Manaia View School, located in the far north in Whangarei, established the Te Puawai Education Programme, initially providing students at six Whangarei schools with tablets facilitating new tools for learning. It is planned to expand this programme to other schools in the region.[174] The access to ultra fast broadband has enabled Manaia View School to involve the pupils in media production of children's programmes for teaching through its television station Pukeko Echo Television and distribution of streaming video on their Channel North website.[175]

Teachers at Manaia View School say learning over the ultra fast broadband has improved numeracy and literacy and greatly increased student attendance and engagement. Moreover, the school has courses for learning at home how to use computers, which have enabled the parents to follow their children's development at the school. High speed broadband can also benefit distance education through virtual classrooms, enabling curriculum sharing and interaction with other students.[176]A further school in the region is Whangarei Boys' High School, with over 1100 students and 100 staff. The school has implemented a range of technologies around the ultra-fast broadband network to connect with Internet and Internet Protocol (SIP trunking) voice calling, to support an innovative approach to education. It has six computer labs, utilises the 'laptop for teachers' scheme and supports Wi-Fi access with over 300 network and Internet enabled devices.

The school says the fibre network has enriched the learning experience for the students by giving them access to relevant, high-quality content and has enabled a wide variety of platforms to produce material, stream media and archives on multiple devices, all of which was previously challenging or unattainable. They add that teachers are transforming the way in which learning takes place, through discovering and utilising new tools and content to facilitate the delivery of the curriculum. It also facilitates

a more flexible learning situation as it is possible to move around but still be connected, through wireless communication, video conferencing, and distance learning. Moreover, the Whangarei Boys' High School, says it has been able to save costs and improved administrative efficiencies.[177]

Potential benefits for the health sector through the availability of ultra-fast broadband include home care, electronic patient health records which are securely stored and universally accessible to authorised medical practitioners, and electronic transfer of advanced medical images. The ultra-fast broadband network offers benefits to rural communities, with the prospect of remote diagnosis and rapid record transfer, while businesses will have faster teleconferencing and better access to the cloud.[178]According to Varnosafaderani (2013) the ultra-fast broadband network in New Zealand will not only have a positive impact on the provision of telehealth in New Zealand, but also ensure universal connectivity, boost economic development and benefit many other sectors and areas, such as education.[179]

Growing share of user on fibre

By June 2014 the share of broadband subscribers that were connected with fibre in New Zealand was 2.4%, compared to 6.8% in Northland. The growth trend indicates that share is going to pass 10% in early 2015, potentially lifting the share of households that were connected by fixed broadband from 63% in mid-2014.[180] Access to ultra-fast broadband has vastly improved communication infrastructure and services in Whangarei, with all the potential benefit for the local economy and society. The early indications from the field of education are promising, even more so as it is the opportunities for young people that will support the long term development of the region.

The undertaking for Northpower has been manageable and with an average capital expenditure of USD 1 183 per connection it indicates that the deployment has been cost efficient. Assuming average wholesale revenue of USD 46 per connection and month and a discount rate of 7.5% and an EBITDA margin of 35% the capital investment would be returned after ten years.

Box 6. Spain - Municipalities and Government co-ordination on communication networks

The wide variety of licenses and procedures to be fulfilled in different municipalities is commonly a major challenge for market players in the deployment of high speed electronic communications networks in different territories of a given country, potentially adding costs for operators, and in the worst case hampering infrastructure investments. Nevertheless, municipalities need to take decisions concerning urban planning, in order to minimise the effects of network deployment on the urban environment, and pursue a homogeneous spatial planning.

In Spain, in order to balance these interests, the General Telecommunications Law of 2014 considers the use of co-ordination instruments allowing the regulatory authorities to assess urban management measures affecting infrastructure for electronic communications. These instruments rest on the requirement for municipalities to obtain a binding report from the Ministry of Industry on their urban planning instruments, which also must examine them and verify the accomplishment of the measures provided according to the General Telecommunications Law. Once they have been examined, a report on the accomplishment has to be submitted within three months. In the case of this not being a favourable report, the municipality may alter those elements that does not comply with the law or submit allegations within one month. The Ministry of Industry shall examine those corrections or allegations, and submit a final binding report within one month. In case the report is not favourable, the municipality is not allowed to approve its urban planning related to the part affecting the deployment of electronic communications networks given that it does not comply with the General Telecommunications Law. The municipality may start the process anew with a new urban planning containing new wording for the articles that were previously not approved.

During the process, an active communication between the Ministry of Industry and the municipality is ongoing, where different arguments and understandings are met, respecting both General Telecommunications Law dispositions and municipalities' urban planning needs. The co-ordination instruments were implemented in May 2014, and by the end of 2014, more than 400 reports had been submitted. Around 100 of the reports had an unfavourable outcome in the first round, and after the second round only two unfavourable final reports were submitted. The co-ordination instruments facilitates a harmonisation of rules that different municipalities apply for the deployment of electronic communications networks, resulting in a more efficient process for market players potentially reducing the costs for deployment of infrastructure.

SWEDEN

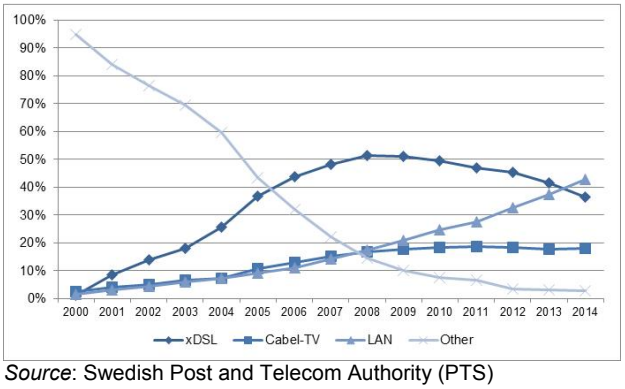
Municipal networks has been decisive for the fibre development

In March 2000, the Swedish government proposed measures with a goal of making the country an information society accessible to all. This included increasing reliance on IT to meet objectives, improve skills to use ICT and to extend accessibility to digital services. Altogether, the new bill underlined the importance of local and regional investment in high capacity broadband infrastructure and included a financial package of USD 0.9 billion. The funding was aimed at providing support for a national operator-neutral backbone, providing incentives for municipalities to develop access networks, support regional networks and connect public institutions. A requirement for interested parties to receive financial support was that networks were operator-neutral, and that no network had been deployed in an area in order to be compatible with European Union state aid rules. In many ways, the bill can be said to have kick started broadband developments in Sweden.[181]

The Swedish government's target is for 90% of households and businesses to have access to at least 100 Mbit/s by 2020.[182] As of October 2014, 61% of households and workplaces had access to 100 Mbit/s, and 54% of the population had access to fibre, with their homes being connected, but not necessarily activated. At that stage, some 13% of the population in rural areas had access to fibre.[183]

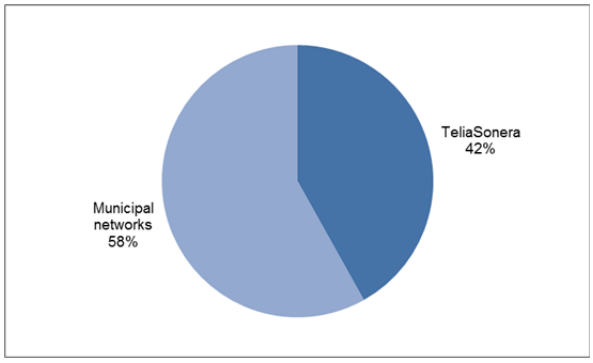
By mid-2014, the number of subscribers with xDSL and fibre were on a par (40%), but by the second half of 2014 the number of fibre subscribers surpassed xDSL, as the influx of new fibre users continued to grow (Figure 12).[184] The focus is on fibre, and 68% of the users have subscriptions with at least 100 Mbit/s, while VDSL only reaches 18% of the population and provide an average actual speed of 22 Mbit/s compared to 82 Mbit/s for fibre.[185]

Figure 12. Market share fixed broadband



Source: Swedish Post and Telecom Authority (PTS)

Figure 13. Provision of fibre lines



Source: OECD estimate

People in Sweden have a growing appetite for fibre, driven by a desire to use streaming video, web browsing, social media and financial services, as well as in handling community and public services.[186] In 2014, for example, 70% of taxation declarations were provided electronically and increasing shares of interactions with public authorities are handled over the Internet in almost every field.[187]

A decisive factor behind Sweden's high take up of fibre (14.8 fibre subscriptions per 100 inhabitants, placing Sweden third after Korea and Japan)[188] and wide availability is that municipal networks have been deployed extensively during the two decades following market liberalisation in 1993.[189] There are around 180 municipal networks in Sweden, but as a number of these networks cover more than one municipality, there are municipal networks in over 200 (out of the 290) municipalities in Sweden, which altogether are responsible for 58% of the fibre lines (Figure 13).[190] Another indication of the significance of municipal networks is that they accounted for 23% of the fixed broadband investments in Sweden during 2014. Municipal networks invest in expansion of fibre to multi dwelling units, single dwelling units, and connect village fibre networks.[191] The majority of municipal networks are relatively small and a consolidation seems to be underway as they sign co-operation agreements, merge, or are acquired by private sector operators. This has been a concern for some. For example, the Swedish Association of Local Authorities and Regions (SALAR) has stated that it is more beneficial for municipalities to maintain the control of their networks. They believe that municipals otherwise risk losing the ability to determine coverage, decide on expansion and maintain open networks.[192]

In Sweden, municipal networks are predominately providing basic infrastructure, operator neutral networks, based on fibre to the building or fibre to the house (FTTB/FTTH), and together with partners provide a fibre optic platform creating conditions for what they say are cost-effective communication solutions for business, the public sector and local citizens.[193] This is in contrast, they say, to the business model pursued by vertically integrated operators whose networks primarily are provided to maximise returns to shareholders. In Sweden, municipal networks, facilitate a wholesale market on dark fibre, open for interested service providers on equal terms in order to provide services to consumers and businesses. This enables the network to be shared between network and service providers, in a form of asset sharing. The proponents of municipal networks in Sweden argue that because their priority is in wholesale there is less risk for a conflict of interest with service providers, and it lowers the entry barrier for interested

parties. Certainly, they have provided backhaul for mobile networks, which has been instrumental in the deployment of competing 4G networks with very extensive coverage in Sweden.

In Sweden, the municipalities' involvement in broadband infrastructure is based on a number of elements, which may not be in common with all OECD countries, where such activities may be undertaken at different levels of government (i.e. provincial/national). First, municipalities in Sweden are responsible for providing a significant proportion of all public services and infrastructure, with utilities, such as energy and water. They are also responsible for city planning and, therefore, are used to handling large projects, all of which was beneficial for their entry into broadband infrastructure provision. For their part, the local governments view municipal networks as a basic infrastructure for society, in the same way as they see other public utilities, which are provided for the common good with the support of the Swedish Local Government Act They believe broadband makes municipalities more attractive for people and businesses and thereby contributing to economic growth.

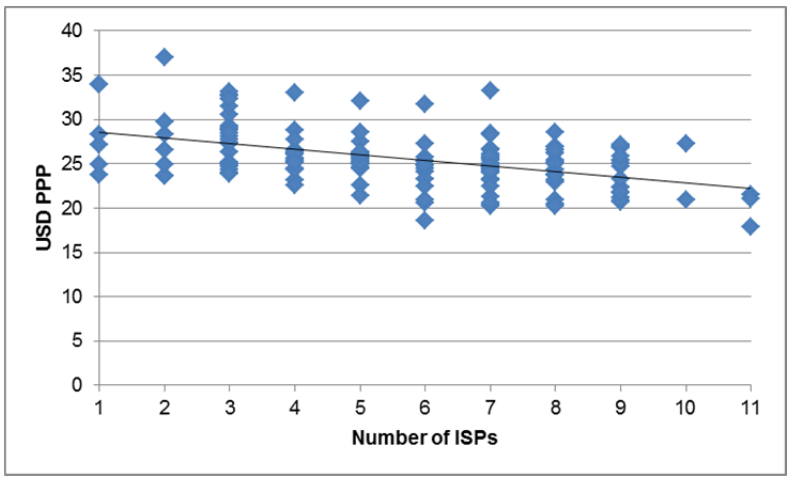
In Sweden, municipalities have a considerable degree of autonomy through the Swedish constitution and local self-government is a longstanding tradition. As a result the Swedish Local Government Act gives municipalities the mandate to engage in business activity if it is conducted without a view to profit and is essentially concerned with providing communal amenities or services for the members of the municipality and take steps for the general promotion of enterprise in a municipality and ensuring that sparsely populated areas are provided with basic infrastructure.[194] Municipalities have independent powers of taxation and are capable of raising capital, which is essential in order to build networks. The municipalities' involvement in broadband is also driven by a need to be able to offer welfare services, i.e. services in education, health and social care over broadband networks.[195] Four out of five municipalities provide e-services, such as for example, home care, nursing services, social services, library services, civil dialogue, and digital security alarms.[196] Moreover, the Swedish population has a positive attitude towards the public sector and there is a general view among local policy makers as well as market actors that publicly owned operator neutral networks safeguard a competitive market on services and applications for the benefit of consumers and businesses.[197]

Lower prices with open municipal networks

Given that municipal networks are local/regional with different cost structures and strategies wholesale prices vary, which leads to geographical variations in retail prices. Altogether, prices for broadband subscriptions, for municipal networks with several ISPs, is somewhere between 23% to 38%, lower compared to national prices. They are also 25% lower compared to municipal networks with only one ISP, which is an exception as only 7% of the municipal networks provide only one Internet service provider.[198] The lowest price for a 100/10 Mbit/s fibre subscription is USD 23 per month. The average price for a 100/100 Mbit/s subscription, in municipal networks with multiple ISPs, is USD 35, while the lowest national price is USD 45. For broadband subscriptions with 700 Mbit/s, prices are around USD 102 per month.[199]

Forzati *et al*. (2013) made a survey on prices that service providers charged for 10 Mbit/s symmetrical Internet services on municipal networks, and found that prices are inversely proportional to the number of competing service providers. As might be expected, the more service providers, the lower the prices.[200] Prices in networks with one supplier vary for the same service between USD 24-34, while the same service in networks with more than 10 suppliers was priced between USD 16-19 (Figure 14).

Figure 14. Price per month for broadband access in municipal networks



TeliaSonera, the historical incumbent telecommunication operator, is extensively rolling out fibre networks to single dwelling units through an FTTH approach, the predominant model in Sweden. Nonetheless, according to its CEO, demand is increasing at a rate that is challenging to meet. Half of its capital expenditure in Sweden is on fibre roll out driven by strong competition, as the company is striving to best place its network in terms of long-term objectives.[201] This is even though the established practice is that owners of single dwelling units pay an installation fee of around USD 2000, although this can vary depending on local conditions.[202] Of the total 2.0 million SDUs in Sweden 17% were connected to fibre networks by October 2014, compared to 13% a year earlier.[203]

In Sweden, the predominant business model for municipal networks is one of open networks where they are physical infrastructure providers (PIP). These networks own and maintain the passive infrastructure and offer wholesale access on a non-discriminatory basis to Network Providers (NP). The NPs operate, and typically own, the active equipment and this role can be performed by incumbent operators, new independent operators and specialised broadband companies. The NPs subsequently provide capacity to ISPs. This means that the passive network is separated from active network provisioning and services, which proponents say reduces the risk for conflict of interest, and promotes a competitive service and retail market.

There are examples of municipal networks that both own and operate the network (PIP + NP), and in some cases also provide retail services (SP). One reason for this development is that it can be challenging to attract service providers to small and remotely located municipal networks due to a lack of sufficient scale. In Sweden, this has been addressed in some locations by forming regional networks, a type of federation of small municipality networks, which can provide the scale, visibility and 'single-interface' towards service providers. Another effect is that they have made it possible for small networks to provide dark fibre on the wholesale market. Moreover, the role of network provider (NP) has changed over time as they initially were independent companies, which were intermediaries between the municipal network and service providers, with a connection to establish indoor wiring in collaboration with housing companies. However, given that the initial NPs had limited capital and the margins were slim, they have subsequently been acquired by operators or media companies providing access to the retail market. Concurrently, municipal networks have moved downwards in the value chain closer to just owning the fibre infrastructure (PIP).

The open access business model poses some challenges in the management of the responsibility areas, such as in fault management and first line support, between the service providers and the network provider, which run the actual network connectivity. A limitation with FTTH is the reliance on power at the end-user

premises. This makes it challenging to deploy critical services on fibre connections, such as alarms to carers for the elderly and reduced mobility citizens. Several options to address these issues have been tested, but none has yet been found to be sufficiently reliable.

Stockholm - Stokab

The municipal network in Stockholm, Stokab, has since its inception in 1994 established a fibre network that connects almost all multi-dwelling units and commercial properties in Stockholm, and up to 2014, had invested USD 0.7 billion.[204] Approximately 88% of the population and 90% of the workplaces in Stockholm have access to fibre based broadband.[205] It is an operator-neutral fibre network, where Stokab owns and maintains the passive fibre network, while market players operate and deliver services over the network, underlining that the infrastructure is available to all. The network is used by 100 operators and 800 enterprises.[206] Stokab has completed their current deployment plans which have led to a gradual declined of capital expenditures to sales to 13% in 2014 (Figure 15). The return on capital employed has been stable around 10% to 11%, indicating a stable and healthy return (Figure 16).[207]

Figure 15. Capex to sales

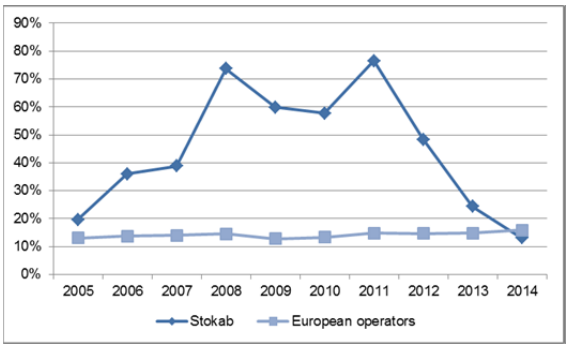
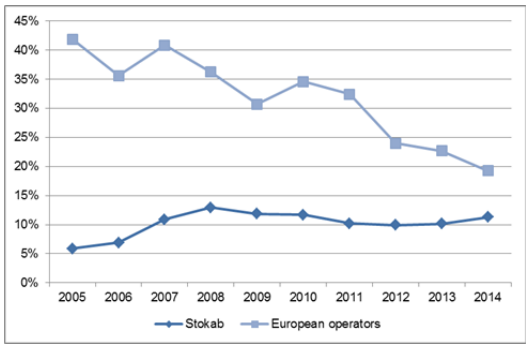


Figure 16. Return on capital employed



Source: Stokab annual reports, Bloomberg[208]

Stockholm is recognised as a leading ICT city in which the municipal network has played an important role. The Networked Society City Index 2014 from Ericsson, which analyses leverage from ICT investment in economic, social and environmental development, marks Stockholm as the world's most ICT-mature city.[209] In May 2014, PWC rank Stockholm as a top three city when it came to technology readiness in the Cities of Opportunity, which analyse the trajectory of 30 cities.[210] Meanwhile, Kista Science City, located in Stockholm, has more than 1 000 ICT companies and around 24 000 employees, as well as 6 800 university students and 1 100 researchers within the field of ICT, which has established a solid foundation for a creative ICT cluster.[211] There are around 22 000 technology companies in Stockholm, and it has among the highest share of 'high tech' employment in the European Union, with 18% of the workforce.[212] Over the years there has been a number of company success stories such as Skype, Spotify, and Mojang (developed Minecraft) supported by the high availability of broadband in Stockholm.[213]

The three large public housing companies in Stockholm[214] have played an important role in the development of broadband to tenants in multi dwelling units as they started to deploy indoor wiring in 2002 and set a target to connect all apartments with fibre by 2011, a target that was accomplished. The Swedish housing company was convinced that tenants were going to demand gradually higher capacity and that fibre networks was the only future proof technology.[215] This paved the way for other property owners to also deploy indoor wiring as the demand for high capacity broadband grew over time. Based on the experience of being locked into exclusive contracts with a cable television company they adopted a policy to establish open networks, which was in line with Stokab's objective, and contracted to a network provider to function as an intermediary between the municipal network and service providers that were

interested to market services to the tenants.[216] The tenants had to pay an extra USD 6 when the network was connected, regardless if they used it or not, together with the cost for the broadband service, making it possible for the housing companies to cover the cost of the network.[217]

Access to fibre networks is vital for mobile network operators as it provide backhaul with unlimited capacity from mobiles sites to core networks, which has been decisive for providing access to 4G networks to the entire population in Stockholm.[218] Given that TeliaSonera has a fibre network through its subsidiary Skanova, the competing mobile operators used Net4Mobility (owned by Tele2 and Telenor) preferred to find other suppliers for its backhaul. This meant that Stokab's network was suitable as it could provide the mobile operator with massive volumes on demanded.[219]

The effects of Stokab's network has been analysed by Forzati and Mattsson (2013). The research estimated the socio economic return to be USD 2.5 billion, over three times the investment.[220] The estimates consisted of the creation of new jobs through the development of advanced services and entrepreneurship worth USD 1.2 billion; the procurement and deployment of the network had generated over USD 0.8 billion of economic activity for the supplier industry; lower cost for communication services for the city of Stockholm and the region was estimated to be USD 0.3 billion; the deployment of fibre network to the housing companies in Stockholm (with 100 000 apartments), which have been equipped with indoor wiring gave a higher property value estimated to USD 0.3 billion as well as increased rental revenues of over USD 4.6 million per year; and with the open network with intense competition on service providers have resulted in lower prices for broadband, estimated at USD 12 million per year if compared to Copenhagen.[221] Altogether, the experience from Stockholm shows that a basic infrastructure can promote service competition and give ISP to develop their business and provide end customers with competitive prices.

Hudiksvall – Fiberstaden

The Hudiksvall municipality, with a population of 37 000, of which 40% lives in the main town, is situated in Gävleborg County, on the northern coast of Sweden, 300 km north of Stockholm. Besides the municipality and county council, which together employs 38% of the workforce, the forest and electronic industry employs a substantial part of the remaining work force. Based on an established production of telecommunication equipment in Hudiksvall a fibre research and speciality production has been developed with support from structural funds provided by the European Union.

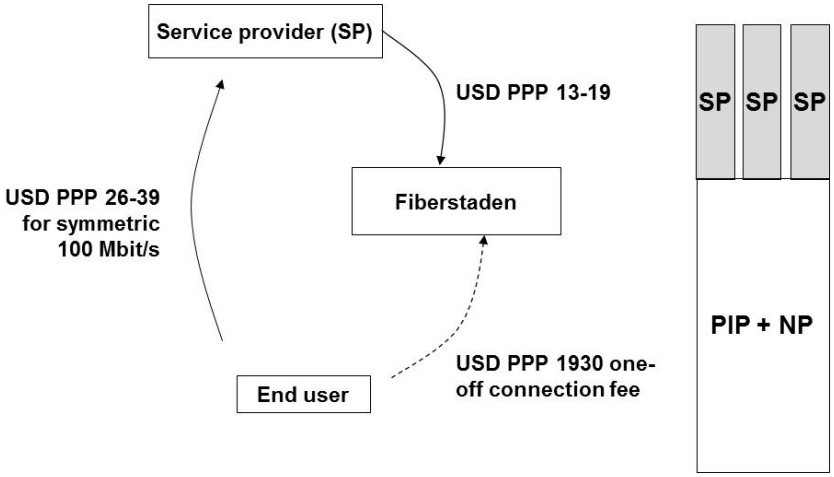
Hudiksvall started to deploy a fibre network in 2002, managed by Fiberstaden, owned by the municipalities, which also manages the IT operations for Hudiksvall and neighbouring Nordanstig municipality. By October 2014, 48% of the population and 43% of the workplaces had access to fibre in Hudiksvall, but given that 81% of the population had access to or lived 354 meter from a property with access to fibre it indicates that the municipal network has an extensive coverage.[222] Given that the municipality combines urban, suburban and rural areas the conditions for fibre varies locally, and in some villages 25-50% of the households are connected to the network, and among those connected, the uptake of Internet services is almost complete.[223]

Fiberstaden operates an open municipal network and functions as a PIP and used an external NP until April 2014, when it took over the NP role, which it always did in Nordansting.[224] Five service providers offer broadband services and VoIP to customers and four companies provide television.[225] The service providers are selected over an online service portal, and once a subscription and service has been purchased the end user pays directly to the service provider. There are also IT services being offered, such as cloud and web based, for small companies (Figure 17).

The development has not been without problems as Fiberstaden initially took up the NP role, but the company ran into trouble with unsatisfied customers. After a recommendation from SALAR, Fiberstaden decided to outsource the active network management to a network provider Zitius. This did not, according to the CEO, make things better as the NP did not have any local staff and Fiberstaden still had active equipment to take care of as part of its roles.[226] Subsequently, Fiberstaden decided to take back the NP function and terminate the contract with the NP.[227]

Fiberstaden offers capacity services, like point-to-point transmission, to companies and dark fibre to broadband and mobile operators. About 30% of Fiberstaden's revenues are generated from dark fibre and wholesale connectivity services. The media converter at the customer's premise is owned by Fiberstaden, who also takes care of customer support and fault handling. The business model pursued by Fiberstaden is described in the following figure, where the end user in a single dwelling unit pays USD 2000 to Fiberstaden to get connected to the network, and then pays USD 27-40 to the SP for a 100 Mbit/s subscription. The SP pays USD 13-20 to Fiberstaden.

Figure 17. The business model for the Fiberstaden fibre network



The Hudiksvall municipality uses the Internet to communicate with its inhabitants, such as for providing a broad range of e-services, financial information, information about the municipality's institutions, business permits, building regulation and permits, fault reporting of roads, lighting, a web page for citizen proposals and library services.[228] As all municipal institutions are connected, it facilitates more efficient internal communication and administration, such as for public procurement.[229]

The municipal network has, according to representatives of Hudiksvall, had a positive effect on the overall business climate in the municipality, and there are examples of companies that have moved from the town to rural areas due to the availability of the network, and lower living costs. Hudiksvall had, like many municipalities in rural Sweden, a declining population, but since the launch of the municipal network the population has stabilised, and with a slight increase since 2012.[230] In a small village called Lindefallet, located 34 km south of Hudiksvalls, some 98% of the households are connected to the network. Authorities report that several families have postponed previous plans to move after obtaining access to the network. Indeed, some have built a new house in the village saying they could have a connected life while being able to live closer to nature. Since the network was deployed in 2004, the population in Lindefallet has increased by 7.5% despite there being no access to other facilities, such as a school and health clinic in the village.[231]

Effects of digital home care services

A number of municipalities in Sweden have tested FTTH-enabled digital services, and one in three municipalities report that they offer social services, as for example related to schools and care services over the Internet. Forzati and Mattsson (2014) analyse the socio-economic effects of the introduction of FTTH-enabled digital services in home care.[232] The analysis takes its starting point in Västerås, with 110 000 inhabitants, situated 105 km west of Stockholm.

The Västerås' study captured the effects of four e-services, which have all been tested and evaluated in the home care service, and the users have been positive, as it has led to greater independence, security, participation and freedom of choice, given that services are optional rather than compulsory. Two of the services comprise video communication that allows the elderly to stay in touch with home care personnel, family and friends. In the first one, communication takes place via a television set, in the second, via a robot-like, remotely-controlled video unit capable to move around in the home. The third is a service, which provides ways of sending and receiving text, voice, images and video messages and is used to manage planning, booking and follow-up of services by the end users. The fourth service uses a night-vision camera to enable the supplementary monitoring of individuals while they sleep, which is complementing or replacing physical visits by which home-video care personnel get video access to end-users' homes at night.

Two scenarios to capture potential effects of digital home care

The cost benefit analysis consists of two scenarios: a cautious, where 10% of the home care users use digital services, and a comprehensive scenario where almost all eventually use digital services. The cost of home care (K_{tot}) consists of the cost per user (k_b) multiplied by the number of users: $0.1 \cdot k_{65}$, where the starting point is that 10% of the elderly (above 65) are home care beneficiaries.[233] The function is as follows: $K_{tot} = 0.1 \cdot k_b \cdot a_{65} \cdot B$ where B is the municipality's population, a_{65} the percentage of people over 65. Cost reductions are calculated for four services that are deployed for 300 residents, around 10% of the home care users, with four different categories.[234] The analyses showed that transport cost can be reduced by USD 2.9 million due to fewer physical visits; shorter missions, as supervised visits via ICT can often be shorter, reduce cost with USD 0.4 million. Fewer visits due to reduced insecurity as it is easier to contact the personnel, which reduced cost with USD 0.5 million. Each of the four services generates cost reductions for a small part of the users and home-care activities; however the introduction of the digital services does not eliminate the need for the traditional home care services.

Based on the Västerås study Forzati and Mattsson (2014) built an analytical model to pursue the cost benefit analysis for different types of municipalities, taking into consideration the average distance between home help entrepreneurs in different types of municipalities, and demographic trends. The saving of a municipality is directly proportional to the cost per user and the number of home help recipients. The savings in transportation costs is proportional to the root of the root of the mean distance of home help recipients. Average distance between home care users are inversely proportional to end-user density, i.e. population density times the number of home care users per capita.

Exploring the potential in three different types of municipalities

Introducing digital services to a new group of users entails one-off costs, and recurrent operating costs. The cost is estimated to be proportional to the square root of the number of home care users who take up digital services. The analysis is conducted on three municipal examples, from small to large cities in Sweden. A sparsely populated municipality with 8 000 inhabitants with 2 inhabitants per square km, a mid-sized city with 90 000 inhabitants with 80 inhabitants per square km, and a large city with 500 000 inhabitants and 1 200 inhabitants per square km. For each municipality the work calculated the current cost

of home care and how it is expected to develop according to the demographic and unit cost trends, which are different in each municipality. Rural municipalities have a more challenging demographic development than the cities as they manage to keep down costs, through larger scale and shorter distances between home care takers. In all three types of municipalities, however, the cost per user increase over time.

In 'Scenario 1' presented by Forzati and Mattsson (2014) digital services are offered to 10% of home care users from 2014, among those wishing to participate and have access to high speed broadband. In 'Scenario 2', digital services are offered to 10% of home care users initially, but is gradually increasing to 90% by 2020. This assumes that high speed broadband is expanded over the period in order to reach full connectivity among the elderly by 2020, and that there is an acceptance of digital services among home care users.

For 'Scenario 1' the cost savings will exceed the investment right from the first year, and the net effect increases over time. For 'Scenario 2', the cost reduction will be significantly larger than the investment already from the first year, and the net effect increases over time compared to Scenario 1. For example, in the sparsely populated municipality the initial investment required the first year is USD 0.13 million; from the second year, the cost grows due to the investment in new installations and the annual cost reaches its highest level in 2020 with USD 0.4 million. The cost reductions that the use of digital services are generating are USD 0.5 million during the first year but this grows quickly as new users start to use digital services, and by 2020 the cost reductions are worth between USD 2.6 - 5.4 million.

The cost of home care for the rural municipality is expected to increase from USD 6.6 million in 2013 to USD 8.2 million in 2020, an increase with 34%. Although cost reductions generated under scenario 1 are significant the total for cost home care continue to increase by 25% between 2013 and 2020. Scenario 2 generates such large potential cost reductions that the total cost of home care in 2020 may even decline with up to 48% compared with 2013.

The cost benefit analysis indicates that it is possible to achieve significant cost reductions by using digital services in home care services. The annual net cost reductions generated if just 10% of home care service recipients use digital services is estimated to be USD 0.6 million for a rural municipality with 8 000 residents by 2020; a medium-sized city with 90 000 residents can lower the cost with USD 3.6 million; and a large city with 500 000 residents can lower the cost with USD 9.2 million. The study showed that under Scenario 2, which assume that 90% of home care service recipients by 2020 used digital services, could lower annual net cost in 2020 by as much as USD 5.0 million for a rural municipality with 8 000 residents, a medium-sized city with 90 000 residents could lower the cost by USD 32 million, and a large city with 500 000 residents could lower the cost by USD 86 million.

The demographic and unit home care cost trend indicates that costs for elderly home care will increase from 20% to 35% by 2020 compared with 2013. A widespread introduction of digital services could stabilise the cost for home care or even decrease it by up to 50% for sparsely populated municipalities, but it requires that end-users have access to high quality, reliable broadband connections. This involves a high degree of co0rdination and planning in any country and a further example can be provided in Italy (Box 7).

Box 7. Co-ordinated actions between central and local government in Italy

In March 2015, in order to accelerate broadband diffusion and increase the benefits of a digital economy, the Italian government adopted two national co-ordinated strategies focusing respectively on infrastructures and digital services. The country has been divided into 94 645 local areas, grouped into four clusters, in accordance with EU Guidelines for state aid rules, that differentiate the rate of the deployment of broadband networks, highlight related market issues and based on these determine the most appropriate economic instruments to be used.

The Italian government estimates that investments in the order of USD 16.4 (EUR 12.3 billion) are required to reach the targets of the European Digital Agenda by 2020. This would enable 100% of the population to have access to 30 Mbit/s and at least 50% of the population to have access to 100 Mbit/s. The plan aims to connect all public administrative buildings, hospitals, schools, industrial areas, logistical hubs, research and technology centres, and courts with infrastructure capable to provide at least 100 Mbit/s. Both public and private local stakeholders play a crucial role to support the central state in order to achieve the targets.

In Italy, many municipals have started to play a role, such as in Cremona. In that city, AEM SpA, a publicly owned neutral fibre network operator, has deployed FTTH infrastructure altogether consisting of 11 000 km of fibre. During the period 1999-2008 AEM Spa invested around USD 26.9 (EUR 21 million) to deploy a network in the Cremona area connecting 3300 buildings and passing through 5 500 households. Subsequently, ultra-broadband services have been provided by AEMCOM, a functionally separated entity from the infrastructure owner (AEM Spa). The network utilizes existing ducts in the subsoil related to the district heating system, covering 50% of the territory, and in total connects 40000 households and 7000 firms.

In order to support local public and private stakeholders in deploying broadband networks, the government has established a national registry of the sub and over soil infrastructures, also known as SINFI, (law 11 Nov 2014 n. 164). The reuse of underground infrastructures like gas, electricity and water significantly reduce trenching costs, which commonly comprise up to 80% of total deployment cost.[235] The SINFI registry, located at the Ministry of Economic Development, is not only an infrastructure database but also a portal, which co-ordinate civil works, monitors national and local structural interventions, offers dedicated services to national and local administrations, private operators and citizens. For example, the FTTH network deployed by Metroweb in Bologna in 2015, in close collaboration with the local government, could be deployed at a 30% lower cost due to the use of the local registry.[236] By implementing this approach at a national level and connecting all the regional registries with the SINFI, the aim has been to boost the diffusion of broadband infrastructures in Italy. In addition, the approach aims to provide possibilities to differentiate business models, opening the market to increased competition, as well as developing services and creating new jobs and opportunities connected with the digital economy.

THE UNITED KINGDOM

Public support to municipalities

In 2012, the United Kingdom launched the 'Broadband Delivery UK' (BDUK), a scheme to promote deployment of ultrafast broadband in local municipalities, with a budget of USD 873 million during the then parliamentary period (with a further USD 494 million to be made available in the future).[237] In order to comply with the scheme, local municipalities were obliged to conduct an open tender process to select a supplier to build and operate a broadband network. Financing could be a combination of state aid, local municipality financing, with a total public budget of USD 2.8 billion, and resources provided by the selected operator, which based on the subsidy could make cost efficient investments. The successful network providers are required to provide wholesale access to other operators in order to comply with state

aid rules.[238] Although the ambition with BDUK was to combine improved broadband coverage with increased competition, the incumbent operator (BT) obtained all the 43 contracts with the local bodies that used the framework, as it was the only bidder. This has enabled BT to benefit from approximately USD 2.8 billion in public sector investments, although the company has also made a significant contribution to the deployment of fibre to the node (FTTN).[239]

Although superfast broadband is widely available in the United Kingdom, there seems to be a demand for fibre to the premises and fibre to the home from some communities, businesses and residential users as there are a growing number of smaller alternative providers of Next Generation Networks, commonly referred to as "altnets". A recent report published by Ofcom identifies 40 altnets that provide NGA solutions in the United Kingdom, co-operating with municipalities, businesses and residential users.[240] The report found this development is characterised by a movement away from vertically integrated networks, a closer co-operation with users, co-investments, private public partnerships, larger re-use of existing physical assets and other utilities through collaboration with municipalities. It could, for example, be a municipality that provides fibre networks like Aylesbury Vale Broadband, which deploys superfast broadband to isolated villages in the North Marston/Granborough and Hogshaw area.[241] Or the community broadband company Gigaclear which deploys fibre networks in the north-west of Peterborough to a number of villages.[242] Another example is how the municipalities of Peterborough in Cambridgeshire has handled the issue of broadband, combining an agreement with BT and a strategic partnership with the company CityFibre.

Peterborough - BT and CityFibre

The Peterborough City Council is part of the Connecting Cambridgeshire programme through a partnership agreement with Cambridgeshire County Council made in 2011. [243] Connecting Cambridgeshire developed a local broadband plan, which was approved on 3rd April 2012, which aims to improve the local infrastructure and ensure access to superfast broadband for at least 90% of the homes and businesses and better broadband for all other premises across the Cambridgeshire and Peterborough. The aim was to boost business and enterprise, bringing jobs and prosperity to the local economy, and to improve the quality of life of local communities. [244]

In 2012, a market consultation was conducted in order to establish where commercial broadband services had occurred, was being made and was planned without public sector intervention for the next three years.[245] The consultation showed that without a public sponsored programme a third of the premises in the area would not have access to faster broadband services (24 Mbit/s and up) and a significant number would be without basic broadband (defined as up to 2 Mbit/s).[246]

In February 2013, Connecting Cambridgeshire signed a contract with BT, after a public procurement, with the target to provide a countywide high speed network with at least 24 Mbit/s to more than 90% of premises and a least 2 Mbit/s to the remainder, all to be completed by the end of 2015.[247] BT contributed with USD 26.4 million to the USD 75.8 million project. Connecting Cambridgeshire was allocated USD 11.1 million from the government through BDUK, complemented with USD 32.9 million from Cambridgeshire County Council and USD 5.1 million provided by the Peterborough City Council.[248]

The Peterborough City Council had, however, more ambitious goals for the town and after it had been approached by CityFibre it signed a strategic partnership agreement with the company in November 2013.[249] CityFibre, founded in 2011, is a designer, builder, owner and operator of fibre networks, primarily targeting cities with a population up to 0.5 million in the United Kingdom. It is pursuing gigabit city projects in Aberdeen, Coventry, and York. CityFibre owns and operates 490 route kilometres of local access networks serving over 800 customer locations in 60 towns and cities in the United Kingdom, and manages over 120 long-term contracts.[250] Cityfibre operates primarily as a wholesaler enabling Internet

Service Providers to deliver ultra-high speed connectivity services to local governments, businesses and consumers as well as providing fibre backhaul to mobile base stations, enabling 4G services.[251]

The strategic partnership between Peterborough City Council and CityFibre consists of three components:

- CityFibre is prepared to invest up to USD 49.4 million to deploy a full FTTH city network and a 90 km fibre network across Peterborough, facilitating high capacity broadband services for the public sector, businesses and residential users provided by Internet service providers. The network is endorsed by the City of Peterborough and funded solely by the company and aims to provide fibre optic broadband to over 4 000 businesses in Peterborough, representing around 80% of Peterborough's firms, but also to connect schools, libraries, hospitals and other community sites.[252]

- Peterborough City Council transfers its existing networks onto CityFibre's in order to improve capacity, transform services and lower costs.

- Change control for the Peterborough City Council's existing ICT managed service contract with Serco, an international service company, to enable the provision of connectivity to a dark fibre network.[253] The Peterborough City Council advised Serco to enter into a contract with CityFibre Holdings for the provision by CityFibre (at CityFibre's own cost) of a dark fibre network with connectivity. Serco was required to implement a new model of provision of the Council's network infrastructure to a dark fibre model.[254] Subsequently, CityFibre signed a 20-year contract with Serco in November 2013 to provide fibre connectivity to over 100 locations in Peterborough, and partnership agreement with local service provider Businesscoms.[255]

The partnership between Peterborough City Council and CityFibre has been estimated to result in substantial savings for the city. It is estimated that overall savings will amount to USD 7.4 million over the next 20 years, in part, by reducing the number of networks the municipality uses, such that all its provision is obtained through CityFibre's fibre optic network enabling lower costs for ICT, but more importantly is the anticipated growth propelled by the fibre network expected to outstrip the savings. [256] Proponents say it will create opportunities for new solutions and services, such as through the connection of CCTVs, which could create further efficiencies and a more responsive service.[257] Moreover, they say, the new fibre network will dramatically improve Peterborough's connectivity, supporting local companies to grow and develop further and attract new businesses to relocate to Peterborough. Council services and buildings are connected via the CityFibre network.

The Peterborough City Council will be able to use the network to improve services, make further efficiencies and save funds, which can be used to protect public services. It is envisaged that schools and libraries will use the network to help transform the services that they currently deliver. In March 2015, CityFibre completed the core fibre deployment in Peterborough, and the company has up to March 2015 invested around USD 6.6 million in the core network and the adoption rate among the businesses in Peterborough has been better than expected.[258] It has already had, according to the City Council, a positive reception from the business community, providing strong support to bring the benefits of gigabit speed connectivity to more and more businesses in the city. They say it is also generating the expected savings for the city.[259] Altogether, this means that Peterborough has access to BT BDUK contract, Cityfibre and Gigaclear, which according to the municipality provide the city with a world class connectivity.[260]

Box 8. Deployment of fibre networks through collaborative approaches

As an increasing amount of economic and social activity is undertaken over communication networks it becomes more challenging to be restricted to low capacity broadband when living in some rural or remote areas. Given that most countries have regions that are sparsely populated it raises the question of how to improve broadband access in these areas.

There is a growing "grass roots movement" Sweden to extend fibre coverage to rural villages. There are around 1000 small village fibre networks in Sweden, in addition to the 190 municipal networks, which on average connect 150 households.[261] These networks are primarily operated as co-operatives, in combination with public funding and connection fees paid by end-users.[262] People in these communities also participate through volunteering their labour or equipment as well as rights of way in the case of the owners of land. The incumbent telecommunication operator, as well as other companies, provides various tool kits and services for the deployment of village fibre networks in order to safeguard that these networks meet industry requirements. As the deployment cost per access in rural areas can be as high as four times what it cost in urban areas, such development may not attract commercial players and rely on such collaborative approaches.

Aside from any public funding, Sweden's experience suggests village networks require local initiatives and commitment as well as leadership through the development of a local broadband plans and strategies. They also require co-ordination with authorities to handle a broad variety of regulatory and legal issues. Moreover, they demand competence on how to build and maintain broadband networks. Nonetheless, the decisive factor is that people in these areas of Sweden are prepared to use their resources and contribute with several thousand hours of work in order to make a village network a reality.[263]

In the United Kingdom, Community Broadband Scotland is engaging with remote and rural communities in order to support residents exploring and developing their own community led broadband solutions. Examples of on-going projects include those in Ewes Valley (Dumfries and Galloway), Tomintoul and Glenlivet (Moray), which are inland mountain communities located within the Moray area of the Cairngorm National Park.[264] Another example of a larger project can be found in Canada and the small Alberta town of Olds with a population of 8500, which has built its own fibre network through the town's non-profit economic development called O-net.[265] The network is being deployed to all households in the town with a number of positive effects being reported for the community.[266]

THE UNITED STATES

The President underscores the significance of municipal networks

The role municipal networks can play in furthering broadband development was underscored by the President of the United States in January 2015. He cited the hundreds of towns and cities around the United States that have developed their own networks.[267] Municipal networks have, according to the President, emerged as a critical tool for increasing access, encouraging competition, fostering consumer choice, and driving local and regional economic development.[268] Approximately 8% of the broadband subscribers are connected with around 300 municipal networks, of which the majority are small, in the United States, implying that municipal networks constitute a minor part of the overall broadband market. Several initiatives have been launched to eliminate obstacles for municipalities to deploy broadband networks, and the Federal Communications Commission has used its mandate to pre-empt state laws in North Carolina and Tennessee that restrict municipal broadband deployment.[269] One municipal network, among around 400 such networks that are present in the United States, is Chattanooga Tennessee, which this section considers.

Chattanooga's Electric Power Board

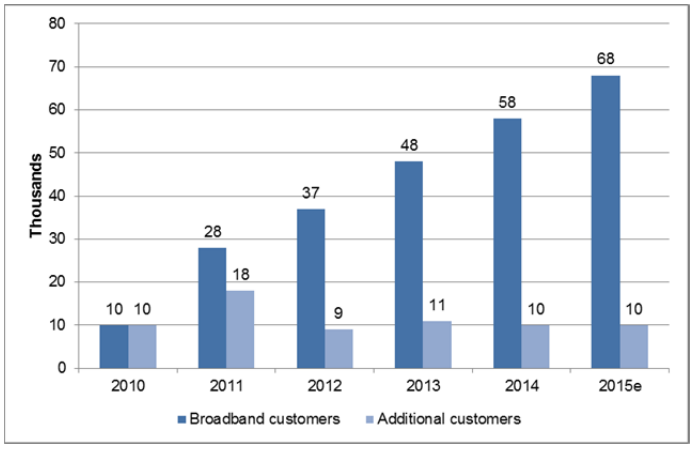
The Electric Power Board of Chattanooga (EPB) provides electricity and, more recently, communication services in parts of Tennessee.[270] Following the enactment into law of the United States Telecommunications Act of 1996, the city owned agency made the decision to begin providing communication services.[271] One important element of this decision was the fibre already in place, laid along power lines, which was used to manage the energy grid. As a result of the fibre, for example, outages could be restored in seconds rather than days.

EBP is one of some 2009 publicly owned utilities in the United States that provides electricity to its municipality. That approach makes up 61% of the electricity providers in that country, though given that they serve 14% of total households, it indicates they are relatively small compared to the privately owned utilities, which connects 69% of the households in the United States.[272] More than 100 public power utilities provide some kind of advanced broadband communication service, and the number is continuously growing.[273]

By 1999, EBP had assembled a staff and the technical components to develop a fibre-optics-based network, providing high speed data, local business telephony and other telecommunication services.[274] These services were launched in the year 2000, as until that time Tennessee legal restrictions limited the types of services and businesses in which a municipal utility could engage.[275] In 2007, EPB announced a decade long plan to expand its fibre network in Chattanooga and, two years later launched triple-play services (Internet, telephony, and television) for residential users. [276] As described by the President and CEO of EPB, the "highway" was in place and EPB added the off-ramps, i.e., connecting business and residential premises to the fibre run along the power lines down every street or road.[277]

EPB has gradually upgraded the capacity of its broadband network to 100 Mbit/s, without raising subscriber prices, and was among the first operators to offer 1 Gbit/s services in the United States. The network stretches 8 000 miles, and covers an area of 1 554 km^2 (600 miles^2) connecting around 60 000 residential and 4 500 business customers out of a potential of 160 000 homes and businesses, with a total population in the area of 0.3 million (Figure 18).[278]

Figure 18. EBP Number of broadband customers



Source: Electrical Power Board (EBP) annual reports 2008-2014

EPB applies a retail model for broadband service offering Internet access direct to users. The two standalone Internet access offers are priced at USD 59.99 per month for unlimited access at 100 Mbit/s or USD 69.99 at 1 Gbit/s (Table 6). Users also have the choice to bundle with telephony or television.

Table 6. EPB prices (February 2015, USD)

Mbit/s	Internet Access		Telephony		Television
100	59.99	Basic	22.99	Bronze	14.99
1000	69.99	120 Long Distance	29.99	Silver	67.99
		Unlimited	39.99	Gold	80.99

Source: https://epbfi.com/enroll/packages/#/fi-tv-gold&fi-speed-internet-100

Fibre expansion

In April 2008, EPB issued revenue bonds amounting to USD 220 million. This was done in order to finance improvements of its electricity distribution system, acquisition of new transformers and construction of facilities to serve new customers as well as to finance the further deployment of the fibre network and to reimburse prior expenditures.[279] EPB has a considerably lower financial leverage, a ratio that indicates the relation between equity/capital and borrowed funds, compared to its listed peers (Figure 19). In 2008, the company estimated that the total capital expenditures for augmenting the fibre network would be USD 169 million, but the outcome was that the total investment for the fibre network was USD 100 million during 2009-2014 (Figure 20).[280]

Figure 19. Financial leverage EBP[281]

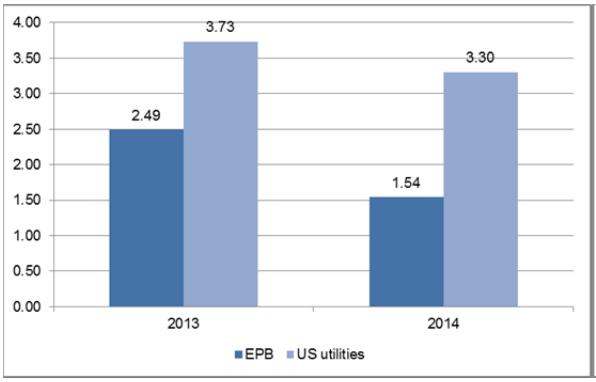
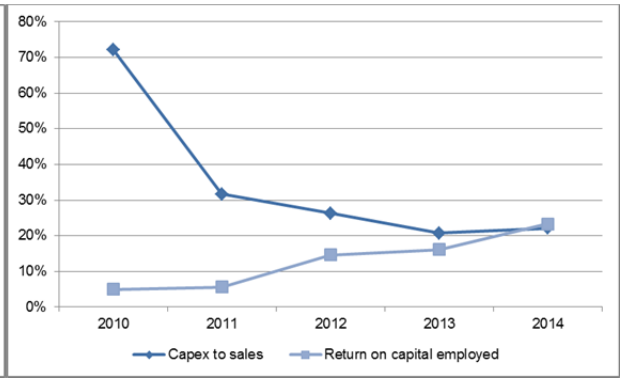


Figure 20. Capex-to-sales and return on capital EPB[282]



Source: Electrical Power Board (EBP) annual reports 2010-2014. OECD, Bloomberg

The fibre network is integrated with a smart grid technology for the electricity network which was facilitated by a USD 111 million grant from the Department of Energy, and now serves 175 000 customers.[283] The smart grid technology facilitates a more effective operation of the utility network as it enables remote monitoring of meters, management of power consumption, the power distribution system and substations. In addition, a wireless mesh network is integrated into the system, which could be used as an alternative to connect homes and business.[284] This has not been utilised, however, as all users covered by EPB's network can avail themselves of the same level of services given the fibre deployment.

Influence on Chattanooga

In recent years there has been increased economic activity in Chattanooga and the broadband network is prominently cited as being one of the main contributors to that development.[285] In 2011, for example, both Amazon and Volkswagen opened major facilities and there were a growing number of smaller firms and start-ups.

Amazon chose Chattanooga for a distribution centre, creating over 2 000 new jobs and undoubted spill over effects for the local economy.[286] While the State of Tennessee and Chattanooga put together a number of incentives for the company, including tax incentives, the fibre network has been widely cited as contributing to the localisation.[287] Amazon's facility, covering an area the size of 20 American football fields, has itself seven miles of fibre in the facility to enable 700 Internet connection points.[288] Amazon has said the two facilities it has built in the area, required investment of USD 139 million.[289]

Volkswagen says it has invested USD 1 billion at its Chattanooga plant creating 3 200 direct jobs and 9 500 indirect supplier employees.[290] The company says it has awarded USD 379 million to local construction contracts and some USD 307 million to local suppliers annually. It is Volkswagen's only production facility in the United States and has established collaboration with the Tennessee Technology Center, Chattanooga State Community College, Tennessee Technology University, and the University of Tennessee-Chattanooga.

Growth of SMEs

Deignan (2014) highlights the challenges Chattanooga has had with its historical manufacturing economy and that the fibre broadband network has been lauded for promoting high-tech economic development. Since the network deployment started the city has, according to Deignan (2014), attracted a cluster of start-ups, structured around organisations that support entrepreneurs.[291] Venture capital funds, which have emerged in Chattanooga in recent years, include Blank Slate,[292] Chattanooga Renaissance Fund,[293] Lamp Post Group,[294] SwiftWing Ventures[295] and the Jump Fund.[296] Start-ups funded by these entities include Quickcue which was sold to OpenTable for USD 11 million (Table 7).[297] A further example of a start-up is Variable, an award-winning electrical design and software development firm for NODE sensors that develops ways to optimise data collection.[298]

Some of the venture capital groups also provide incubators for start-ups. In addition an entity called CO.LAB began as a project aiming to make Chattanooga a more creative and vibrant city, which was attractive for entrepreneurs and was subsequently turned into an accelerator, promoting start-ups and helping entrepreneurs to develop ultra high speed broadband applications.[299] An important element of initiatives such as CO.LAB is the aim to make Chattanooga more attractive for young entrepreneurs.

Table 7. New companies in Chattanooga

Company	Description	Business
Blank Slate Ventures	Seed fund, investing in start-ups in Chattanooga	Has invested in companies active in telemedicine, gadgets, social media, and supply management. First investment was made in Quikcue, which raised USD 3 million, developed a tablet-based guest-management system for restaurants, which was sold to OpenTable in 2013 for USD 11.5 million.
Chattanooga Renaissance Fund	Angel capital fund aimed at encouraging entrepreneurship and fuelling economic growth within Tennessee and the surrounding regions	Invests in companies providing wireless sensors, medical devices, interactive marketing, supply management
Co. Lab	Incubator focused on creating a more robust and dynamic entrepreneurial ecosystem in Chattanooga	The Company Lab is instrumental to Co.starters, a development programme; Accelerator, a mentor driven start-up accelerator and GIGtank, a 12 week tech accelerator programme.
Feetz	Manufactures and sells custom made footwear	Raised USD 1.25 million in seed funding from Khosla Ventures, the JumpFund and ex-Reedbok CEO. Utilising 3D scanning and printing technology to produce customer unique footwear
Lamp Post Group	Provides investment services, invests in start-ups. USD 50 million in investment fund, 150 employees.	Has invested in logistics, gaming, e-commerce, health insurance
The JumpFund	Venture capital firm focusing on female led companies, USD 2.4 million fund	Has invested in: eDivv, online market place for beauty products; Feetz, customised shoes; Demours, importer, roaster and wholesaler of coffee; Rooibee Red Tea, markets rooibos tea

Source: Bloomberg, company's web sites

Beneficial for the municipality

Lobo et al (2008) sought to quantify the economic effects of broadband in Hamilton County, where Chattanooga is located.[300] The study indicated that household broadband expenditures over the period 2001-2005 supported 548 jobs and contributed USD 110 million in income and taxes to Hamilton County. It concluded that Hamilton County would benefit from the investment of a fibre network technology as it would result in income and taxes exceeding USD 352 million while creating over 2 600 new jobs.[301] Based on previous work Lobo (2011) estimates the combined economic and social impact for the community of EPB's investments in fibre network and smart grid.[302] The study employs two approaches, where the first approach uses the IMPLAN methodology and software, Impact Analysis for Planning, which offers a way to derive the direct/indirect/induced effects on employment, output and business taxes in Hamilton County. The second approach uses analytical methods to delve into the social and indirect effects of the fibre optic broadband and smart grid infrastructure, complemented with anecdotal evidence from interviews with EPB's customers. The estimated economic value to Hamilton County of the expected capital expenditures of USD 396 million on fibre optic infrastructure and a smart grid is, according to Lobo (2011), roughly equal to USD 590 million in added income and taxes, and estimate that at least 3 716 new jobs can be associated with the investments. Moreover, Lobo (2011) estimates social and indirect benefits of the project to be USD 209 million annually, with a present value over USD 1 billion. This consists of savings/benefits from smart grid (42%), improved utilisation of existing grid, savings/benefits from health/home care (27%), telecommuting and lower cost for communication (25%), lower electricity bill (4.5%) and other social benefits (1%). In total, the estimated capital expenditures of USD 396 million is, according to Lobo (2011), estimated to generate incremental economic and social benefits of about USD 1.2 billion and at least 3 700 new jobs for Hamilton in the future.

Using the fibre network as backhaul, Chattanooga has deployed a wireless network that supports various city functions including public safety and traffic management. Collado (2013) highlights a couple of examples on positive effects of the fibre network in Chattanooga: first, a remote-controlled LED traffic light system is expected to generate savings around USD 1 million per year for the city; second, the smart meter system implemented by the Electrical Power Board is estimated to have an economic effect of USD 300 million over ten years; and third, an additional USD 350 million in social benefits are estimated to flow from the network's effects on education and economic development over ten years.[303]

Results from research on growth rates between 2001 and 2010 conducted by Whitacre *et al* (2014) suggest that high levels of broadband adoption in rural areas positively and potentially causally impacted income growth, and negatively influenced unemployment growth.[304] Similarly, low levels of broadband adoption in rural areas lead to declines in the number of firms and total employment numbers in a county. Gilett *et al* (2006) says that Municipal Electric Utilities may be more willing to serve in communities whose demand profiles are less attractive to the private sector, often with the rationale that the services they provide will help improve exactly that profile, e.g., attract information-intensive industries and jobs to the community.[305] Moreover, Gilett *et al* (2006) highlight a strong positive coefficient for internal infrastructure underscoring the importance of scope economies between last-mile telecommunications and the management of local electricity distribution.

The outcome of a municipality network depends, according to Null (2013), on a variety of factors, such as that municipalities should be ready to respond to incumbents that will strongly contest municipal broadband plans both in the courts and in the legislature. Also, depending on how the municipality chooses to run the network, it should be prepared to interact with customers on a personalised basis, including for technical and business issues. While these issues and others present challenges to municipalities, empirical data show that municipalities can be very successful Internet providers. While some have met with challenges, many have overcome them.[306] Null (2013) concludes with stating that deploying a municipal network is significant undertaking, and it is technical, political, and complex, but, it can be done. This has clearly been demonstrated by Chattanooga and, at a country level, something that is being undertaken in Colombia (Box 9).

Box 9. Colombia national and municipal networks

The Colombian government has consistently strived to develop the digital economy, create jobs, and reduce poverty by improving the availability and use of the Internet as well as facilitating a development of applications and local content. It has been spearheaded by the 2010-2018 digital strategy *Plan Vive Digital*, of which a major initiative has been the deployment of a national fibre network, launched in 2011. It aims at bringing fibre backhaul connectivity to 788 municipalities and to 2 000 public institutions in the country. The government contributed more than one third of the total investment of USD 547 million (COP 1011 billion) for the network that the joint venture, formed by the Mexican companies Total Play and TV Azteca, have been commissioned to deploy. Through the National Fibre Optics Project, a node is installed in each of the included municipalities, which has to be complemented with last mile infrastructure for enabling local customers to access high speed Internet services. The network could reduce the costs of providing fixed broadband services to end-users, as well as facilitating the deployment of 4G mobile networks, which by 2018 is expected to cover almost all municipalities in Colombia. These could also benefit from more cost efficient deployment and operation through network sharing, facilitated by the regulatory framework.

Municipalities not covered by the fibre network could be connected with either radio or satellite links. The view is that the market should provide the majority of the infrastructure investments, but if required, public financing could be provided. By 2018 the plan is to have all municipalities connected to high-speed networks, and in addition1000 municipalities will have access to free Wi-Fi hotspots. Moreover, the Government has provided subsidies for provision of fixed broadband to up to two million households. Altogether, Vive Digital has increased the use of Internet in Colombia from 2.2 to 10.1 million connections as of 2015.

The fixed broadband market in Colombia consists of publicly owned municipal network operators, some of them partly privately owned, and most local providers have a prevalent position on local or regional markets. Operators such as ETB (Empresa de Telecomunicaciones de Bogota) and UNE-EPM, a joint venture between EPM (Empresas Públicas de Medellín) and Millicom, hold one-third or more of the fixed lines in their regions. UNE-EPM and ETB are currently investing in fibre networks and providing IPTV services where it does not own cable networks. In order to stimulate the deployment of fibre networks, the regulation in Colombia facilitates access to ducts and poles owned by telecom operators or utilities.

ANNEX II

Broadband, Informational Communication Technology and Firm Level Productivity in the United Kingdom, Data

Detailed information on firm IT usage and performance comes from the Ci Technology Database (CiTDB), produced by the Aberdeen Marketing Intelligence (formally known as Harte Hanks), an information and international marketing company. Firm establishments are surveyed annually, providing specific information on hardware and software usage such as the number of computers and users, various forms of software including business management systems, intranet infrastructure and Internet use.[307] The dataset also provides information on performance at the enterprise level such as sales and employment in addition to the exact location of the unit given by the postcode.

Information on the rollout of ADSL broadband across the United Kingdom comes from the Office of the Regulator for Telecommunications (OFCOM). This data is quite rich in that it provides exact location (by postcode) and the timing of enablement (by day) of each telephone exchange in the United Kingdom.[308] By using firm postcode information from the CiTDB with the postcode of the telephone exchange from the broadband dataset we are able to match firms to their respective exchange box. This allows the study to identify when each firm in the sample gains access to ADSL broadband. In addition, as the CiTDB provides some information on the type of Internet usage (such as leased-line, cable, and wireless), it is possible to exclude non-ADSL broadband users from the sample. After cleaning and merging the datasets, this work described here is left with an unbalanced panel of 11 600 observations for 6 842 locations across six years, from 1999 to 2004. Firm locations are small to medium size where mean employment is 246 and median number of workers 120. With regards to IT usage, the average location has 120 personal computers with median usage of 47 units.

Empirical Analysis

To examine the potential relationship between ICT intensity and productivity this work starts with a simple multivariate regression model, equation (1). $Productivity_{it}$ represents labour productivity (sales per worker) of firm i at time t. ICT_{it} signifies IT intensity, which is measured by the total number of personal computers per employee.[309] X_{it} is a vector of control variables, thought to be correlated with productivity such as year, region, sector and firm size and ε_{it} is the error term.

$$\text{Productivity}_{it} = \alpha_0 + \alpha_1 ICT_{it} + \alpha_2 X_{it} + \varepsilon_{it} \quad (1)$$

It is reasonable to assume that IT technology effects firm productivity by allowing firms to communicate more effectively, restructure their organisation more appropriately, improve scheduling of purchasing and sales and so on. However relying solely on equation (1) will not likely allow causal inference. For example, the usage of IT may be related to the productivity of the firm. Hence, it could be that the highest performing firms have a greater likelihood of employing IT. In addition, there may be unobservable factors other than IT such as management, organisational structural, geographic location and

so on which influences firm performance. Therefore, in order to control for endogeneity and examine a potential causal link an instrument variable approach is used.

ADSL enablement is employed as an instrument for IT intensity. Broadband enablement is an appropriate instrument for several reasons. From a technical perspective, broadband as such is of no value without at least a computer and a combination of operating and communicating software. Therefore, broadband enablement raises the returns to ICT, but not productivity other than through ICT. In addition, the way in which broadband was enabled across the United Kingdom suggests that the initial rollout was unanticipated by firms and consumers, making it unlikely that firms self-selected themselves into early enabled locations. The rollout commenced in July 1999 however as of February of that year, BT still had not informed the public of any plans for broadband service (BBC 1999a). In addition, even when it was announced when a region was to be enablement, it was not clear when consumers could start accessing the service, since BT insisted on using its own engineers for line modification and equipment installation (BBC 1999a).[310]

In addition, a short time window during which ADSL was installed is plausibly exogenous to firm performance. The ADSL enablement in the United Kingdom was carried out in two distinct stages. Stage one commenced in July 1999 and ended in November 2001, taking BT until 2002 to finish installations. Enablement during this period was based on BT's anticipated demand for broadband usage. However, the rollout stopped after 16 months, due to low uptake. From the middle of 2002, BT changed its rollout approach in favour of a consumer driven demand procedure known as the pre-registration scheme.[311], The work here only focuses on phase one of the role out, given that the nature of enablement in the second phase may be endogenous to firm performance. Although regions enabled during the first phase were urban, exchange installation was unsystematic primarily due to the limited supply of engineering technicians required at every installation site, both at the exchange and consumer location (BBC 1999a, BBC 1999c) in addition to the wear and tear of each exchange box and therefore likely exogenous.[312]

Empirical Results

The analysis starts by examining the relationship between IT intensity and labour productivity with a standard Ordinarily Least Square analysis. Table 8, represents a baseline model illustrated in equation 1. Here, this study finds evidence of a positive relationship between IT intensity and labour productivity. In addition, control variables are incrementally added to analyse the extent to which other factors are influencing labour productivity. These include year, region and two digit sector dummies, as well as firm size, represented by plant numbers. The ICT intensity coefficients are statistically significant at the 1% level, ranging from 0.401 to 0.311 from model 1 to model 5. Although there is some variation between models three to five this is not surprising given heterogeneity across sectors and firm size. The initial hypothesis regarding a positive and significant relationship between ICT intensity appears to be correct. Model five suggests that a 10% increase in ICT intensity leads to a 3% increase in labour productivity. However this does not mean that ICT and productivity are causally related, given the likelihood of endogeneity.

Table 8. Effects of ICT Intensity on Labour Productivity, OLS[313]

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
ICT Intensity	0.401***	0.404***	0.378***	0.349***	0.311***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Controls					
Year		✓	✓	✓	✓
Region			✓	✓	✓
2 digit Sector				✓	✓
Multi Plant					✓
R-squared	0.072	0.082	0.089	0.153	0.149
N. of cases	11,600	11,600	11,528	11,528	6,831
Note: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses.					

In order to examine the extent to which ICT is causally related to productivity an IV estimation technique is used, employing ADSL enablement as an instrument for ICT intensity. Empirical results provide some support that ADSL is an appropriate instrument for ICT usage. After controlling for years, the work here finds that ADSL enablement is positively correlated with ICT intensity at the 1% level of significance. The F statistics in models two through five are either above or close to the critical value of 10 providing some assurance that the bias in the instrument variable approach is likely to be less in comparison to the bias of the OLS results (Table 9).

For the second stage results, this study finds a positive and significant effect of ICT intensity on labour productivity after controlling for years. The magnitudine of the coefficient does not appear to be overly sensitive to the inclusion of the various control variables with estimates ranging from 1.432 in model two to 1.035 in model five. The sizes of the IT intensity coefficients are substantially larger than the OLS results in Table 8, which give cause for some concern. One explanation for the larger coefficients in the IV estimation could be that ADSL induces firms to invest in a certain type (Varian 2002) or a combination of ICT which leads to substantially higher productivity gains. For example, Atkinson and McKay (2007) find that Internet on-line expenses software employed by Oracle, lowered per claim costs from USD 25 to USD 10 and on-line travel booking software employed by IBM enabled them to obtain monthly savings of USD 2.5 million.[314] Both forms of technology are likely to be more compatible with a faster broadband communication infrastructure.

Table 9. Impact of ICT Intensity on Labour Productivity, IV Estimation

Second Stage	Model 1	Model 2	Model 3	Model 4	Model 5
ICT Intensity	-0.031	1.432***	1.276***	1.278**	1.035**
	(0.02)	(0.31)	(0.41)	(0.53)	(0.52)
First Stage					
ADSL Enablement	-4.129	0.292***	0.214***	0.161***	0.180***
	(3.78)	(0.05)	(0.05)	(0.05)	(0.06)
Controls					
Year		□	□	□	□
Region			□	□	□

2 digit Sector				□	□
Multi Plant					□
Cragg-Donald F Test	1.59	32.99	17.96	10.61	9.77
Hansen J Statistic	-	-	-	-	-
N. of cases	8,345	8,345	8,288	8,288	5,015

Note: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors in parentheses.

ANNEX III

Implications of broadband for a local economy and the environment: an econometric analysis Sweden

Methodology

This work examined what happened after fibre networks have been deployed and the analysis use multivariate regressions to relate fibre penetration to the evolution of socio economic indicators of interest in Sweden's 290 municipalities.[315] As the economic and social development in a municipality certainly depends on more factors than just the availability of fibre networks the analysis is based on a model that takes into account as many relevant factors as possible, formalised in the following function:

$$Y=f(X_1, X_2,....,X_N), \qquad (2)$$

Where Y is the socio-economic indicator that the analysis aims to explain (the explained variable), and Xn are the various factors that have an effect on the indicator (the explanatory variables). When the model has been developed it is possible to observe how well it reflects reality by measuring Y and $X_1, X_2,..., X_N$ in a number of different municipalities. The difference between Y and $f(X_1, X_2, ..., X_N)$ gives the error, ε, which depends on the model's limitations. In multivariate regression analysis, equation (2) is written as a function of some parameters to be optimised, generally by means of ordinary least squares (OLS), through which the sum of the square of ε for all observations is minimised.[316] In order to check for multicollinearity among the independent variables mutual regressions have been done.

Demographic and socioeconomic data has been collected from Statistics Sweden's (SCB) annual yearbook of administrative districts of Sweden.[317] Data for fibre penetration in municipalities has been retrieved from the Swedish Post and Telecom Authority's (PTS) online database.[318] For 2010 and onwards fibre penetration is expressed as the percentage of the population living in a building which is connected with a fibre access network, and fibre is either drawn all the way to the household (FTTH), or terminated in the basement, while each household is connected by dedicated CAT 5 Ethernet cables in the in-building point-to-point network (FTTB). Prior to 2010, fibre penetration was defined in terms of percentage of population living within 353 meter from a fibre-connected premise. Data for the presence of active municipal FTTH-building engagement has been provided by the Swedish Local Fibre Alliance (Svenska Stadsnätsföreningen), SSNf.[319]

Driven distance per inhabitant per year

The two figures 21/22 illustrate the overall predicted values of the regression model versus real observed values of the driven distance per year per inhabitant, and the fibre penetration effect by taking away all the other predicted significant factors' influence, plotted versus the fibre penetration among the population, respectively. This shows that close to 70% of the driven distance per inhabitant per year can be explained by the independent values. A multicollinearity check of the significant independent variables through a self-regression revealed R^2 values in the range of 0.14-0.44, implying that multicollinearity was not a problem among the independent variables.

Table 10. Regression analysis on driven distance per inhabitant per year

R Square	0.685	driven_mil_total_2010_2012	*Coefficients*	*Standard Error*	*t Stat*
Adjusted R Square	0.683	Intercept	1027.697	14.580	70.487
Observations	870	urbanisation_total_2010_2012	-4.171	0.181	-23.063
		delta_pop10_total_2010_2012	-1.969	0.308	-6.389
		Employment_total_2010_2012	170.612	22.854	7.465
		fibreb_total_2010_2012	-135.401	12.045	-11.241

Figure 21. Actual compared to predicted driven distance per inhabitant per year

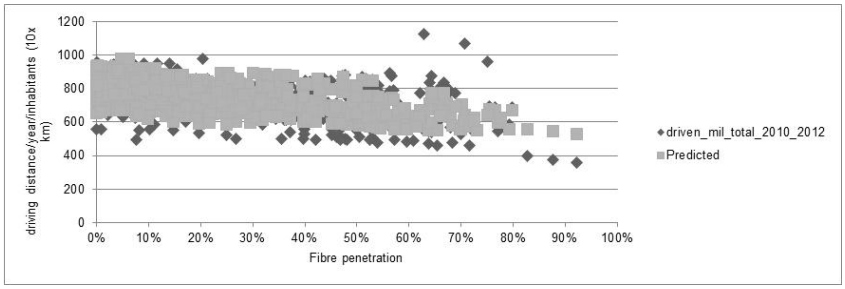
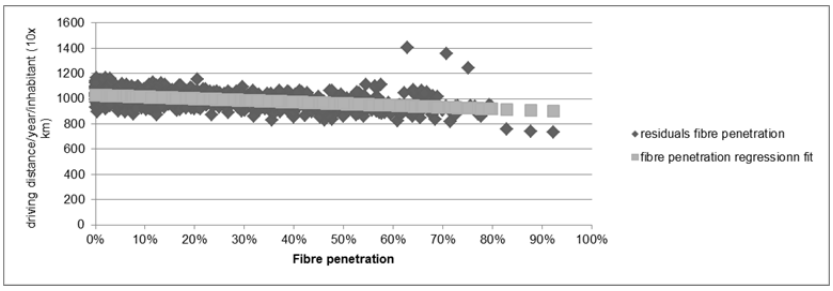


Figure 22. Residuals compared to regression fit



Regression analyses on driven distance based on the different urbanisation levels

Table 11. Low urbanisation level - driven distance per inhabitant per year

R Square	0.333	driven_mil_total_2010_2012	*Coefficients*	*t Stat*
Adjusted R Square	0.315	Intercept	1408	12.3
Observations	114	urbanisation_total_2010_2012	-9.07	-5.06
		delta_pop10_total_2010_2012	-1.61	-2.95
		fibreb_total_2010_2012	-65.54	-2.31

Table 12. Medium urbanisation level - driven distance per inhabitant per year

R Square	0.246	driven_mil_total_2010_2012	*Coefficients*	*t Stat*
Adjusted R Square	0.229	Intercept	1375	11.4
Observations	186	urbanisation_total_2010_2012	-7.471	-4.99
		delta_pop10_total_2010_2012	-2.326	-4.41
		Employment_total_2010_2012	-114.3	-2.47
		fibreb_total_2010_2012	6.93	0.396

Table 13. High urbanisation level - Driven distance per inhabitant per year

R Square	0.722	driven_mil_total_2010_2012	*Coefficients*	*t Stat*
Adjusted R Square	0.717	Intercept	779	96.7
Observations	96	delta_pop10_total_2010_2012	-3.459	-5.54
		fibreb_total_2010_2012	-249.7	-14.7

Employment

The tables below show the results for the regression analysing the correlation between fibre penetration and employment. The highest R^2 is obtained when controlling for urbanisation level, population evolution, income, education level and business creation. Other parameters that were investigated in the regression model but found statistically insignificant were, for example, the tax rate, the population age distribution, and share of foreigners and immigrants. Furthermore, a multicollinearity check among the significant independent variables through self-regression revealed R^2 values between 0.24 and 0.54. As the same for the previous analyses, Huber-White heteroscedastic consistent estimates were also carried out and verified the significance of the independent variables. The two figures 23/24 illustrate the overall predicted values of the regression model versus real observed values of the employment rate, and the fibre penetration level effect by eliminating all the other predicted significant factors' influence, plotted versus the fibre penetration among the population, respectively. It can be seen that, given all the control variables constant, a 10% higher fibre penetration is correlated to 1.1% higher employment.

Regression analysis employment

Dependent Variable	Employment_total_2010_2012	Independent_Variable	Coefficient	t-statistic	std_err
R-squared	0.285	fibreb_total_2010_2012	0.107	6.447	0.017
Rbar-squared	0.280	delta_pop10_total_2010_2012	-0.005	-8.766	0.001
Nobs	870	urbanisation_total_2010_2012	0.001	4.329	0.000
		Average_Yearly_Income_total_2010_2012_tkr	-0.002	-10.914	0.000
		Under_Graduate_total_2010_2012	1.355	9.681	0.140
		New_Company_total_2010_2012	0.009	4.710	0.002
		beta_0	0.257	7.931	0.032

Figure 23. Actual employment compared to predicted

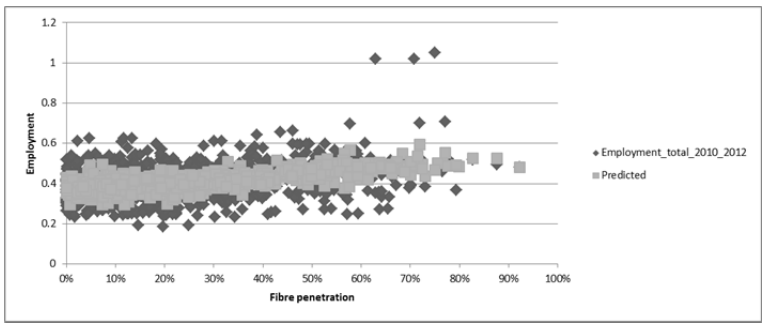
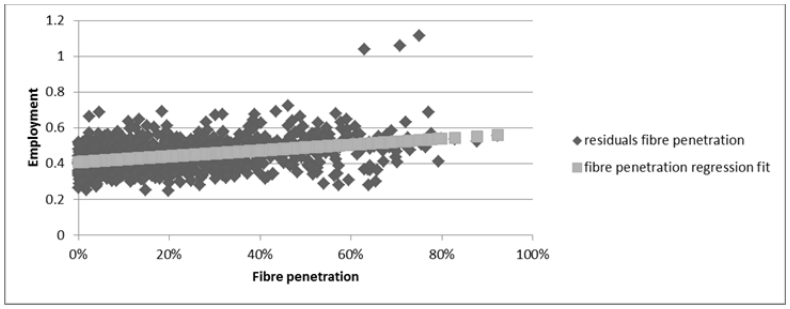


Figure 24. Residuals compared to regression fit



Regression analyses on employment based on classified urbanisation levels

Low urbanisation level – employment

R Square	0.197	Employment_total_2010_2012	*Coefficients*	*t Stat*
Adjusted R Square	0.175	Intercept	1.067	5.93
Observations	114	urbanisation_total_2010_2012	-0.006	-2.33
		Average_Yearly_Income_total_2010_2012_tkr	-0.001	-4.07
		fibreb_total_2010_2012	0.118	2.65

Table 14. Medium urbanisation level: - employment

Dependent Variable	Employment_total_2010_2012_inter2	Independent_Variable	Coefficient	t-statistic	std_err
R-squared	0.258	fibreb_total_2010_2012_inter2	0.069	2.516	0.027
Rbar-squared	0.242	delta_pop10_total_2010_2012_inter2	-0.005	-5.038	0.001
Nobs	186	Average_Yearly_Income_total_2010_2012_tkr_inter2	-0.001	-2.470	0.000
		Under_Graduate_total_2010_2012_inter2	1.354	5.090	0.266
		beta_0	0.249	3.043	0.082

Table 15. High urbanisation level - educational level

Dependent Variable	Employment_total_2010_2012_inter2	Independent_Variable	Coefficient	t-statistic	std_err
R-squared	0.571	fibreb_total_2010_2012_inter3	0.166	2.998	0.055
Rbar-squared	0.552	delta_pop10_total_2010_2012_inter3	-0.008	-5.192	0.002
Nobs	96	Average_Yearly_Income_total_2010_2012_tkr_inter3	-0.002	-4.282	0.001
		Under_Graduate_total_2010_2012_inter3	1.378	3.974	0.347
		beta_0	0.587	6.241	0.094

New company registration

The analysis shows that among other significant parameters the fibre penetration is slightly below the significant threshold at the .95 confidence interval. However, if the fibre penetration parameter of its level at office is used it showed that the fibre penetration became significant, with the R^2 value over 0.4. Furthermore, multicollinearity check among the significant independent variables through self-regression revealed R^2 values between 0.2 and 0.47. The two figures 25/26 illustrate the overall predicted values of the regression model versus the real observed values of the new company registration, and the pure fibre penetration effect by taking away all the other predicted significant factors' influence, plotted versus the office fibre penetration, respectively.

Table 16. Fibre penetration – population

R Square	0.422	*New_Company_total_2010_2012*	*Coefficients*	*Standard Error*	*t Stat*
Adjusted R Square	0.419	Intercept	1.450	0.494	2.933
Observations	870	urbanisation_total_2010_2012	-0.027	0.004	-6.078
		delta_pop10_total_2010_2012	0.096	0.008	11.857
		Average_Yearly_Income_total_2010_2012_tkr	0.024	0.002	12.062
		fibreb_total_2010_2012	0.407	0.274	1.486

Table 17. Fibre penetration – office

R Square	0.426	*New_Company_total_2010_2012*	*Coefficients*	*Standard Error*	*t Stat*
Adjusted R Square	0.423	Intercept	1.616	0.497	3.253
Observations	870	fibrea_total_2010_2012	0.797	0.289	2.758
		urbanisation_total_2010_2012	-0.028	0.004	-6.555
		delta_pop10_total_2010_2012	0.098	0.008	12.025
		Average_Yearly_Income_total_2010_2012_tkr	0.024	0.002	11.768

Figure 25. Actual number of new companies compared to predicted

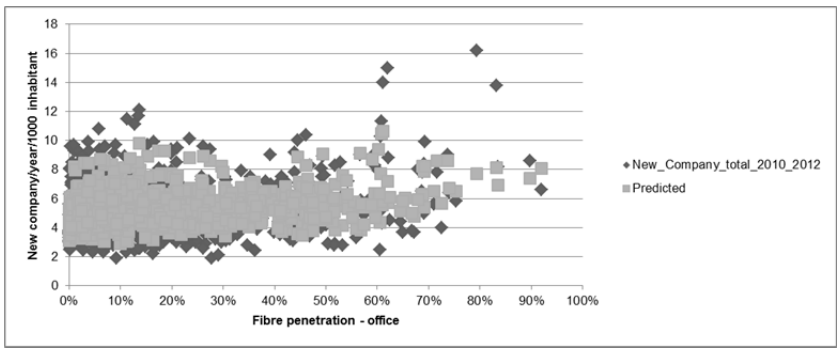


Figure 26. Residuals compared to regression fit

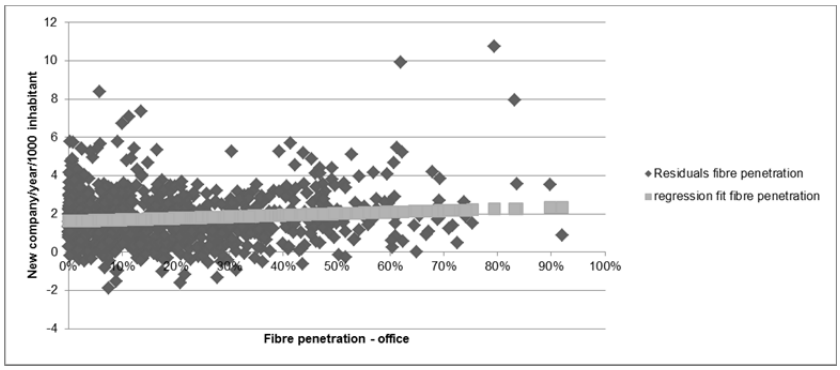


Table 18. Active municipal FTTH-building engagement and FTTH penetration

Dependent Variable	fibreb_total_2010_2012	Independent_Variable	Coefficient	t-statistic	std-err	95%-low	95%-high
R-squared	0.349	stadnat_active_total_2010_2012	0.061	5.265	0.012	0.038	0.083
Rbar-squared	0.346	delta_pop10_total_2010_2012	-0.004	-4.029	0.001	-0.006	-0.002
Nobs	870	urbanisation_total_2010_2012	0.005	10.488	0.000	0.004	0.006
		Average_Yearly_Income_total_2010_2012_tkr	-0.001	-2.616	0.000	-0.001	0.000
		Under_Graduate_total_2010_2012	2.315	8.553	0.271	1.784	2.847
		beta_0	-0.593	-9.563	0.062	-0.714	-0.471

NOTES

1 A municipal network is defined as a high speed network that has been fully or partially facilitated, built, operated, by local governments, public bodies like utilities or other organisations that have a public connection. It could also be accomplished through public private partnership with a local or regional focus, or networks that are privately owned but which have been divested by municipalities, or networks that have been established in communities through initiatives made by individuals or co-operatives.

2 Prepared Remarks of FCC Chair Tom Wheeler "The Facts and Future of Broadband Competition" 1776 Headquarters, Washington, D.C. September 4, 2014 at https://apps.fcc.gov/edocs_public/attachmatch/DOC-329161A1.pdf

3 ibid

4 Federal Communications Commission, (2015), Broadband Progress report and notice of inquiry on immediate action to accelerate deployment, January 29, 2015, FCC 15-10, and news release FCC finds U.S. broadband deployment not keeping pace, January 29, 2015.

5 There is an extensive literature on the subject and references are presented in the Box 1 on what works, in relation to the section about the analysis on ICT and firm performance and the econometric analysis in the latter part of the report.

6 The European Commission (2014), "Guide to High-Speed Broadband Investment", Release 1.1 – 22 October, link http://ec.europa.eu/digital-agenda/en/news/broadband-investment-guide

7 "Fibre expansion abounds at AT&T, Comcast, Cox, CenturyLink", Telegeography, 7 May 2015. https://www.telegeography.com/products/commsupdate/articles/2015/05/07/fibre-expansion-abounds-at-att-comcast-cox-centurylink/

8 http://www.orange.com/fr/content/download/28716/628803/version/2/file/Orange+Networks+Fact+Sheet.pdf

9 In April 2013, the State, the Paris region, Orange and SFR signed a common declaration to the two operators on fibre roll out on capital equity to make the Paris region the first region with fibre in Europe by 2020.

10 Leila Abboud and Gwenaelle Barzic, "Orange in talks with buyers of fibre assets to get Jazztel deal approved", 5 May 2015. http://uk.reuters.com/article/2015/05/05/uk-orange-jazztel-m-a-idUKKBN0NQ1O220150505

11 FTTH boost for Telefónica, 20 November 2014. http://www.broadbandtvnews.com/2014/11/20/ftth-boost-for-telefonica/

12 See for example: "Orange Spain starts EUR 5 mln San Sebastian fibre rollout", Telecompaper, 6 May 2015. http://www.telecompaper.com/news/orange-spain-starts-eur-5-mln-san-sebastian-fibre-rollout--1080677

13 Bloomberg, July 2, 2014. Mlex 27 October, 2014, Vodafone, Irish utility welcome EU regulator's approval for their joint venture.

14 http://www.independent.ie/business/technology/news/eircom-promises-new-rural-fibre-broadband-will-overtake-city-speeds-31158182.html, http://www.independent.ie/business/technology/news/broadband-firm-to-bring-superfast-1000mbs-service-to-300-more-towns-31139923.html

15 http://www.independent.ie/business/technology/news/broadband-firm-to-bring-superfast-1000mbs-service-to-300-more-towns-31139923.html, Mlex 8 October 2014, Ireland expects broadband plan to win EU approval next year.

16 The centre is a collaboration between the London School of Economics and Political Science, Centre for Cities and Arup (an international consultancy working with complex projects), and is funded by the Economic & Social Research Council, The Department for Communities and Local Government and The Department for Business Innovation & Skills.

17 Evidence review 6, Broadband, March 2015, What Works Centre for local economic growth, link: www.whatworksgrowth.org

18 Cave, M. (2014), "The ladder of investment in Europe, in retrospect and prospect", *Telecommunications Policy*, Vol. 38, pp. 674-683

19 Briglauer, B. and K. Gugler (2013), "The deployment and penetration of high speed fibre networks and services: Why are EU member states laggning behind?", *Telecommunications Policy*, Vol. 37, pp. 819-835.

[20] Percentage of fibre connections in total broadband (December 2014), OECD Broadband Portal. http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm

[21] The Stadtwerke Norderstedt funded the Wilhelm.tel Gmbh in 1999 and has deployed a fibre ring in Norderstedt, where 95% of the 33 000 households are connected, and expanded to other cities, like Hamburg, Henstedt-Ulzburg, http://www.wilhelm-tel.de/unternehmen/ueber-uns/. Stadtwerke Munich, SWM and its subsidiary M-net have equipped 32000 buildings in Munich, with fibre networks, http://www.swm.de/privatkunden/unternehmen/innovation/glasfaser.html. http://www.stadtwerke-bochum.de/privatkunden/produkte/telekommunikation.html

[22] http://convergenciadigital.uol.com.br/cgi/cgilua.exe/sys/start.htm?infoid=39520&sid=8

[23] Cave, M. and I. Martin (2010), "Motives and means for public investment in nationwide next generation networks", *Telecommunications Policy*, Vol. 34, pp. 505-512.

[24] Prices in the report are expressed as USD Purchasing power parities (PPPs), which is the rate of currency conversion that eliminate the differences in price levels between countries

[25] Based on concepts presented to the European Commission (2014), "Guide to High-Speed Broadband Investment", Release 1.1 – 22 October.

[26] Gomez-Barroso, J. L. and C. Feijo (2010), "A conceptual framework for public-private interplay in the telecommunications sector", *Telecommunications Policy*, Vol. 34, p. 487.

[27] Noam, E. (2010), "Regulation 3.0 for Telecom 3.0", *Telecommunications Policy*, Vol. 34, pp. 4-10.

[28] ibid

[29] Li, G. (2012), "The return of public investment in telecommunications: Assessing the early challenges of the national broadband network policy in Australia", *Computer Law & Security Review*, Vol. 28, Issue 2, April, pp. 220-230

[30] Davidson, C. M., and M. J. Santorelli (2014), Understanding the debate over government-owned broadband networks, Advanced Communications Law & Policy Institute, New York Law School, June.

[31] Troulos, C. and V. Maglaris (2011), "Factors determining municipal broadband strategies across Europe", *Telecommunications Policy*, Vol. 35. Pp. 842-856

[32] The Treaty of the Functioning of the EU (TFEU), article 107, article 1. The broadband State aid rules explained, An eGuide for Decision Makers, final report, A study prepared for the European Commission DG Communications Networks, Content & Technology Digital Agenda for Europe. 2013. European Commission, EU guidelines for the application of State aid rules in relation to the rapid deployment of broadband networks, 26.1 2013 (2013/C 25/01). The Regulation is part of the State Aid Modernisation (SAM) (see IP/12/458).

[33] European Commission, EU Guidelines for the application of state aid rules in relation to the rapid deployment of broadband networks (2013/C 25/01), 26.1.2013.

[34] See http://ec.europa.eu/competition/sectors/ICT/overview_en.html, like for example State aid SA.35834 (2012/N) Spain, Extension of high speed broadband in Spain; State aid SA.35000 (2012/N) – Germany NGA Bayern; Staatliche Beihilfe N 263/2005 – Österreich Brediband Kärnten

[35] European Commission, state aid SA.30317 – Portugal, High-speed broadband in Portugal, Brussels 19.01.2011 C(2011)312 final.

[36] European commission, state aid SA.37864 (2013/N) – Portugal, High speed broadband in Portugal prolongation, Brussels 04.02.2014.

[37] The broadband State aid rules explained An eGuide for Decision Makers, Final Report A study prepared for the European Commission DG Communications Networks, Content & Technology Digital Agenda for Europe. 2013, page 41. Commission Decision, 11 December 2007, On the state aid case C 53/2006 (ex N 262/2005, ex CP 127/2004), Investment by the city of Amsterdam in a fibre-to-the home (FTTH) network.

[38] Adopted by the European Commission on December 20, 2011, which will apply from January 31, 2012. The Commission published a guide on SGEI and social services of general interest on February 18, 2013. It has to fulfil conditions specified in the Altmark ruling, C-280/00 of July 2003.

[39] A joint venture between cable operator Numericable (95%) and mobile operator SFR (5%). Commission Européenne, Aide d'Etat N 331/2008 France, Compensation de charges pour une Délégation de Service Public (DSP) pour l'établissement et l'exploitation d'un réseau de communications électroniques à très haut débit dans le Département des Hauts-de-Seine, Bruxelles, le 30.09.2009 (C(2009) 7426 final.

[40] European Commission, State aid: Commission approves public financing worth EUR 59 million for broadband project in

the French Hauts-de-Seine department, Brussels, 30 September 2009, IP/09/1391.

41 The Court of Justice of the EU on February 11, 2015 dismissed appeals by French telecoms operator Orange and Iliad against the Court of Justice of the European Union. Source mLex.

42 European Commission, EU guidelines for the application of State aid rules in relation to the rapid deployment of broadband networks, 26.1 2013 (2013/C 25/01).

43 ibid

44 OECD, Directorate for Financial and Enterprise Affairs, Competition Committee, Working party No 2 on Competition and regulation. Financing of the roll-out of broadband networks – Note by the United States, 16 June 2014.

45 European Commission (2014), "Guide to High-Speed Broadband Investment", Release 1.1 – 22 October

46 Ibid. Forzati. M., and C. Mattsson (2015), "Sweden", in W. Lemstra and W. H. Melody (eds.), in W. Lemstra, and W. H. Melody (eds.) *The Dynamics of Broadband Markets in Europe*, , Cambridge University Press.

47 The concept of operator neutral networks means that it is focused on providing dark fibre on the wholesale market, implying it is not active on the retail market.

48 Forzati. M., and C. Mattsson, (2015), "Sweden", in W. Lemstra, and W. H. Melody, (eds.), *The Dynamics of Broadband Markets in Europe*, Cambridge University Press.

49 Directive 2014/61/EU of the European Parliament and of the council of May 2014, on measures to reduce the cost of deploying high-speed electronic communications networks. Cullen International describes the stages that have been reached: vote on draft report in European Parliament plenary: April 15, 2014, adoption by the Council: May 8, 2014, publication in the Official Journal of the EU: May 23, 2014 entry into force: June 12, 2014. Next steps: transposition into national law: January 1, 2016 applicable from: July 1, 2016.

50 Bresnahan, F.T., E. Brynjolfsson, and L. M. Hitt (2002), "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence", *The Quarterly Journal of Economics, Vol.* 117 (1), pp.339–376. Bloom, N., R. Sadun, and J. Van Reenen (2005), "It Ain't What You Do, It's The Way That You Do IT.–Testing Explanations of Productivity Growth Using US Affiliates." Centre for Economic Performance, London School of Economics. Hubbard, T. N., (2003), "Information, Decisions, and Productivity: On-Board Computers and Capacity Utilization in Trucking", *The American Economic Review*, Vol. 93 (4), pp. 1328–1353. Brynjolfsson, E., A. McAfee, M. Sorell, and F. Zhu (2008), "Scale Without Mass: Business Process Replication and Industry Dynamics", Harvard Business School Technology & Operations Mgt", Unit Research Paper, no. 07-016. Bartel, A., C., Ichniowski, and K. Shaw (2007), "How Does Information Technology Affect Productivity? Plant-Level Comparisons of Product Innovation, Process Improvement, and Worker Skills", *The Quarterly Journal of Economics*, Vol. 122 (4), pp. 1721–1758.

51 Leased-line broadband was also available during this time, however given the substantial costs, only the largest, most productive firms could afford to pay for this service.

52 Arthur D Little (2010), Socioeconomic effects of broadband investments. LECG, (2009), "Economic Impact of Broadband: An Empirical Study," final report for Nokia Siemens Networks. Crandall, R., W. Lehr and R. Litan (2007), "The Effects of Broadband Deployment on Output and Employment: A Cross-sectional Analysis of US Data", *The Brookings Institution: Issues in Economic Policy,* Number 6, July. Czernich, N., O. Falk, T. Kretschmer and L. Woessmann (2009), "Broadband Infrastructure and Economic Growth", *CESifo Working Paper No. 2861*. Fornefeld, M., G. Delaunay and D. Elixmann (2008), "The Impact of Broadband on Productivity and Growth", *Micus Management Consulting* (on behalf of the European Commission). Koutroumpis, P. (2009), "Broadband Infrastructure and Economic Growth: "A Simultaneous Approach", *Telecommunications Policy,* Vol. 33(9), pp. 471-485. OECD (2009), The Role of Communication Infrastructure Investment in Economic Recovery.

53 Van Ark, B., V. Chen, A. Gupta, G. Levanon and A. Therrien (2010), "The 2010 Productivity Brief: Productivity, Employment and Growth in the World's Economies," The Conference Board, 319(1).

54 Katz, R., S. Vaterlaus, P. Zenhäusern, S. Suter and P. Mahler (2009), "The Impact of Broadband on Jobs and the German Economy". Majumdar, K., S. (2008), "Broadband adoption, jobs and wages in the US telecommunications industry", *Telecommunications Policy,* Vol. 32, pp. 587-599. Pociask, S. (2002), "Building a Nationwide Broadband Network: Speeding Job Growth", TeleNomic Research, LLC, 29. Herndon, Virginia.

55 Forzati, M. and Larsen, C. P. (2008), "Broadband Access and its Impact on the Economy, a Swedish Perspective", proceeding of International Conference on Transparent Optical Networks (ICTON), paper Mo.B1.5, Athens, Greece.

56 Kenny, R. and C. Kenny, (2011), "Superfast broadband: is it really worth a subsidy?", info, Vol. 13 Issue 4, pp. 3-29; Gruber, H., J. Hätönen and P. Koutroumpis, (2014), "Broadband access in the EU: An assessment of future economic

benefits", Telecommunications Policy, Vol. 38, p 1046-1058; Rohman, I. K., and E. Bohlin (2012), Does Broadband speed really matter for driving economic growth? Investigating OECD countries. SSRN Electronic Journal, (Chalmers University working paper April 2012); Teppayayon, O. and E. Bohlin (2011), Challenges of fibre-based infrastructures: a review of the NGA debate in Europe, Int. J. Management and Network Economics, Vol. 2, No. 2.

57 Ovum (2009), "Socio-economic Benefits of FTTH", Ovum draft report to the Market Intelligence Committee of the FTTH Council Europe, February. Ida, T., Y. Horiguchi (2008), "Consumer benefits of public services over FTTH in Japan: comparative analysis of provincial and urban areas by using discrete choice experiment", Information Society, Vol. 24, Issue 1, pp. 1-17. Felton B. (2010), "Socioeconomic Benefits, FTTH Bulgaria", Yankee Group, January.

58 Paul Budde Communications Pty Ltd: Australia – Telecommunications Company Profiles – TransACT Communications Pty Limited (April 2011), p.2.

59 ActewAGL was set up in October 2000 when the then Australian Gas Light Company (AGL), and ACTEW Corporation, an ACT Government owned corporation, entered into Australia's first utility joint venture. ActewAGL is made up of two partnerships. http://www.actewagl.com.au/About-us/Who-is-ActewAGL.aspx

60 Bloomberg news, March 12, 2015. Bloomberg news September 2, 2015

61 Australian Competition & Consumer Commission, ACCC to not oppose acquisition of iiNet by TPG, media release 20 August 2015

62 Shareholder Ministers' Statement of Expectations to NBN Co, 8 April 2014: www.communications.gov.au/__data/assets/pdf_file/0014/221162/SOE_Shareholder_Minister_letter.pdf. NBN Co Half-Year Report, for the six month ended 31 December 2014

63 See Appendix 2 of the 'National Broadband Network – Market and Regulatory Report', August 2014, for further information on the current broadband industry structure and regulation in Australia: www.communications.gov.au/broadband/national_broadband_network/cost-benefit_analysis_and_review_of_regulation/nbn_market_and_regulation_report

64 See the *Carrier License Conditions (Networks supplying Superfast Carriage Services to Residential Customers) Declaration 2014* and the accompanying explanatory statement for further detail: http://www.comlaw.gov.au/Details/F2014L01699

65 See the Australian Government's policy paper 'Telecommunications Regulatory and Structural Reform',December 2014, for further detail on this policy: www.communications.gov.au/broadband/national_broadband_network/cost-benefit_analysis_and_review_of_regulation

66 Copies of the exemption instruments and explanatory statements are available at: www.communications.gov.au/policy_and_legislation/Telecommunications_Act_Parts_7_and_8_requirements_and_exemptions/ministerial_exemptions_from_parts_7_and_8_of_the_telecommunications_act_1997

67 http://www2.nbnco.com.au/connect-home-or-business/technology-choice-program.html

68 Mark Gregory, "The NBN fibre cost shock", Business Spectator, 19 March 2015. https://www.businessspectator.com.au/article/2015/3/19/technology/nbn-fibre-cost-shock

69 Review under Section 152EOA of the Competition and Consumer Act 2010, www.communications.gov.au/broadband/national_broadband_network/cost-benefit_analysis_and_review_of_regulation/panel_reports_to_government

70 The cost-benefit analysis was prepared by an expert panel led by Dr. Michael Vertican AC, Independent cost-benefit analysis of broadband and review of regulation, Volume II – The cost and benefits of high-speed broadband, August 2014, link http://www.communications.gov.au/broadband/national_broadband_network/cost-benefit_analysis_and_review_of_regulation/independent_cba_of_broadband

71 Independent cost-benefit analysis of broadband and review of regulation, Volume II, August 2014, page 94.

72 Definitive agreements between NBN with Telstra. The rights of access have an initial term of 35 years, with two options each exercisable at NBN Co's discretion, of 10 further years each. Source NBN Co Half-Year Report for the six month ended 31 December 2014,

73 Amounted to AUS 76 million H1, FY 2015. Telstra half year 2015 results announcement, note 8, page 33

74 Telstra Corporation Limited – Financial results for the half-year ended 31 December 2014 – Analyst briefing Presentation and Materials

[75] National Broadband Network, Corporate plan 2014-2017, 11 November 2104. Telstra half year 2015 result announcement. NBN has signed an AUD 400 million contract with Arris Group to upgrade Telstra's as well as Optus cable TV network. Bloomberg News February 22, 2015.

[76] NBN Goals 2020 published in National Broadband Network Corporate Plan, 11 November 2014.

[77] The fibre project started with the vision of 'fibre to all' in the three small municipalities in South Jutland; Rødding, Gram and Nørre Rangstrup. Later Vojens joined the project and these four municipalities grouped together to establish the first fibre ring in the area. A reform of the municipalities in Denmark brought Rødding in the north together with three other small municipalities (Holsted, Brørup and Vejen) and formed the new Vejen municipality. Gram and Vojens and a small part of Nørre Rangstrup joined the new Haderslev, while the rest of Nørre Rangstrup joined new Tønder municipality. The first fibre ring is operated jointly by the Vejen, Haderslev and Tønder municipalities. A second fibre ring was established in 2006 by is owned by Vejen municipality. The two fibre rings are connected by a common line.

[78] Simon Simonsen, Vejen municipality, Fibernet og mobildækning til alle optimale muligheder for trivsel, kvalitet og vækst i Vejen Kommune, 2. december 2013.

[79] Mandag Morgens 'Navigation', June 2013.

[80] ibid

[81] Mandag Morgens 'Navigation', June 2013.

[82] Primo in the village Lintrup, which now takes home production from Germany and creates new jobs.

[83] Investeringer og incitamenter i telesektoren, report, Incentive September 2014.

[84] Wikipedia, Electricity sector in Denmark.

[85] OECD estimate based on Danish Business Authority, telestatistics, first half year 2014. TDC, Telenor, TeliaSonera and Dansk Kabel-TV have 71% of the fixed broadband subscribers.

[86] SE covers about 75% and TRE-FOR 25% of the geographic area of Vejen municipality.

[87] Inventive, 'Investeringer og incitamenter i telesektoren', report, September 2014. SE annual report 2013.

[88] Stofa, Press release, 25 October 2012, https://stofa.dk/sites/default/files/121025_stofadk.pdf

[89] SE annual report 2013.

[90] Danish Business Authority, telestatistic, second half year 2014, https://erhvervsstyrelsen.dk/telestatistik. SE annual report 2013.

[91] Danish Business Authority, telestatistics, second half year 2014, https://erhvervsstyrelsen.dk/telestatistik, Dansk Kabel-TV is owned by TDC.

[92] EU: Digital Agenda Scoreboard 2014 at http://ec.europa.eu/digital-agenda/en/scoreboard

[93] Danish Business Authority, telestatistics, second half year 2014, https://erhvervsstyrelsen.dk/telestatistik. OECD estimates.

[94] OECD estimate.

[95] Bloomberg, transcript TDC, Q4 2014 earnings call, 5 February 2015.

[96] Danish Business Authority, telestatistics, second half year 2014, https://erhvervsstyrelsen.dk/telestatistik..

[97] Danish Business Authority, Broadband mapping 2013, https://erhvervsstyrelsen.dk/sites/default/files/bredbaandskortlaegning-2013.pdf. and Mandag Morgens 'Navigation', June 2013.

[98] Danish Business Authority, https://erhvervsstyrelsen.dk/bredbaandsmaal

[99] OECD Broadband portal, http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm. European Commission, Broadband markets, Digital Agenda scoreboard 2014, https://ec.europa.eu/digital-agenda/en/news/scoreboard-2014-trends-european-broadband-markets-2014

[100] http://en.wikipedia.org/wiki/Municipal_wireless_network

[101] https://hotspot.internode.on.net/partners/adelaidefree/

[102] http://www.paris.fr/english/english/how-to-access-the-wi-fi-free-of-charge-in-paris/rub_8118_actu_109289_port_19237

[103] http://www.heraklion.gr/en/e-heraklion/e-wireless/e-wireless.html, http://www.lagadas.gr/index.php/2014-09-02-17-49-36/2014-09-02-17-52-50/14-2014-09-02-17-28-47/124-wifi, http://free-wifi.gr/en/find-free-hotspots/thessaloniki

104 http://www.rte.ie/news/2013/0131/365427-dublin-city-centre-wifi/

105 http://www.cittadinanzadigitale.it/

106 https://www.panoulu.net/, and Characterizing the usage of a large municipal Wi-Fi network Timo Ojala, Toni Hakanen, Ossi Salmi, Mikko Kenttälä, Juha Tiensyrjä & Pauli Närhi MediaTeam Oulu, University of Oulu, Finland

107 http://tradlosetrondheim.no/index.php?option=com_content&view=article&id=8&lang=nb-NO, http://tradlosetrondheim.no/

108 http://www.raleighnc.gov/home/content/ITechAdmin/Articles/OutdoorWiFi.html, http://web.albanyfreenet.net/site/

109 Matt Fledgeheilmer, "Pay Phones in New York City Will Become Free Wi-Fi Hot Spots", 17 November 2014. http://www.nytimes.com/2014/11/18/nyregion/pay-phones-in-new-york-city-will-become-free-wi-fi-hot-spots.html?_r=0

110 Erik Sass, "NYC Plans Free WiFi Via Digital Kiosks Carrying Ads", 18 November 2014. http://www.mediapost.com/publications/article/238495/nyc-plans-free-wifi-via-digital-kiosks-carrying-ad.html

111 Town's official website, http://www.town.kamiyama.lg.jp/

112 Presentation by the town for a meeting in the national government, 2014 www.kantei.go.jp/jp/singi/sousei/kihonseisaku/dai6/s3.pdf. Press release published by the Ministry of Internal Affairs and Communications to report decision of expenditure for the project, 2014 http://warp.ndl.go.jp/info:ndljp/pid/235321/www.soumu.go.jp/snews/2004/040811_1.html)

113 "An option to work in a mountain side town in Shikoku – Kamiyama, the town attracting IT companies", December 2012, http://www.ashitalab.jp/special/637/ (retrieved on 23 February 2015)

114 Organic food production from satellite offices? What future the Kamiyama town foresees where immigrants bring about new changes http://wanderer.jp/t06/

115 An interview by Jiji.com with the mayor, 2013, http://www.jiji.com/jc/v2?id=20130620top_interview28_110

116 Law No. 8642, General Telecommunications Law, and Law No. 8660, Law on the Strengthening and Modernization of Government Institutions in the Telecommunications Sector,

117 In Costa Rica, the Free Trade Agreement between Central America, the Dominican Republic and the United States (CAFTA) took effect in 2008. The treaty stipulates that the market for electronic communications should be open for new suppliers and operators in order to strive towards effective competition. Annex 13 Chapter 13

118 Executive Decree No. 36577-MINAET

119 Executive Decree No. 36550, Law No. 9046, Executive Decree No. 36577-MINAET

120 Dutch online telephone museum, http://www.telefoonmuseum.com/index.php/dutch-telephone-history-timeline

121 Lemstra, W. (2015), "The Netherlands", in W. Lemstra, and W. H. Melody (eds.) *The Dynamics of Broadband Markets in Europe*, , Cambridge University Press, p. 58

122 Geschiedenis van de kabeltelevisie in Nederland, Broadband TV News, http://www.nederland.broadbandtvnews.com/2012/12/15/geschiedenis-van-de-kabeltelevisie-in-nederland/ and http://www.npogeschiedenis.nl/nieuws/2008/oktober/Kabelvezelnet-de-draadomroep-deed-het-al-in-de-jaren-dertig.html

123 Courts have forbidden such regulations under the freedom to receive information clause of the Dutch constitution. However debate on the topic continued, in 2015 a housing corporation won a case at a lower court against a tenant who had attached a satellite dish.

124 Lemstra, W. (2015), "The Netherlands", in W. Lemstra, and W. H. Melody (eds.), *The Dynamics of Broadband Markets in Europe*, , Cambridge University Press, p. 60.

125 Most of the cable operators are members of NLKabel, there are however some, such as, Cogas (70,000 households, and CAI Hoogvonderen (1500 households) that are not members http://nlkabel.nl/leden-nlkabel/

126 Subsidieregeling Breedband Kenniswijk http://wetten.overheid.nl/BWBR0013686/geldigheidsdatum_24-02-2015 15 cities applied for subsidy and Eindhoven-Helmond won. The pilot project met some difficulties when incumbent operators were reluctant to invest and a new entrant, Bredbandbolaget of Sweden, left the market soon after having deployed only 300 connections. KPN then deployed another 900 connections. It was when the project area was expanded to include Nuenen, that another 75 000 customers were added.

127 Handreiking goed op weg met breedband. http://www.bwpartner.nl/rapporten/Handreiking%20Goed%20op%20weg%20met%20breedband.pdf

128 The City of Amsterdam sold its shares in the A2000 network to Philips Electronics and United Global Communications, which became UPC. Liberty already had an ownership United Global Communications and merged to form Liberty Global in 2005.

129 European Commission, State aid No C 53/2006 (ex N 262/05) – the Netherlands Citynet Amsterdam – investment by the city of Amsterdam in a fibre to-the home (FTTH) network

130 Based on its preliminary assessment the Commission could not exclude that the notified measure includes elements of State aid within the meaning of Article 87(1) EC

131 Commission Decision of 11.XII.2007 ON THE STATE AID case C 53/2006 (ex N 262/2005, ex CP 127/2004).

Investment by the city of Amsterdam in a fibre-to-the home (FTTH) network http://ec.europa.eu/competition/state_aid/cases/218055/218055_760366_119_1.pdf

132 Commission decision of 19 July 2006 on the measure n° C 35/2005 (ex N 59/2005) which the Netherlands are planning to implement concerning broadband infrastructure in Appingedam http://ec.europa.eu/competition/state_aid/cases/201779/201779_615386_67_1.pdf. Lemstra, W. (2015), "The Netherlands", in W. Lemstra, and W. H. Melody (eds.), *The Dynamics of Broadband Markets in Europe*, Cambridge University Press, p. 70.

133 In the Western part of the Netherlands, particularly in Amsterdam the situation was much the opposite with an oversupply of networks in some areas. This pulled bandwidth intensive businesses from the peripheral regions to Amsterdam. For example Booking.com moved from Enschede, where it had started at Twente University and had enjoyed cheap university bandwidth to Amsterdam.

134 Art. 5.14 of the Telecommunication law of the Netherlands. For the changes that the Crisis and Recovery law introduced see parliamnentary document 32 127 Regels met betrekking tot versnelde ontwikkeling en verwezenlijking van ruimtelijke en infrastructurele projecten (Crisis- en herstelwet) nr. 3 Memorie Van Toelichting

135 How Amsterdam was wired for open access fibre, Herman Wagter Mar 19, 2010, Ars Technica.

136 Telecommonitor Third quarter 2014, data for 2014 show the number for the third Quarter

137 OECD broadband portal, http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm

138 Telecommonitor Third quarter 2014, data for 2014 show the number for 3 Quarter

139 OECD Communication 2013, table 2.1

140 http://broadbandnow.com/Fixed-Wireless-Providers

141 http://www.utilitieskingston.com/Networks/Performance.aspx

142 Broadband Access in Rural Canada: The role of connectivity in building vibrant communities, Federation of Canadian Municipalities, 2014, and http://www.onewayout.ca/

143 http://www.coonvalleytelco.com/power-net.htm

144 http://www.cdwwireless.com/internet/index.htm

145 http://www.lbcfree.net/, https://www.khnet.info/, http://slavicin.unart.cz/, http://www.hkfree.org/

146 http://www.nbnco.com.au/connect-home-or-business/information-for-home/fixed-wireless.html

147 See for example Internote's NBN offers at: http://www.internode.on.net/residential/wireless_broadband/nbn_plans/

148 http://www.nbnco.com.au/connect-home-or-business/technology-choice-program.html

149 Northpower shares are held in trust by the Northpower Electric Power Trust (NEPT).

150 Public private partnership (PPP). Milner, M. (2009), "Playing the telecommunications game in New Zealand: The evolving story of telecommunications public policy in New Zealand", *Telecommunications Journal of Australia*, Vol. 59(2). In 2011, the New Zealand government introduced a rural broadband initiative (RBI), providing USD 237 (NZD 300) million for the roll-out of broadband services to rural communities, that will not get fibre in the foreseeable future. Vodafone New Zealand Ltd and Chorus Ltd Limited were jointly awarded the contract. Commerce Commission New Zealand. Both GPON (Gigabit Passive Optical Network) and Point-to-Point technology are used for the broadband network.

151 http://www.crownfibre.govt.nz/. A Crown entity is an organisation that forms part of New Zealand's state sector established under the Crown Entities Act 2004.

152 Given J. (2010), "Take your partners: Public private interplay in Australian and New Zealand plans for next generation

broadband", *Telecommunications Policy* , Vol. 34, pp. 540-549, highlights that it was commonly perceived around 2005 that New Zealand was lagging behind in broadband development. The Ministry of Economy Development acknowledged in 2005 that Telecom New Zealand had not fulfilled its 2003 commitment to achieve a broadband uptake of more than 250 000 residential consumers (Milner, 2009).

153 It is labelled Ultra Fast Broadband (UFB) in New Zealand, 100 Mbit/s downlink and 50 Mbit/s uplink. The selected infrastructure operators are required to provide open network access acting purely as wholesalers, offering layer 1 (unlit or dark fibre) or 2 services (bitstream), according to the OSI model. The conditions for the network providers are spelled out in the Deed of undertaking.

154 Given J. (2010), "Take your partners: Public private interplay in Australian and New Zealand plans for next generation broadband", *Telecommunications Policy*, Vol. 34, pp. 540-549.

155 Crown Fiber Holding Annual report 2014

156 Northpower Annual Review 2011, page 16

157 Webb, M., M. Toner, and J. Cox (2014), "Taking the initiative: lessons from New Zealand's experience with the ultra-fast broadband initiative", *International Journal Technology Policy and Law*, Vol. 1, No. 4.

158 Ultrafast Fibre Ltd was established by WEL Networks Ltd in 2010, in order to rollout a 3000 km fibre network, passing about 162 000 premises in Hamilton, Tauranga, Wanganui, New Plymouth, Tokoroa, Hawera, Cambridge and Te Awamutu.

159 Enable Services Limited (ESL), owned by Christchurch City Holdings Limited, LFC Enable Networks Limited (ENL) has been created through a partnership between Crown Fibre Holdings Limited and Christchurch City owned Enable Services Limited. It is building a fibre network for 180 000 homes and businesses in Christchurch, and Waimakariri and Selwyn Districts (Rangiora, Kaiapoi, Woodend, Lincoln, Prebbleton, Templeton and Rolleston). http://www.enable.net.nz/about-enable/.

160 Wikipedia

161 Northpower Annual Review 2011. Northpower Fibre Limited Annual Report 2014, note 15

162 Layer 2 services. Northpower Annual Review 2008, page 3. Northpower Fibre Limited Annual Report 2013, Chairpersons report. The company's initial name was Whangarei Local Fibre Company Limited. Northpower Annual Review 2011, page 16. Northpower Annual Review 2009, page 2, 3

163 The World Factbook, Central Intelligence Agency (CIA)

164 Crown Fibre Holding

165 Northpower Fibre Limited Annual Report 2014, Chief executive report page 2, note 15, Crown Fibre Holding

166 Wikipedia

167 Whangarei District Council

168 Whangarei District Council, 2012-2022, Long term plan. www.wdc.govt.nz

169 Northpower Fibre Limited Annual Report 2014, Chief Executive report, http://www.northpowerfibre.co.nz/index.php/about-us. Case studies about Northpower Limited look at link: Schools, hospitals. http://www.northpowerfibre.co.nz/index.php/case-studies. More on youtube https://www.youtube.com/channel/UCRwCRJ5BrTIyk0fBGOGw5Rg

170 Broadband deployment continues to deliver, 11 February 2015. http://www.crownfibre.govt.nz/2015/02/broadband-deployment-continues-deliver/

171 Crown Fibre Holding

172 Statistics New Zealand, Census 2013

173 http://www.med.govt.nz/sectors-industries/technology-communication/fast-broadband). Beltran quoting Given (2010)

174 Northpower Fibre Limited Annual Report 2014

175 Pukeko Echo Television. Marilyn Small, deputy principal at the Manaia View School. Channel North: http://tvnorth.co.nz/channelnorth/index_bs.php

176 http://edtalks.org/video/impact-ultrafast-broadband

177 Steve Merritt, Whangarei Boys High Schoolwbhs.school.nz., www.callplus.co.nz/CaseStudyWBHS

178 http://northpower.com/about/news/entry/whangarei_becomes_new_zealands_first_ufb_city

179 Varnosafaderani, R. Siamak, (2013), "Future of Telehealth in New Zealand", University of New Zealand, January

180 Statistics New Zealand, Internet Service Provider Survey 2014

181 Regeringens proposition 1999/2000:86, Ett informationssamhälle för alla, (An information society for all), 29 March 2000.

182 Ministry of Enterprise, Energy and Communications, (2009), Broadband strategy for Sweden, Link http://www.government.se/content/1/c6/13/49/80/112394be.pdf.

183 PTS (Swedish Post and Telecom Authority), (2015), PTS bredbandskartläggning 2014, En geografisk översikt av bredbandstillgången i Sverige, (Mapping of broadband coverage 2014, A geographic overview of broadband access in Sweden), PTS-ER-2015:11, 2015-03-24 PTS, (2015), Uppföljning av regeringens bredbandsstrategi, (The monitoring of the government's broadband strategy), PTS-ER-2015:16, 2015-04-30.

184 PTS, (2014), Swedish Telecom Market full year 2014, PTS Statistics Portal, PTS, (2015), Uppföljning av regeringens bredbandsstrategi, (The monitoring of the government's broadband strategy), PTS-ER-2015:16, 2015-04-30

185 PTS, (2015), PTS bredbandskartläggning 2014, En geografisk översikt av bredbandstillgången i Sverige, (Mapping of broadband coverage 2014, A geographic overview of broadband access in Sweden), PTS-ER-2015:11, 2015-03-24.

186 Ekengren Oscarsson, H., and A. Bergström (red), SOM-Institutet, Swedish Trends 1986-2013, Göteborgs Universitet.

187 The Swedish Tax Agency, Skatteverket, http://www.skatteverket.se/omoss/omskatteverket/statistik.4.6704c7931254eefbe718000121.html. Henrik Ekengren Oscarsson, Annika Bergström (red), SOM-Institutet, Swedish Trends 1986-2013, Göteborgs Universitet (in Swedish)

188 OECD Broadband portal, www.oecd.org/sti/broadband/oecdbroadbandportal.htm

189 Sandgren, P., (2014), Varför finns lokalt ägda bredbandsnät I Sverige? Stadsnät som medel för att nå ett resursmässigt oberoende på den svenska marknaden för elektronisk kommunikation, (Why do locally owned broadband networks exist in Sweden? Municipality owned networks as a means to achieve resource independence in the Swedish market for electronic communications), MBA Thesis, Stockholm University, School of Business, MBA Programme.

190 PTS, (2015), Uppföljning av regeringens bredbandsstrategi, (The monitoring of the government's broadband strategy), PTS-ER-2015:16 2015-04-30. OECD has made the estimate based on the information provided in TeliaSonera Q1 2015 presentation page 23, PTS Bredbandskartläggning 2014, PTS Svensk Telemarknad, and SCB. Including in municipal networks are private companies that own municipal networks.

191 PTS, (2015), Uppföljning av regeringens bredbandsstrategi, (The monitoring of the government's broadband strategy), PTS-ER-2015:16, 2015-04-30.

192 http://skl.se/tjanster/press/vdskronika/vdskronika/dendubblarollen.2469.html

193 Säffle Kommunikation AB (Säkom) Annual report 2013.

194 Swedish Local Government Act (1991:900)

195 Bredband för Sverige in i framtiden, Staten Offentliga Utredningar, SOU 2014:21

196 SKL, Kartläggning E-tjänster och appar – hur är läget i kommunerna? E-Förvaltning and E-tjänster i kommunerna 2014

197 Swedish Association of Local Authorities, http://skl.se/tjanster/englishpages.411.html, Kommuninvest. http://kommuninvest.se/en/, Ekengren Oscarsson, H., och A. Bergström (red), SOM-Institutet, Swedish Trends 1986-2013, Göteborgs Universitet (in Swedish)

198 PTS, (2015), Prisutvecklingen på mobiltelefoni och bredband 2014, PTS Prisrapport 2014, (Price Report 2014, Price trends for mobile telephony and broadband), PTS-ER-2015:6, 2015-02-04. The Swedish Local Fibre Alliance, Stadsnätsundersökningen 2014, www.ssnf.org/

199 PTS, (2015), Prisutvecklingen på mobiltelefoni och bredband 2014, PTS Prisrapport 2014, (Price Report 2014, Price trends for mobile telephony and broadband), PTS-ER-2015:6, 2015-02-04

200 Forzati, M., C. Mattsson and Z. Xiong, (2013), Bredbandspriser i Sverige, (Broadband prices in Sweden), Acreo Swedish ICT, January. The study surveyed prices at 282 networks in Sweden, and network is defined as an active network operated by a specific Network Provider (NP). This implies that different parts of a municipal network fibre could be operated by different NPs, which leads to that the number of networks in this study are more than the number of municipal networks in Sweden.

201 Bloomberg, TeliaSonera Q1 2015 quarterly earnings conference transcript

202 PTS, (2015), Prisutvecklingen på mobiltelefoni och bredband 2014, PTS Prisrapport 2014, (Price Report 2014, Price trends for mobile telephony and broadband), PTS-ER-2015:6, 2015-02-04.

203 PTS, (2015), PTS bredbandskartläggning 2014, En geografisk översikt av bredbandstillgången i Sverige, (Mapping of broadband coverage 2014, A geographic overview of broadband access in Sweden), PTS-ER-2015:11, 2015-03-24.

204 Stokab, Annual reports 1996-2014

205 PTS, (2015), PTS bredbandskartläggning 2014, En geografisk översikt av bredbandstillgången i Sverige, (Mapping of broadband coverage 2014, A geographic overview of broadband access in Sweden), PTS-ER-2015:11, 2015-03-24. Stokab, Annual report 2014.

206 Stokab company facts, https://www.stokab.se/Om-oss/Foretagsfakta/

207 Stokab Annual reports 2005-2014.

208 Return on capital employed (ROCE) is a ratio that indicates the efficiency and profitability of a company's capital investments, and is calculated as Operating profit/(total assets-current liabilities). European operators are calculated as an average of TeliaSonera, BT, Orange and Telefonica. Source: Bloomberg.

209 http://www.ericsson.com/res/docs/2014/networked-society-city-index-2014.pdf

210 PWC, (2014), Cities of opportunity 6, http://www.pwc.com/es_MX/mx/publicaciones/archivo/2014-05-cities-of-opportunity.pdf

211 http://www.tillvaxtverket.se/euprogram/artighetsmeny/englishpages/results20072013/goodexamples.4.5a5c099513972cd7fea2c8b3.html

212 Goos, M., I. Hataway, J. Konings and M. Vandeweyer, (2013), High-Technology Employment in the European Union, Vives, Discussion paper 41, December, http://feb.kuleuven.be/VIVES/Onderzoek/discussionpapers/DP/dp2013/final-20131223-3rd.pdf. http://stockholmitregion.com/2014/05/16/stockholm-tech-numbers/

213 Skype was acquired by eBay in 2005, and after being owned by private equity Microsoft acquired Skype in 2011, http://en.wikipedia.org/wiki/Skype; Microsoft acquired Mojang in 2014 for USD 2.5 billion, http://en.wikipedia.org/wiki/Minecraft

214 They are owned by the city of Stockholm: Svenska Bostäder (Swedish Housing), Stockholmshem and Familjebostäder.

215 Svenska Bostäder, avtal avseende tjänstekoncession – kommunikationsoperatör, styrelseärende 2013-02-10

216 http://www.nyteknik.se/nyheter/it_telekom/bredband/article259021.ece

217 ibid

218 Stokab, Annual report 2014.

219 Tele2, transcript, Year-end report 2010, 8 February 2011.

220 Forzati, M. and C. Mattsson, (2013), "Stokab, A socio-economic study", Acreo report acr055698, Stockholm July, https://www.acreo.se/sites/default/files/pub/www.acreo.se/upload/publications/acr055698en_-_stokab_-_a_socio-economic_analysis.pdf

221 Forzati, M. and C. Mattsson, (2013), "Stokab, A socio-economic study", Acreo report acr055698, Stockholm July.

222 PTS, (2015), PTS bredbandskartläggning 2014, En geografisk översikt av bredbandstillgången i Sverige, (Mapping of broadband coverage 2014, A geographic overview of broadband access in Sweden), PTS-ER-2015:11, 2015-03-24.

223 Fiberstaden, http://www.fiberstaden.se/

224 Fiberstaden, Annual report 2013.

225 ibid

226 Forzati. M., and C. Mattsson, (2015), "Sweden", in W. Lemstra, W. H. Melody, (eds), The Dynamics of Broadband Markets in Europe, Cambridge University Press.

227 Fiberstaden, Annual report 2013.

228 http://www.helgebiblioteken.se/

229 http://www.inkopgavleborg.se/, www.hudiksvall.se,

230 Statistics Sweden, http://www.scb.se/

231 Interview with customers to Fiberstaden, http://lindefallet.com/

232 Forzati, M. and C. Mattsson, (2014), "Effekter av digitala tjänster för äldrevård: En ekonomisk studie", Acreo dokument nr. acr057005, Stockholm. Forzati, M. and C. Mattsson, (2014), "FTTH-enabled digital home care – A study of economic gains", Department for Networking and Transmission, Acreo

233 It is the average ratio for Sweden, but it varies between municipalities and between different years.

234 Västerås Kommun, "Projekt Behovsstyrt IKT-stöd – Införandet av eHemtjänst, Rapport aug 2012", Västerås 2012. Mats Rundkvist, Kostnadsminskningar i samband med införande av eHemtjänst, Västerås stad, augusti 2012.

235 Chatzi, Lazaro, Prat, Tomkos "*A techno economic study on the outside plant cost of current and next generation fiber to the x deployments*" Taylor and Francis Group, Fiber and Integrated Optics Vol 32, n 1, pp 12-27. S. Verbrugge, M. Van der Wee, J. Van Ooteghem, IEEE ICTON 2015 Conference.

236 The FTTH Metrowed network connects 160000 households with a G-PON based system architecture for a total investment of around EUR 70 million

237 For more details about BDUK see https://www.gov.uk/broadband-delivery-uk

238 European Commission, State aid SA.33671 (2012/N) – United Kingdom National Broadband scheme for the UK – Broadband Delivery UK, Brussels 20.11.2012, C(2012) 8223 final

239 National Audit Office, the superfast (rural) broadband programme: update, memorandum, January 2015

240 Report on UK NGA provision by non-major providers, A Prism Business Consulting report for Ofcom, December 5, 2014

241 http://www.peterboroughtoday.co.uk/news/latest-news/council-turns-broadband-provider-1-6626600

242 http://www.gigaclear.com, http://ultrafastpeterboroughvale.info/

243 http://www.peterborough.gov.uk/news/latest_news/2014/january/scheme_launched_to_help_get.aspx. http://www.peterborough.gov.uk/council_and_democracy/peterborough_leaders_blog/leaders_blog_archive_2014.aspx. http://www.peterboroughcore.com/. http://www.peterborough.gov.uk/news/latest_news/2013/november/partnership_to_transform.aspx

244 Local Broadband Plan - APR12/CMDN/041. Superfast Broadband Contract Award - JAN13/CMDN/010. http://www.cambridgeshire.gov.uk/CMSWebsite/Apps/Committees/Meeting.aspx?meetingID=605 Publication date: 31/01/2013

245 Open market consultation on broadband in Cambridgeshire and Peterborough, request for information, 20 March 2012, 21137-113, Analysys Mason

246 Connecting Cambridgeshire, Extend coverage of Superfast Broadband across Cambridgeshire and Peterborough, State aid public consultation, 15th September 2014. http://www.connectingcambridgeshire.co.uk/wp-content/uploads/2014/09/Connecting-Cambridgeshire-State-Aid-Public-Consultation-15092014.pdf

247 http://www.cambsacre.org.uk/rural-broadband.php, www.connectingcambridgeshire.co.uk

248 The funding arrangements for the project are included within the Medium Term Financial Strategy. http://democracy.peterborough.gov.uk/ieDecisionDetails.aspx?Id=623

249 Peterborough Council Strategic Infrastructure Partnership - NOV13/CAB/090, Peterborough Cabinet 4 November 2013, Strategic partnering with CityFibre Holdings

250 CityFibre Infrastructure Holdings plc, IPO prospectus, 23 May 2014

251 CityFibre has signed a National framework agreement with EE, Three UK and MBNL to deploy the UK's first dark Fibre-to-the-Tower network. CityFibre Infrastructure Holding, Full year results for the year ended 31 December 2014, 23 March 2015

252 http://www.broadbandchoices.co.uk/news/2014/04/peterborough-1gb-fibre-240414

253 Peterborough Cabinet, 4 November 2013, Strategic partnering with CityFibre Holdings

254 05/11/2013 http://democracy.peterborough.gov.uk/ieDecisionDetails.aspx?ID=854 http://democracy.peterborough.gov.uk/mgIssueHistoryHome.aspx?IId=13296&Opt=0

255 CityFibre Infrastructure Holdings plc, IPO prospectus, 23 May 2014, and http://www.businesscoms.co.uk/about-

businesscoms/

256 Peterborough, council agenda, Wednesday 5 March 2014, medium-term financial strategy budget 2014/2015 and medium-term financial plan 2023/2024, Peterborough Cabinet, 4 November 2013, Strategic partnering with CityFibre Holdings, item 9.1.3

257 Covers lower ICT cost and reduced costs through new broadband provision during the period 2-14/15 to 2018/19. Peterborough, council agenda, Wednesday 5 March 2014, medium-term financial strategy budget 2014/2015 and medium term financial plan 2023/2024

258 CityFibre Infrastructure Holdings PLC, release 19 March 2015, Completion of Peterborough network construction, and CityFibre Infrastructure Holdings, James Enck, email 27 March 2015

259 Peterborough is transformed into a Gigabit City as CORE build is completed, March 19, 2015, http://www.peterboroughcore.com/peterborough-is-transformed-into-a-gigabit-city-as-core-is-completed/, and https://www.peterborough.gov.uk/council/budgets-spending-and-performance/our-finances/

260 Richard Godfrey, Peterborough Council, email April 1, 2015

261 Swedish Broadband Forum, http://www.bredbandivarldsklass.se/Om-Bredbandsforum/The-Swedish-Broadband-Forum/

262 http://www.fibre-systems.com/news/story/survey-over-1000-rural-broadband-networks-sweden, February 5, 2015

263 Sandgren, P. (2015), Perspective on village fibre, Broadband Forum January 26, version 2.

264 http://www.hie.co.uk/community-support/community-broadband-scotland/cbsprojects/default.html

265 www.o-net.ca

266 http://www.cbc.ca/news/technology/small-alberta-town-gets-massive-1-000-mbps-broadband-boost-1.1382428

267 The Executive office of the President, Community-based broadband solutions, the benefits of competition and choice for community development and highspeed internet access, The Executive Office of the President, January 2015, page 3

268 The Executive office of the President, Community-based broadband solutions, the benefits of competition and choice for community development and highspeed internet access, The Executive Office of the President, January 2015, page 4

269 Federal Communications Commission (FCC) grants petition to pre-empt state laws restricting community broadband in North Carolina, Tennessee, February 26, 2015

270 Bloomberg

271 Henry, l., Erin, (2013), "Not just keeping the lights on: using push-pull stakeholder engagement for mutual gain at a utility", Harvard Business School, draft November.

272 American Public Power Associations, 2014-15 Annual Directory & Statistical report

273 Waterhouse, Desmarie. Why community broadband makes sense, Public Power, March-April 2015, Vol. 73, No. 2

274 https://www.epb.net/about/our-company-and-history/

275 Davidson, C. M., and M. J. Santorelli (2014), "Chattanooga Case Study", June. http://www.nyls.edu/advanced-communications-law-and-policy-institute/wp-content/uploads/sites/169/2013/08/ACLP-–-Chattanooga-Case-Study-–-June-2014.pdf.

276 The city of Chattanooga, Electric system revenue bonds, series 2008A (Bond prospectus), April 23, 2008

277 See a CBS video of the network and interview with Harold DePriest, President and Chief Executive Officer, at: http://www.cbsnews.com/videos/which-city-has-the-fastest-internet-in-the-nation/

278 The Executive office of the President, Community-based broadband solutions, the benefits of competition and choice for community development and highspeed internet access, The Executive Office of the President, January 2015, page 14, and EPB Annual report 2014

279 ERP Annual report 2008, page 47, The city of Chattanooga, Electric system revenue bonds, series 2008A (Bond prospectus), April 23, 2008:

280 ERP, Annual report 2008, page 47. The city of Chattanooga, Electric system revenue bonds, series 2008A (Bond prospectus), April 23, 2008, p. 8. Prospectus page 28: The plan for capital expenditure: year 1 USD 28.2 million, year 2 USD 56.3 million, year 3 USD 56.3 million and year 4 USD 28.1 million. The total capital expenditure estimated is based on numbers in the Annual reports 2009-2014.

281 Net debt is a metric that shows a company's overall debt situation by netting the value of a company's liabilities and debt with its cash and other similar liquid assets. EBITDA is the earnings before interest, taxes, depreciations and amortisations. The estimates for the utilities in the United States are a market cap weighted average with data for Northeast Utilities (NU US), PG&E Corp. (PCG US), Edison International (EIX US), NextEra Energy (NEE US), and Exelon Corp (EXC US). Bloomberg.

282 The return is measured as the ratio between net operating income and the book value of the fibre broadband network (not yet validated with the company)

283 EPB Annual report 2014

284 City of Chattanooga, Tennessee, CAFR 2014, Comprehensive Annual Financial Report for the year ended June 30, 2014, note 13, and The city of Chattanooga, Electric system revenue bonds, series 2008A (Bond prospectus), April 23, 2008, page 9

285 Fast internet is Chattanooga's new locomotive, New York Times, February 3, 2014, http://www.nytimes.com/2014/02/04/technology/fast-internet-service-speeds-business-development-in-chattanooga.html?_r=0

286 Chattanooga, TN, Community profile, revised June 2014. Available at www.chattanoogacando.com

287 FCC Chairman Tom Wheeler was quoted as saying: "Amazon has cited Chattanooga's world-leading networks as a reason for locating a distribution centre in the area, as has Volkswagen when it chose Chattanooga as its headquarters for North American manufacturing." Town and New Market/ Sandell and Associates, "Initial Stakeholder Meeting and Gigabit Corridor Economic Impact Statement", 21 July 2014. http://www.newmarket.ca/en/business/resourcelibrary/Gigabit-CorridorEconomicImpactStatementpreparedbySandelAsociates.pdf

288 Chattanooga Times Free Press

289 http://www.timesfreepress.com/news/news/story/2012/jan/08/amazons-chattanooga-distribution-center-plans-expa/67750/

290 http://www.volkswagengroupamerica.com/facts.html

291 Deignan, B. (2014), "Community broadband benefits? An economic analysis of local government broadband initiatives", Mercatus Center, George Mason

292 http://blankslateventures.com/

293 http://chattanoogarenaissancefund.com

294 http://lamppostgroup.com

295 http://swiftwingventures.com

296 http://www.venturetennessee.com/keyword/The-Jump-Fund

297 Ellis Smith, "San Francisco-based OpenTable acquires Chattanooga startup Quickcue for USD11.5 million", 17 December 2013. http://www.timesfreepress.com/news/business/aroundregion/story/2013/dec/17/opentable-acquires-quickcue/126680/

298 http://variableinc.com

299 www.colab.com

300 Lobo, J. B,, S. Ghosh, and A. Novobilski (2008), "The Economic Impact Of Broadband: Estimates From A Regional Input-Output Model", *The Journal of Applied Business Research*, Second Quarter, Vol. 24, Number 2, pp. 103-114

301 ibid

302 Lobo, J.B. (2011), The Economic and Social Value of EPB's Fibre Optic Infrastructure in Hamilton County, University of Tennessee at Chattanooga, October 20.

303 Study provided by David Collado for the FCC 2013, Appendix A – Municipal broadband cost savings case studies, http://apps.fcc.gov/ecfs/document/view?id=60000869858

304 Whitacre, B., Gallardo, R., Strover, S. (2014), "Broadband's contribution to economic growth in rural areas: Moving towards a causal relationship", *Telecommunications Policy*, Vol. 38, pp. 1011-1023

305 Gillett, E. S., W. H/ Lehr and C. A. Osorio (2006), "Municipal electric utilites' role in telecommunications services", *Telecommunications Policy*, Vol. 30, pp. 464-480.

306 Null, E. (2013), "Municipal Broadband: History's Guide", *I/S: A Journal of Law and Policy*, Vol. 9, p 21

[307] CiTDB is used in other empirical work such as Bresnahan, F.T., E. Brynjolfsson, and L. M. Hitt (2002), "Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence", *The Quarterly Journal of Economics*, Vol. 117 (1), pp. 339–76. Brynjolfsson, E., and L. M. Hitt (2003), "Computing Productivity: Firm-Level Evidence," *Review of Economics and Statistics*, Vol. 85 (4), pp. 793–808. Bloom, N., M. Draca, and J. Van Reenen, (2011), "Trade Induced Technical Change? The Impact of Chinese Imports on Innovation, IT and Productivity", National Bureau of Economic Research, and Bloom, N., L. Garicano, R. Sadun, and J. Van Reenen (2013), "The Distinct Effects of Information Technology and Communication Technology on Firm Organization", CEPR Discussion Paper 9762. C.E.P.R. Discussion Papers.

[308] All but 37 of the telephone exchanges in the United Kingdom were enabled and operated by British Telecom (BT). The remainder were serviced by Kingston Communication

[309] This measure of ICT intensity measure is consistent with other papers in the literature such as Beaudry, P., M. Doms, and E. Lewis, (2006), "Endogenous Skill Bias in Technology Adoption: City-Level Evidence from the IT Revolution", National Bureau of Economic Research, and Bloom, N., R. Sadun, and J. Van Reenen (2007), "Americans Do IT Better: US Multinationals and the Productivity Miracle", National Bureau of Economic Research.

[310] BBC News (1999a) 'The DSL Dinosaur', Online at: http://news.bbc.co.uk/2/hi/science/nature/284208.stm: Accessed on 3/18/2014

[311] Department for Business Innovation (2004) 'UK National Broadband Strategy, 2004', online at http://www.dti.gov.uk/files/file13444.pdf (accessed 20/03/2014).

[312] BBC News (1999c), 'ADSL priced high for consumer', Online at: http://news.bbc.co.uk/2/hi/ science/nature/406819.stm: Accessed on 3/18/2014

[313] The coefficients of the control variables have been excluded for brevity as they are not the main focus of the empirical exercise. This is a common practice as most readers are not interested in the full list of coefficients for example across all 2-digit sectors, which would require a table of more than 100 rows. The complete list of coefficients could be provided upon request.

[314] Varian, H., R. E. Litan, A. Elder, and J. Shutter, (2002), "The Net Impact Study." January. Atkinson, D. R., and A. S. McKay, (2007), "Digital Prosperity: Understanding the Economic Benefits of the Information Technology Revolution." Available at SSRN 1004516.

[315] Gujarati, N., D. (2004), Basic Econometrics, 4th ed., McGraw-Hill, New York.

[316] The regression analysis is done in MATLAB

[317] Statistiska centralbyrån, SCB, Årsbok för Sveriges kommuner (Statistical yearbook of administrative districts of Sweden) 2006-2011.

[318] PTS, Bredbandskartläggning 2010 – en geografisk översikt av bredbandstillgången i Sverige, PTS-ER-2011:10, 16 March 2011, available at http://www.pts.se/upload/Rapporter/Internet/2011/2011-10-bredbandskartlaggning-2010-tabellbilaga.xlsx,

[319] SSNF, http://www.ssnf.org/