The 19th ITS Biennial Conference 2012

“Moving Forward with Future Technologies: Opening a Platform for All”

18 - 21 November 2012, Thailand

COVER PAGE FOR PAPER SUBMISSION

Identifying and quantifying the indirect benefits of broadband networks: a bottom-up approach

Marlies Van der Wee[1], Menno Driesse[2], Bernd Vandersteegen[1]*, Pierre Van Wijnsberge[1]*, Sofie Verbrugge[1], Bert Sadowski[2], Mario Pickavet[1]
(1) Ghent University-IBBT, (2) TU Eindhoven
*** Master thesis students, no longer affiliated to the univerisity**

marlies.vanderwee@intec.ugent.be

For ITS Secretariat Use Only	
Date of Presentation (delete where applicable):	Monday, 19 Nov. 2012 Tuesday, 20 Nov. 2012 Wednesday, 21 Nov. 2012
Panel Assigned:	

Abstract
Although the phenomenon of the internet only emerged about 25 years ago, it is hard to imagine life without it. More and more people use the available connectivity for both professional and private life, and the number of services grows continuously. This increasing demand for capacity and speed should be answered by upgrading the current access networks. However, the income from customer's subscriptions is insufficient to cover the high investments needed for these upgrades. These revenue calculations should therefore be extended with the value that other advantages of a fast and reliable internet connection can entail: indirect benefits, like savings on travel, less waiting time by introducing an e-counter, or reducing traffic jams by allowing employees to work at home.
This paper describes a bottom-up quantification model of the indirect benefits of two sectors: eGovernment and eBusiness, and applies this model to two cities: Ghent (Belgium) and Eindhoven (the Netherlands). The results are summed per actor (authority, large company etc.), so that they can be used in decision-making processes to improve the business case for new investments in fiber networks. Finally, the results obtained in this paper are compared to the results of earlier studies, both bottom-up and top-down.

Keywords: *indirect effects, social benefits, investment decision, broadband, FTTH, eGovernment, eBusiness*

1 Introduction and motivation

The emergence of computer networks and the internet in general has changed everyday life drastically. Telecommunication networks and connectivity have influenced the way people communicate, look for information, spend their spare time etc. Upgrades of existing and launching of new services, pushes the demand for capacity and speed. The investments needed to upgrade current networks are huge and can hardly be covered by current incremental monthly subscription fees for customers. There are, however, other positive effects resulting from a stable and fast broadband connection. For example, travel time and costs can be reduced because a fast internet connection enables employees to work from home. If these indirect benefits, which yield advantages not only on the telecom domain, but to the entire cultural and economic society, are included, the economic viability of a business case for fiber network deployment increases.

In other areas of infrastructure development such as transport infrastructure, these wider public benefits such as travel savings due to telecommuting are extensively quantified and widely used (Eijgenraam et al., 2000). Before the beginning of large infrastructure projects in the Netherlands, a calculation of the indirect benefits has to be included in the analysis since 2003. Infrastructure projects such as the extension of the Rotterdam harbour ("Tweede Maasvlakte") or the high speed train to Germany ("Betuwelijn"), had to undergo a detailed calculation of these indirect costs and benefits in terms of environmental effects ("Tweede Maasvlakte") and savings on travel time ("Betuwelijn"). As the investment costs have been too high for private companies, these projects have been co-financed by different public parties as the expected social benefits have been considered as sufficient to justify public investment. With respect to investment in the broadband infrastructure in the Netherlands, national government intervention has been seen as unnecessary as it did not represent - according to the Netherlands Bureau for Economic Policy Analysis – a case of a market failure (CPB, 2005). As a result, a number of local, small-scale fiber network initiatives have been developing across the Netherlands which did not quantify the expected indirect benefits of these networks. In addition, similar studies on the calculation of these indirect benefits on a national scale have been rather scarce (Elixmann, Ilic, Neumann, & Plueckebaum, 2008).

Although the key question for investment in broadband infrastructure has been to choose projects which "have the longest lifespan, highest efficiencies and strongest social benefits" (OECD, 2009), these social benefits are not taken into account in most techno-economic analysis of investments in Next Generation Access (NGA) infrastructures. By quantifying indirect benefits for municipal broadband networks, decision-makers are forced to think about "real" solutions to municipal problems, such as savings achieved by telecommuting or eGovernment.

There has been some discussion in the literature proposing that there is no evidence that service innovation has been realized by existing fiber deployments (Department for Business Innovation and Skills, 2010). Rather, service trends illustrate that consumers currently use fiber for information and communication services and online gaming and entertainment, but no new speed-reliant applications (Howell & Grimes, 2010). Furthermore, service benefits of fiber can also be delivered on the basis of other broadband technologies (Kenny & Kenny, 2010; Noam, 2008). In addition, consumers may not be willing to pay for fiber if prices are perceived to be too high compared to other broadband technologies. Regardless of what is actually consumed, there is a growing body of evidence that believes that bandwidth consumption will substantially increase. In the following, we examine in more detail some of these arguments.

Although some studies already focused on the value of these indirect benefits, they are rare and frequently not transparent in their methodology. It is furthermore not always clear if the baseline for comparison is a low-speed broadband (e.g. dial-up), higher-speed broadband (e.g. ADSL) or no internet connection at all. The study performed by Columbia Telecommunications (2009) for example, claims to calculate the additional social effects of FTTH on top of traditional broadband, but a meta-study by Hayes (2011) shows that these claims do not hold.
Other studies (e.g. New Zealand Institute, 2007) take, apart from sector-specific effects, also increased economic growth and innovation into account, which increases the monetary value of the effects, but on the other hand enhances the risk of double-counting some values.

Furthermore, the methodology used differs from study to study. Katz et al. (2010) and Forzati et al. (2012) use macro-economic data in top-down statistical analysis. However, they do not provide reliable calculations on the cost and benefits of the different parts of a fiber network, but use specific estimates on a national level instead.

In this context, the paper investigates the indirect benefits using a bottom-up approach, and focuses on two specific sectors: eBusiness and eGovernment, where most indirect benefits can be expected in the near future (Hayes, 2011). In a first step, the bottom-up approach quantifies the effects from individual services. Secondly, the impact on the society at large can be calculated by grouping all important and significant effects.
The model is applied to two cities: Ghent in Belgium and Eindhoven in the Netherlands. These two cities were chosen based on comparability regarding number of inhabitants and high-tech enterprises, the presence of a university, etc. Combining this comparability with the main diversity between the two cities: a well-established Fiber-to-the-Home (FTTH) network in Eindhoven versus traditional DSL and cable networks in Ghent, allows to investigate the possible impact of a fiber network in terms of indirect effects.
Even if a bottom-up approach is sensitive to input assumptions, it provides more detailed and reliable results compared to top-down approaches (will be explained in more detail later). Furthermore, the bottom-up approach allows us to show the different indirect effects and their impact separately. To check for the generalization of the analysis, we compare our results with the outcome of previous studies in the area.

After having introduced the concept of social benefits, and the motivation for investigating them in this introductory section, section 2 explains the methodology used for both identification and quantification of the indirect effects. This methodology will then be applied to the sectors eBusiness and eGovernment: the results of the identification and categorization process are summarized in section 3, while section 4 describes the results for the two cities under study: Ghent and Eindhoven. In section 5, these results are benchmarked with previous studies and the value is interpreted in comparison with NGA deployment costs in section 6. Finally, section 7 concludes the paper and gives recommendations for future work.

2 Bottom-up methodology for identification and quantification of social benefits

This section will describe the model designed for evaluating the value of the indirect effects of a broadband and FTTH network using a bottom-up approach. This type of approach allows to more clearly link the monetary results to the individual effects, while a top-down method starts from aggregated macro-economic data. We selected this bottom-up methodology because of its transparency and because it enables us to predict the individual indirect effects of broadband deployment.

The methodology consists of two main parts: firstly, the important effects are identified by means of a tree structure (section 2.1) and secondly, the individual effects are modeled and quantified (section 2.2). The value for the entire sector or actor can then be calculated by summing the values of the related effects.

2.1 Identification approach: building a tree structure

The identification process takes the form of a tree structure, starting from the different sectors that can be influenced (e.g. eGovernment), to identifying specific services that are deployed (e.g. an e-counter deployed by the city or municipality), to finally arrive at the actual effects of these specific services (e.g. reduced number of visits to the administrative center, leading to reduced travel and waiting time and costs, as well as reallocation of the administrative personnel's time). A generic example of this tree structure is given in Figure 1.

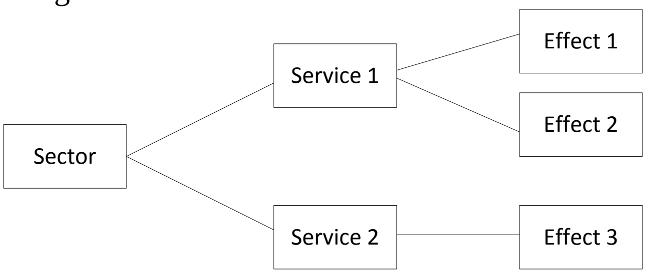

Figure 1: Generic example of identification tree

The individual effects are subsequently categorized along three axes: measurability, term and actor. A summary of the categorization axes, as well as their abbreviations, can be found in Table 1 in section 3.

The axis measurability indicates whether the value of the effect can easily be transformed into a monetary value. There is a distinction between subjective (cannot be converted in a monetary value) and objective (can be more easily converted into a monetary value).

The second axis is the term: here the effects are grouped on basis of the period in which the underlying services need to become "operational", meaning that 50% of the target audience uses the specific service and will therefore be impacted by the effect. A distinction is made between short term (the service is operational within 2 years after deployment of the network) and long term (the service needs more than 2 years to become sufficiently adopted). Examples of short term effects are the gains in travel time due to working at home, or the reduction in letters sent when changing to an e-counter at the administrative center of the city. Long term effects are then for instance the reduction in operational expenditures of a company that allows its employees to work (partly) from home, or a reallocation of the administrative personnel of the city from front to back office.

The third and last axis of categorization refers to who benefits from the effects. The distinction is made between "government" (all local and general authorities), "companies" (all private entities, both SME's (Small and Medium Enterprises) and larger firms), "individuals" (inhabitants of the region under study) and "society" (a more general actor that accounts for e.g. environmental effects).

2.2 Quantification of the individual effects

After the identification of the different effects, the most important (and quantifiable) effects are monetarized by multiplying the amount of savings that can be gained for one entity (e.g. per person) with the total amount of entities influenced. A schematic overview of the different steps in the model is given in Figure 2.

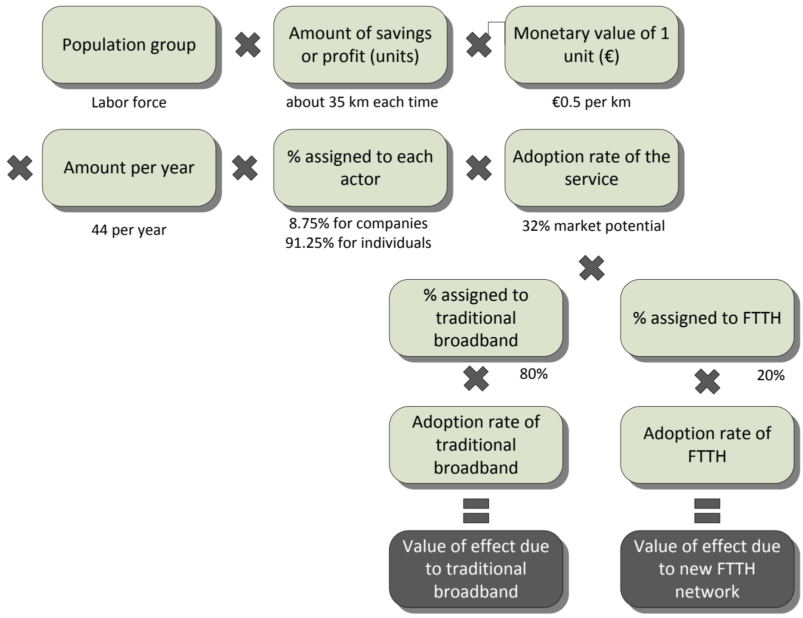

Figure 2: Overview of the quantification model with integrated example for teleworking

The model calculates the monetary value per effect by multiplying eight different parameters. The indirect effects of teleworking are used to elaborate on these parameters in the following paragraph.

Firstly, it is assumed that each specific effect only influences a specific section of society, so only the right *population group* is taken into account. For example, teleworking will only be possible for the labor force (people aged between 18 and 65). Secondly, the *amount of savings or profit* that can be made per member of the population group is evaluated (e.g. amount of km saved by avoiding commuting). This value should then be "transformed" into a *monetary value in Euro*. In our teleworking example, 1 km equals €0.5 (taking into account the fuel and insurance costs of the vehicle, according to own calculation based on (FOD Financiën, 2012) and (Travelcard, 2012)). If we multiply this with the *amount per year* (in case of teleworking, we assume that people work 1 day per (work)week from home, which leads to 44 days a year), it gives us the average saving for the entire population per year. Of course, these savings should be *assigned to the right actor* (in the example, around 90% of the cars are privately owned, while about 10% of the employees drive with company cars, which leads to 90% assigned to "individuals" and 10% to "companies") and the *adoption rate of the service* should furthermore be taken into account. This adoption rate reflects how fast the service is adopted (relates to the short/long term classification), as well as the maximum percentage of the population group that is eligible for using the service - the market potential, 32% in our example (PWC, 2004). Finally, the split between traditional broadband (up to 20 Mbps) and

FTTH is made, where the *specific adoption rates of both technologies* are taken into account, as well as a *percentage* that indicates if traditional broadband suffices, or higher-speed FTTH is necessary.

This methodology can be followed for all the indirect effects individually. The results for the specific sector (e.g. eBusiness and eGovernment) and/or for specific actors (like "individuals" and "companies") can then easily be calculated by summing the related values.

3 Identification and categorization of indirect benefits for eGovernment and eBusiness

As mentioned in the introduction of this paper, we will only focus on the effects identified for the sectors eGovernment and eBusiness, because in these sectors, the most important effects for the near future can be found (Hayes, 2011).
eGovernment or electronic government utilizes the ICT environment in an integrated manner to offer public services to all, at any moment of the day. Using eGovernment will improve the quality and speed of those public services, and will enhance the support of the government policy and the democratic process (FOD economie, 2012).
eBusiness on the other side, is typically defined as the application of ICT for the support of all kinds of business activities. Using ICT in the working environment improves the efficiency of the employees, can help to improve the productivity of the company and allows flexibility in working hours and location.

This section will identify the most important indirect effects of both sectors, and will categorize them based on the three axes described in section 2.1. The abbreviations used in the identification tables, are shortly explained in the table below:

Table 1: Abbreviations used for categorization

S/O	S	Subjective
	O	Objective
Term	LT	Long term
	ST	Short term
Actor influenced	G	Government and local authorities
	C	Companies
	I	Individuals
	S	Society

3.1 eGovernment: from physical contact to electronic forms

Within the eGovernment sector, two main services have been identified, and their effects are summarized in Table 2. The first includes all applications for which the citizen needs to contact the administrative centre (e.g. extraction out of birth certificate, application for a driver's license, etc.). Transforming this physical contact into an electronic format, saves the citizens (at least some of) the travels to the city hall. For the (local) authorities, this effect entails a huge amount of savings on paper and letters to be sent. One typical example of this electronic format is the online submission of taxes, which is now already used by a fair amount of the population in both Ghent and Eindhoven.

Table 2: Identified services and effects for eGovernment

Service	Subservice	Effect	S/O	Term	Actor	Quantified?
eGovernment						
Government-citizen transactions	Switching from personal contact to electronic contact (income tax preparation and return, applying for licenses, paying for tickets, etc.)	Reallocation of the time of the administrative personnel (capacity can be used for other services, like back office)	O	LT	G	Yes
		Time gain	O	ST	I	Yes
		Travel cost saving, both fuel and parking costs	O	ST	I, C	Yes
		Decreased consumption of paper (e.g. sending letters)	O	ST	G	Yes
		Decreased traffic jams and road accidents	O	LT	S	Yes
		Less stress	S	LT	I	No
		Reduced CO_2 emission (and other harmful gasses)	O	LT	S	Yes
	Providing information and resources for citizens online (e.g. e-newsletters, city information, personal profile, etc.)	Time gain	O	ST	I, G	No
		Reallocation of the time of the administrative personnel	O	LT	G	No
		Travel cost saving	O	ST	I, G	No
		Decreased consumption of paper (e.g. brochures)	O	ST	G	No
		Retrieving information outside office hours	S	LT	I	No

3.2 eBusiness: travel savings from teleworking and distance training

In eBusiness, the most important services that create indirect effects are teleworking (also referred to as working-at-home) and training of employees (from a distance). A high-speed broadband connection (preferably over fiber) will allow people to access their files at home as quickly as they would be able to do from the office, or enable employees to discuss with colleagues all over the world through real-time HD videoconferencing. These options permit employees to work (partly) from home, reducing their commuting time and cost, give the companies the opportunity to cut back their operational expenditures (e.g. rental fees for office space), while videoconferencing decreases the necessity of business travel. These services and their categorized effects are summarized in Table 3.

Table 3: Identified services and effects for eBusiness

Service	Subservice	Effect	S/O	Term	Actor	Quantified?
eBusiness						
Teleworking	Working from home	Reduced travel (time and costs for both fuel and parking)	O	ST	I, C	Yes
		Decreased traffic jams and road accidents	O	LT	S	Yes
		Reduced emission of CO_2 (and other harmful gasses)	O	LT	S	Yes
		Reduced stress	S	LT	I, C	No
		Decreased number of absenteeism by illness	O	LT	C, G	Yes
		Reduced office space and operational expenditures	O	LT	C, G	Yes
		Higher independency and flexibility for the employee	S	ST	I	No
		Reduced spending on human resources	O	LT	C, G	Yes
	Videoconferencing	Less business trips	O	LT	C	Yes

Training of employees	Grouped management of ICT infrastructure for clustered companies	Reallocation of the time of the support staff	O	LT	C	No
		More efficient use of network- and ICT services	O	LT	C	Yes
	Online training (possibly from home)	Reduced travel (time and costs for both fuel and parking)	O	ST	C, I	Yes
		Reduced stress	S	LY	C, I	No
		Reduced emission of CO_2 (and other harmful gasses)	O	LT	S	No
		Decreased traffic jams and road accidents	O	LT	S	No

4 Calculating the value of the indirect effects for Ghent and Eindhoven

4.1 Overview of the input parameters

The model will be applied to two case studies: Ghent, an urban city in Belgium with a well-developed DSL and cable network (but no FTTH yet), and Eindhoven, a city in the neighboring country the Netherlands that owns a well-established FTTH network, deployed in 2007, but which doesn't cover the whole city yet.

The authors chose to compare these two cases because of comparability on demographical, geographical, economical and cultural basis (Table 4). Both cities can be categorized as urban, they both house a well-established university with comparable number of students, as well as a business campus where lots of smaller high-tech enterprises are settled (among which grew as spin-off companies from the respective universities). Exactly this combination of a high degree of comparability with the difference in telecommunication networks present, will allow evaluating the impact of FTTH on the effects that have been identified.

Table 4: Comparison of regional data for both case studies: Ghent and Eindhoven (Stad Gent, 2012), (Eindhoven Buurtmonitor, 2012)

Parameter	Ghent	Eindhoven
Number of inhabitants	246,719	217,223
Number of households	106,805	97,523
Number of SMEs	7,289	6,513
Number of students at the university	31,445	21,743
Commuting population	138,597	143,100

In order to be able to compare both cases in a fair way, the economic parameters will be kept the same for both cases. The calculation period will be limited to 2012-2030, and the discount rate set at 10%, which is realistic when compared to the official discount rate as mentioned by the Belgian incumbent, Belgacom (9.61%), (BIPT, 2010) and the discount rate of KPN (incumbent in the Netherlands): 10% (OPTA, 2008).

For the same reason, the parameters that determine the adoption curve will also be kept the same for both cases (Belgium and the Netherlands are two neighboring countries with similar economic and cultural background), only the introduction years of the services may vary when data about their first implementation year are available. Similarly, the parameters for the adoption curves of the technologies (traditional and FTTH) will be kept similar, apart from the introduction years (since FTTH is already present in Eindhoven and not in Ghent). For Eindhoven, we take the introduction year at 2007 (the year of the deployment of FTTH there), while in Ghent, we assume a deployment at the start of the business case analysis, which means that first FTTH effects will be visible in 2014.

4.2 Impact of FTTH: empirical results

Before we elaborate on the output of our model, we would like to discuss some interesting observations that came forward in the process of data gathering. First of all, there is a significant difference in the penetration rates of both municipalities. The penetration of FTTH (homes connected) in the municipality of Eindhoven is about 17%. The total internet penetration is 92%, which is in line with the Dutch average. The fiber penetration is significantly higher than the country's average, which is 4.19% (OECD, 2012). At the time of this analysis, there is no FTTH rolled-out in the municipality of Ghent. The total internet penetration is similar to the Dutch situation though. In the outcomes, this will have an impact on the results, since the effects of fiber will be present from the start in the case of Eindhoven.

The second observation relates to the adoption of the eGovernment services of both cities. In both cases the e-counter was introduced in 2003. Though, the number of requests shows significant differences nowadays. In 2011, the number of digital migration registrations was 9,612 in Eindhoven and 5,858 in Ghent. The number of request of an extract out of the birth certificate was 5,330 in Eindhoven en 1,617 in Ghent. This would imply that the e-counter in Eindhoven is more mature or adopted than the one in Ghent. It is on the other hand hard to conclude to what extend this can be addressed to the fact that the city is partially covered by an FTTH network. There furthermore might me differences in the pace in which different services were introduced via this new distribution channel.

The final observation that we would like to discuss here relates to teleworking. In the results for eBusiness (see further down in this section), there is a prominent role for teleworking. If a portion of the workforce can work at home for at least one day a week, this will have an impact on travelling time of the employee and expenses by the employer on electricity and office space rent. PWC (2004) already made an analysis concerning this matter and made observations of the proportion of the workforce that are (potential) teleworkers. It turned out that 2.3% of the Belgian workforce worked at least one day at home, but it had a potential of 31%. For the Netherlands these numbers were respectively 9.0% and 41.0%. The Central Agency for Statistics (CBS) presented more recent numbers on this matter and stated that 7% of the workforce structurally works at home in the Netherlands. 30% does this on an incidental basis (Centraal Bureau voor de Statistiek, 2012). The problem with these numbers is the large variety per region and per industry. We were not able to identify the values for the specific regions that are the subject of our study.

4.3 Results from the bottom-up methodology, and comparison of Ghent and Eindhoven

While the previous section tried to subtract conclusions from the input data gathered for both cases, this section will focus on the results of the actual bottom-up calculation. We will first discuss the total value of the indirect effects for both sectors, identify the most important effects, to finally evaluate the value per actor (according to the categorization axes as described in section 2.1).

4.3.1 Total value

The first result we show is the total value for both sectors and both cities (Figure 3). This total value represents the addition of the effects due to current broadband and the effects of fiber. The total value for Ghent sums to €930 million, for Eindhoven this is €1,140 million (cumulative and discounted until 2030). Clearly, the value of the indirect effects from the eBusiness sector is much higher than the value for the eGovernment sector (about a 1/10 ratio). The explanation can be found in the individual effects that make up this total value, on which will be elaborated further in section 4.2. The higher value for Eindhoven in comparison to Ghent can be explained by the influence of the presence of the FTTH network there (see further for more details).

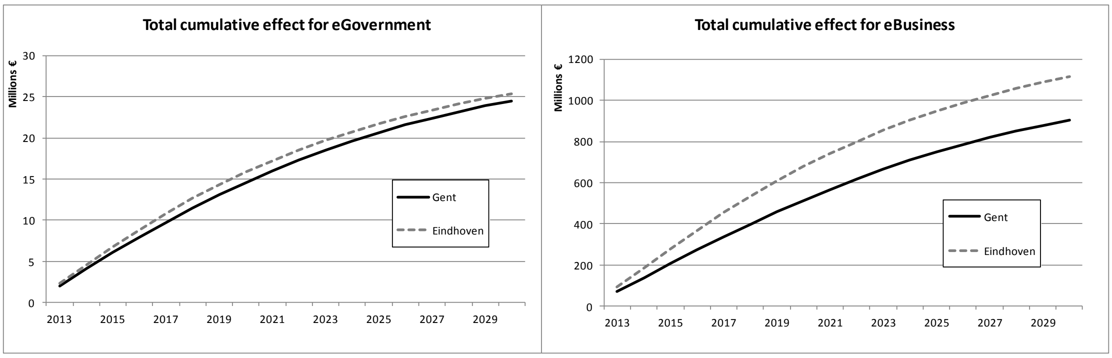

Figure 3: Total cumulative effect for both cities, both sectors (cumulative and discounted with 10%)

Evaluating this total value is of course relevant, but calculating down to the value per individual (for eGovernment) or per company (eBusiness) might give a better insight. These values are shown in Figure 4 (cumulative and discounted over 20 years), where a distinction is made between the value obtained by customers that have "normal" broadband, and those who are subscribed to fiber. It is clear that the portion taken up by "fiber" is much higher in Eindhoven than in Ghent, which can easily be explained by the fact that there are already more FTTH subscribers.

A more important result that can be concluded from this graph, is that there is a clear advantage of FTTH for the eBusiness sector, since the value per company for Eindhoven is significantly higher than that for Ghent, and the portion taken up by fiber is also significantly bigger. For eGovernment on the other hand, the additional value that fiber brings is only limited. This can be explained by the services that were identified for eGovernment: most of them can also easily be used on "normal" broadband (for more details on these services, see Table 2).

The value of eGovernment is only €100 spread out over 20 years, so this value might not provide an incentive to invest in fiber infrastructure. The value of about €150,000 per company, on the other hand, is significant.

Figure 4: Value of the indirect effects for eGovernment per individual, and eBusiness per company

4.3.2 Most important effects

To identify the most important effects, we step away from the adoption curve of the technology, but only look into the maximum potential of the service itself. Referring to Figure 2, only the first six parameters are taken into account. We opted to compare the services in this way to exclude the impact of adoption of the technology, so that we can compare both cases on a fair basis.

The comparison for eGovernment is made in Figure 5. We see similar results for both cases: the travel savings take up the largest part (88% for Ghent, 86% for Eindhoven, respectively). These savings include savings on time, fuel costs, parking costs and other costs related to automobiles, like insurance. It has to be mentioned that these costs only apply to inhabitants that visit the administrative centre of the city hall by car. We didn't take public transport or biking into account, so this value could even be higher. The other effects are much smaller, but not negligible.

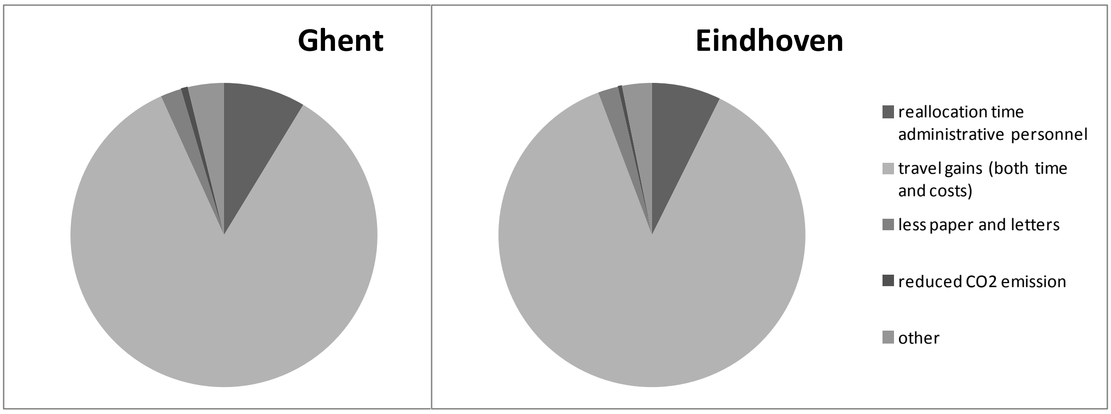

Figure 5: Indication of the most important effects for eGovernment

The same analysis can be performed for the eBusiness sector (Figure 6). Here, about 80% is taken up by savings in travel and office space (about €103,000 per company in Ghent, €120,000 in Eindhoven). Allowing people to work from home, can on the long term reduce the amount of office space needed. On a shorter term, these effects are already translated in operational savings (for e.g. lightning, electricity, cleaning staff, etc.). A common remark made on these operational savings is that they are not really saved, but transferred to the employee itself (since this employee now has to pay for the electricity, heating, etc. at home). However, this electricity cost represents only a small part of the total savings, the largest part of the savings is made by renting costs for office space and furniture. Quantifying these savings might therefore provide companies with the incentive to pay the internet subscription of their employees at home, which in turn can provide a higher willingness to pay and as such an incentive to deploy fiber networks.

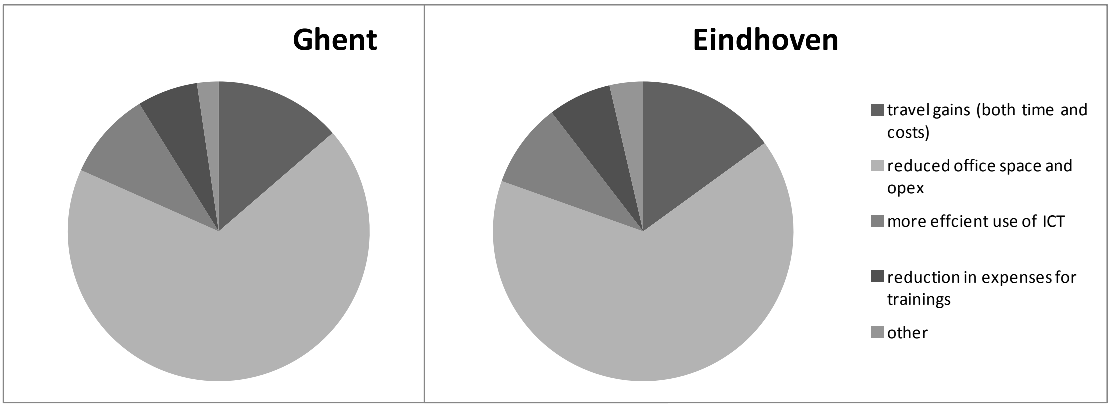

Figure 6: Indication of most important effects for eBusiness

The same reasoning holds for a more efficient use of ICT: if a fast broadband connection is present, companies can centralize their ICT infrastructure (servers etc.), which allows sharing this infrastructure among different locations.
Although not included in the eGovernment sector (we assumed one administrative center location in each city), this sharing of ICT infrastructure could also entail large savings for the authorities, and should be kept in mind when evaluating public investment in fiber infrastructure.

4.3.3 Value per actor

To conclude this results section, we give an overview of the results per actor (Figure 7). The spreading of the results do not differ much between Eindhoven and Ghent, and this can mainly be explained by the value of the input parameters, which were very comparable.

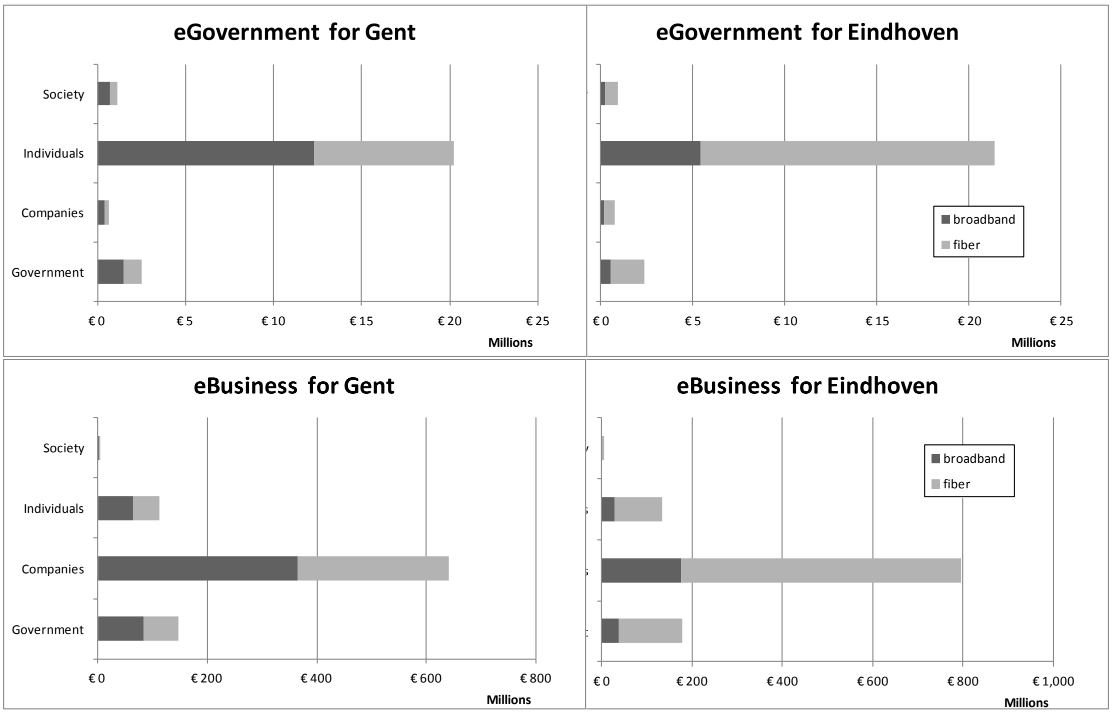

Figure 7: Overview of the value of the indirect effects per sector and per actor

Clearly, the largest part of the savings for eGovernment can be allocated to the individuals. This can be easily explained by comparing Figure 5 and Figure 7: the largest effect: travel savings, is of course an advantage for the inhabitants of the city.

The same reasoning holds for eBusiness: the largest part is taken up by savings in operational expenditures and office space, which is of course a saving for the companies. The individuals primarily benefit from the savings in travel time and costs. Surprisingly, the government also gains a fair share of the savings of eBusiness. This is due to the split in types of businesses: private and public enterprises, whereas the advantage for the public enterprises is allocated to the actor “government”.

5 Benchmarking our results: comparison to other studies

To benchmark our results, we will compare them with other studies available in literature. Based on transparency and degree of comparability, three studies were selected, among which two of them also used the bottom-up approach (New Zealand Institute, 2007 and Columbia Telecommunications, 2009), the third study opted for a top-down methodology (Katz et al., 2009).

5.1 Comparison with other bottom-up studies

Both studies identify different types of effects, but chose to only quantify the more objective effects (similar to the strategy followed in this paper). Furthermore, they both claim to quantify the incremental effects of high-speed broadband on top of existing infrastructures. Although this seems to be the case for New Zealand, the metastudy of Hayes (2011) showed that the baseline for Seattle is no broadband at all. We will therefore compare the results of New Zealand with the incremental effects of FTTH found in this study, and the results for Seattle with the total effects of this study (from traditional broadband and FTTH combined). Not that these incremental effects are different from the results described in section 4, as section 4 also included the effects for “normal” broadband for the fiber customers (so that Ghent and Eindhoven could easily be compared).

The methodology of the New Zealand Institute is most comparable to the methodology used in this paper: they also start from a number of sectors, for which they expect indirect benefits. Evidence and values for these indirect effects are gathered from national and international sources. The main difference is that they quantified the value for the each effect at once, and did not start from the value per individual or unit, as was done in this paper.
The study of Columbia Telecommunications is less transparent in its methodology, the main similarities with our study are that they also used a categorization tree, they only quantified actual monetary savings, and they used interviews with experts on the field to identify the effects and gather input data.

5.1.1 Comparison with New Zealand for eBusiness effects

Unfortunately, the New Zealand Institute did not quantify the effects for eGovernment, so there is no basis for comparison here. They did quantify the effects for eBusiness extensively, allowing us to make a detailed comparison. Table 5 gives the value per individual and per year for the three cases: Ghent, Eindhoven and New Zealand.
The results for New Zealand and Ghent are very comparable, while the value for Eindhoven is more than double. This can be explained by a higher fiber adoption in Eindhoven (already 16.5% today - 2012), but also in the higher benefits from fiber for eBusiness. The highest benefits for eBusiness for New Zealand were also found in remote working (or teleworking) and reduced travel costs in general.

Table 5: Comparison of the monetary value of the incremental effects of FTTH, per capita and per year, for eBusiness

	This study - Ghent	This study - Eindhoven	New Zealand
eBusiness	€15	€38	€12

5.1.2 Comparison with Seattle

Comparing the results of our study with the study of Columbia Telecommunications (2009), is less straightforward than the comparison with the study for New Zealand, because the report is not very transparent in explaining its methodology. The positive point is that they do calculated values for eGovernment. Table 6 shows that the results are in same order of magnitude.
When comparing eBusiness, it is clear that the value found in Seattle is higher than the results of this study (around double). This can however be explained by the type of effects that were taken into account in both studies: in Seattle, more than two third of this value can be accounted to a reduction in traffic congestion, an effect that we did not quantify (because of subjectivity, and a lack of available input data).
The same, almost doubled, result is found for the eGovernment sector. Again, this value can be explained by the fact that this study did not take an effect into account that was rather important for Seattle: the more efficient use of ICT by sharing infrastructure amongst governmental buildings. As mentioned before (see section 4.3.2), we did not take this value into account because we started from the assumption of one administrative center per city.

Table 6: Comparison of the monetary value of the total effects of broadband and FTTH, per capita and per year, for both eBusiness and eGovernment

	This study - Ghent	This study - Eindhoven	Seattle
eBusiness	€193	€270	€547
eGovernment	€5	€7	€15

5.2 Comparison with a top-down study for the impact of broadband on the German economy

Katz et al. (2009) investigated the impact of broadband on the German economy, using input-output analysis on two investment scenarios, a national broadband strategy (50 Mbps for all by 2014), and an ultra broadband strategy (at least 50 Mbps on VDSL, 100 Mbps on fiber by 2020). The results of this study predict that the German GDP (Gross Domestic Product) will grow with €170.9 billion between 2010 and 2020.
This total value counts both direct and indirect effects, and includes all sectors (so doesn't limit to eBusiness and eGovernment). The direct effects include the direct economic activity related to the deployment of the network (job creation and the purchasing of expensive equipment), the indirect effects consist of a faster innovation process and the creation of new business activities.

It is of course far from straightforward to compare a macro-economic analysis starting from general economic indicators with a bottom-up analysis that identifies the value for the different effects separately. We opted for an estimation of the importance of eBusiness and eGovernment vis-à-vis the other sectors (like eHealth, eEntertainment

etc.), and used this percentage to calculate the macro-economic value of eBusiness and eGovernment, as found by Katz et al.
Based on van Wijnsberge and Vandersteegen (2012), the combined share of eGovernment and eBusiness in the total share of possible indirect effects, is 59%. Calculating the value found by Katz et al. down to this percentage (Table 7), leads us to the conclusion that these values are very similar. The value for Eindhoven is again higher due to the extra benefits already perceived for eBusiness on fiber.

Table 7: Comparison of bottom-up (this study) to top-down (Katz et al., 2009) (yearly basis)

	Total value per capita	Percentage allocated to eBusiness and eGovernment	Result: value per capita for eBusiness and eGovernment
This study (Ghent)	€198	100%	€198
This study (Eindhoven)	€276	100%	€276
Katz et al. (Germany)	€333	59%	€196

6 Interpretation of the results: how does this value relate to the deployment costs for NGA networks?

The model did not only allow us to calculate the total values of the indirect/social effects that were discussed in the previous sections, it also enables us to calculate the added value of the replacement of a traditional broadband network with an FTTH solution. If we compare this effect with the deployment costs and direct revenues, we can draw some interesting conclusions. Let us start with the costs that are involved with the roll-out of all-fiber access networks.
The typical costs per home passed vary between €880 and €1000. A home is passed when the fiber cable is installed in the street and the possibility is foreseen to subtract one (or multiple) single fibers. The price difference is mostly explained by the type of network architecture. The high number represents a fiber rich point-to-point (P2P) network, the low number a point-to-multipoint (P2MP) network in which fibers are shared. These numbers are subject to scale advantages and will lower due to learning effects in case of multiple projects over time.
It obviously requires an extra investment to turn a home passed into a home connected. A single fiber should be connected to the house and the necessary Customer Premises Equipment (CPE) should be installed. This leads to extra installation costs. The typical total costs to pass and connect vary between €1200 and €1800. The difference is again explained by the selection of the network architecture.
These typical costs play an important role in the assessment of the operator whether or not to invest in the roll-out of this new solution. The deployment is usually done on a neighborhood basis, but even then it involves a multiple million investment decision. The potential direct extra revenues therefore play an important part in this process. The typical revenues per customer are displayed in the following tables. Many customers have a preference for dual- or triple-play packages, but we leave that out of the equation for now and focus solely on the costs for internet access.

Table 8: Current customer charges for broadband in the Netherlands (Eindhoven)

	KPN	UPC	Percentage of customers
Economic	€25.00/month	€20.00/month	25%
Standard	€35.00/month	€30.00 /month	65%
Premium	€45.00/month	€45.00/month	10%
Average	€35.00/month	€31.67/month	€33.33/month

Table 9: Current customer charges for broadband in Belgium (Ghent)

	Belgacom	Telenet	Percentage of customers
Economic	€24.95/month	€24.95/month	25%
Standard	€34.95/month	€44.95/month	65%
Premium	€44.95/month	€64.95/month	10%
Average	€33.45/month	€41.95/month	€37.7/month

Table 10: Current customer charges for fiber in the Netherlands (Eindhoven)

	Ons Brabant Net	XS4ALL	Percentage of customers
Standard	€34.95/month	€45.00/month	70%
Premium	€44.95/month	€55.00/month	30%
Average	€39.95/month	€50.00/month	€44.98/month

(*OnsBrabantNet and XS4ALL are subsidiaries of KPN.)

The comparison shows that fiber is a premium service that roughly leads to a €10 increase in the monthly revenues for internet access. If we assume that the cost structure of the operator is similar to the old situation, then we can conclude that this €10 is extra revenue that can be used to cover the investments needed for the network upgrade. This would imply that it takes 12 to 18 years per home connected to cover the expenses, leaving out any administrative and overhead costs. It is therefore unlikely that an operator is willing to invest in this new technology on a large scale. The inclusion of the additional effects per household changes the picture though. If we take the indirect effect of eGovernance and eBusiness into account, the added effect of fiber per inhabitant proved to be €740 for Eindhoven and €293 for Gent over a period of 20 years. If we multiply these numbers with the representative number of inhabitants per household (2.22 and 2.31, (Stad Gent, 2012), (Eindhoven Buurtmonitor, 2012)) it results in a total added effect of €1642.8 and €676.83. These indirect effects already cover the investments to a great extent, meaning that it would be a good investment from a societal perspective.

In Eindhoven, the estimated costs of installing a city-wide fiber network have been approximately €97 million using current data with respect to number of households and connection costs per households (homes passed) for a point-to-point network. However, the implementation of a fiber network has taken a different route - starting in 2003 - with the "Glasrijk" vision of the Municipality Eindhoven (Gemeente Eindhoven, 2003). In 2005, the municipality started in setting up its own municipal internal fiber network which was aimed at connecting the different locations of the

municipality with each other and with a number of other parties in the region (e.g. hospitals). This new municipal network was called BRE – Breedband Eindhoven - and replaced the leased lines provided by KPN. Investment in the network was undertaken in 2005 (€1.4 million). Within one and half years, this investment provided positive returns. It furthermore took away any future capacity problems, which could have become a problem with the leased lines.
Part of the “Glasrijk” vision was the installation of a city-wide network in Eindhoven. In 2006, Ons Net Eindhoven started with the installation of a fiber network in two neighborhoods in Eindhoven. After an intensive period of installation of fiber between 2006 and 2007 in these two neighborhoods, no further growth was realized until 2012. During this time, the costs of installing fiber per household were decreasing from €1200 to currently around €1000. New plans for the extension of the fiber network across the city of Eindhoven have recently been agreed upon between different market parties and the municipality in Eindhoven which aim at providing fiber access across the city in short period of time (2-3 years). All connections are homes connected.

Comparisons between typical broadband (only) versus fiber (only) connections show that in Eindhoven, fiber is put in the market as a premium service. The price premium already appeared in the price comparison tables above. The diffusion of fiber packages does not follow the typical diffusion curve though. The expansion of fiber services across the city is driven by demand aggregation which takes place on the neighborhood level. Demand aggregation is jointly done by a number of internet service providers in a neighborhood in order to achieve sufficient subscriptions to different fiber service packages using different marketing techniques.

7 Conclusions and future work

Telecommunications networks and services are characterized by a constant and rapid evolution: the available bandwidth keeps on increasing, the number of offered services grows almost continuously, and so does their quality. The next big steps in the evolution of telecom networks is the upgrade towards all-fiber networks, like Fiber-to-the-Home. These upgrades require a huge upfront investment, which is too high to be covered only by the direct revenues from subscribers.
This paper presented a bottom-up quantification model of other revenues, so-called indirect or social benefits, which the deployment of a high-speed broadband network would definitely also entail. Including these social benefits in the cost-benefit analysis of the business case of a FTTH deployment, can increase the incentives to invest.

The authors opted for a bottom-up methodology because it allows to model the effects separately, and in more detail. It is true that this model is more influenced by the values of the input parameters than a top-down approach (which uses statistical data in regression analyses), but gives on the other hand a clear causal relationship between these input parameters and the final result. This approach therefore allows identifying the most important effects, which gives the parties involved in the project the ability to first focus on the development of the services that provide those effects, so that these will lead to savings or extra profits already in an early stage of the project. Within the sectors eGovernment and eBusiness, which were the focus of this study, the most important effects (leading to the highest monetary value), are travel gains from reduced physical contact in the administrative center, and operational savings for companies by introducing teleworking.

By applying the methodology on two case studies: Ghent (without FTTH) and Eindhoven (with a well-established FTTH network), it became clear that some services actually don't really need this fiber connection (e.g. the e-counter for eGovernment), while others, like teleworking, clearly benefit from the presence of a FTTH network.

To benchmark our results, they were compared to earlier studies found in literature. In general, the results of this study are in line with the outcome of previous investigations. There are of course differences, but they can be easily countered by logical explanations like the impact of the population density and time period of the study.

Future work in this domain includes the extension of the study to other sectors, like the health and entertainment industry, as well as the extension of the study towards other regions, like more rural areas (where the effects of travel savings will be even higher). Furthermore, we should evaluate the different services separately, to see what bandwidth speeds they actually need and what kind of limitations they have, so that a more accurate calculation can be performed.

Acknowledgement

The authors of this publication have received funding from the Agency for Innovation by Science and Technology in Flanders (IWT), and this research was partially carried out in the framework of the projects TERRAIN, OASE and NGInfra project: What are the Public Benefits of Open Access? Evaluating the Social Cost and Benefits of Municipal Fibre Networks. The IBBT TERRAIN project is co-funded by IBBT, IWT and Acreo AB, Alcatel-Lucent, Comsof, Deutsche Telekom Laboratories, Digipolis, FTTH Council Europe, Geosparc, Stad Gent, TMVW, TE Connectivity, UNET and WCS Benelux BV. The OASE project has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 249025. The NGInfra project was supported by the Next Generation Infrastructures (http://www.nginfra.nl/).

References

BIPT. (2010) *Broba Ethernet.* Belgian Institute for Postal Services and Telecommunications. Brussels, Belgium.

CPB. (2005). *Do Market Failure Hamper the Perspective of Broadband?* CPB Document 102, December 2005.

Centraal Bureau voor de Statistiek. (2012). *Tijd- en plaatsonafhankelijk werken in 2010.* Den Haag: Centraal Bureau voor de Statistiek.

Columbia Telecommunications Corporation (2009) *Benefits Beyond the Balance Sheet: Quantifying the Business Case for Fiber-to-the-Premises in Seattle.*

Department for Business Innovation and Skills (2010) *Broadband deployment and sharing other utilities' infrastructure – a discussion paper.* Retrieved from http://www.bis.gov.uk/assets/biscore/business-sectors/docs/b/10-1046-broadband-deployment-discussion-paper

Eijgenraam. C., Koopmans, C., Tang, P. & Verster, A. (2000) *Evaluatie van Infrastruurprojecten. Leidraad voor Kosten-Batenanalyse*. Den Haag: CPB.

Elixmann, D., Ilic, D., Neumann, K.-H., & Plueckebaum, T. (2008) *The Economics of Next Generation Access*. Bad Honnef: WIK.

Eindhoven Buurtmonitor (2012) *Eindhoven in cijfers*. Retrieved from http://eindhoven.buurtmonitor.nl/.

FOD Economie (2012) *eGovernment.* FOD Economie, KMO, Middenstand en Energie.

FOD Financiën (2012) Gemiddelde brandstofprijzen. Retrieved from http://fiscus.fgov.be/interfaoifnl/vragen/gemiddeldebrandstofprijzen/index.htm.

Forzati, M., Mattsson, C. Wang, K. & Popp Larsen, C. (2011) *The uncaptured value of FTTH networks.* Conference paper at FTTH Council Europe, Munich, Germany.

Gemeente Eindhoven. (2003). *Glassrijk Eindhoven. Visie en Strategie Breedbandinfrastructuur*. Eindhoven: Gemeente Eindhoven

Hayes, R. (2011) *Valuing Broadband Benefits: A selective report on issues and options.* Melbourne Business School, University of Melbourne, February 2011.

Howell, B. & Grimes, A. (2010) *Productivity questions for public sector fast fibre network financiers*. Communications and Strategies, 78(2), 127-145.

Katz, R.L. & Vaterlaus, S. (2009) *The impact of broadband on jobs and the German economy.* Intereconomics, 45(1), p. 26-34.

Kenny, R. & Kenny, C. (2010) *Superfast broadband: Is it really worth a subsidy?* Communications Chambers, USA.

Noam, E. (2010) *If fibre is the medium, what is the message?* Columbia University Business School. Retrieved from at http://www.elinoam.com/

OECD (2009) *The Role of Communication Infrastructure Investment in Economic Recovery*.

OECD (2012) *OECD Broadband statistics*. Retrieved form http://oecd.org/sti/ict/broadband.

OPTA (2008) *Beleidsregels - Tariefregulering Ontbundelde Glastoegang*. Den Haag: Onafhankelijke Post en Telecommunicatie Autoriteit

Price Waterhouse Coopers (2004) *Technical assistance in bridging the "digital divide": A cost benefit analysis for broadband connectivity in Europe.* Frontier economics.

Stad Gent (2012) *Gent in cijfers.* http://gent.buurtmonitor.be/

The New Zealand Institute (2007) *Defining a broadband aspiration: how much does broadband matter and what does New Zealand need?*

Travelcard (2012) *Travelcard praktijkverbruik, de norm voor een goede budgettering van het brandstofverbruik.* Retrieved from http://www.werkelijkverbruik.nl/.

Van Wijnsberge, P. & Vandersteegen, B. (2012) *Hoe kunnen indirecte effecten de economische haalbaarheid van de uitrol van een breedbandnetwerk positief beïnvloeden?* Master's Thesis. Faculty of Engineering, Ghent University, Belgium.