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

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Second resubmission of JTPO-D-13-00054: "Identifying and quantifying the indirect benefits of broadband networks for eGovernment and eBusiness: a bottom-up approach" for Telecommunications Policy

Response to reviewers

Dear editor, dear reviewer,

Thank you to take the interest in reviewing this paper for the second time. Again, we appreciate the comments and suggestions, and adjusted the paper accordingly, so that it becomes more clear and better underpinned. Our response to the comments and the changes in the paper are indicated below. We focused in our responses first on the general comments. A short reaction to the more detailed comments follows afterwards.

The authors made great strides in revising the manuscript. There are three primary concerns and several specific questions that need to be addressed before this piece could be considered publication worthy.

First comment: The first concern is the need for specific citations to back up the assertions made by the authors. Citations should be added to Table 3 or noted that this is the authors' creation if this is the case. Several blanket statements are also made throughout the piece without referencing the relevant literature. For example, on pg. 10 the authors state: "They however did not assign the right benefits to the right actors, but only calculated an overall economic benefit." What are the right benefits? Who are the right actors? How is this grounded in the literature? Some instances where clarification is needed are listed in the specific comments below, but it is recommended the authors go through the text and add citations to the piece where necessary, above and beyond those instances mentioned below.

Our response: *Citations were added through the document, an overview is given here, per section:*

- *<u>Introduction and motivation</u>*
    - *chosen based on comparability regarding number of inhabitants and information-intensive enterprises, size, presence of university, etc (Stad Gent, 2012; Eindhoven Buurtmonitor, 2012)*
- *<u>Identification and categorization of indirect benefits for eGovernment and eBusiness</u>*
    - *eBusiness on the other hand is typically defined as the application of ICT for the support of all kinds of business activities (Chaffey, 2007).*

- *The literature studied included publications in national and international journals, consultancy reports, presentations, press releases and websites (concrete references are referred to further in this paper).*
        - *As summing all the references used would be very long, and not relevant here. The important references are referenced further down in the paper.*
    - *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 (FOD Financiën, 2013; Belastingsdienst, 2013)*
    - *These options permit employees to work (partly) from home, reducing their commuting time and cost, give the companies the opportunity to cut back on their operational expenditures (e.g. rental fees for office space), while videoconferencing decreases the necessity of business travel (Vari et al., 2011).*
- <u>*Calculating the value of the indirect effects for Ghent and Eindhoven*</u>
    - *The penetration curves of traditional broadband could therefore be based on existing data for both cases. For FTTH, the introduction year for Eindhoven was set at 2007 (the year of the deployment of FTTH there (OnsNet Eindhoven, 2012))*
    - *The penetration of FTTH (homes connected) in the municipality of Eindhoven is about 17% (Poulus & Compter, 2012).*

Note that other citations were also added following the specific comments made below, these were added in the responses there, and are as such not included in the list above…

Concerning the citation about right actors and benefits, this sentence aimed at describing the difference in methodology followed between our study and the PWC study: while in the PWC study, only an overall economic benefit was calculated, we added the allocation to the involved actors. The statement was adjusted accordingly: "While in that study, only an overall economic benefit was calculated, this study adds the allocation of the benefits to the different actors".

Second comment (a): A second area of concern is the discussion and conclusion. The authors present case study evidence about the value of their bottom-up approach for computing indirect benefits. Are these indirect benefits likely to be the same in other places? Ghent and Eindhoven are relatively small cities with a specific economic and cultural context. Isn't it likely that the magnitude of indirect benefits will vary by region, as demonstrated in recent broadband work by Mack et al., 2011 and Mack and Rey, 2013, as well as classics such as Forman et al., 2005a? Another item that merits more thorough treatment is the industry specific nature of this impact. Looking at e-business across all companies does not deal explicitly with the potential for industry specific variation in indirect benefits related to the importance of agglomerative forces and industry specific business processes. Prior work by Forman et al. (2003, 2005b) finds industry specific variation in dial-up adoption by firms, and this is likely the case for broadband and the indirect impacts associated with e-business. The authors mentioned this in the introduction of the original manuscript and should include it in a more thorough discussion of future work.

Our response: *The magnitude of the effects will certainly vary across regions, and the industry sector will have an impact, this is a rightful comment. A separate section 5.3 was added to the paper to indicate this. Reference was made to regional characteristics such as human capital, geographical location, population density, etc. using the references suggested. Furthermore, an indication of this impact of regional differences was added to the conclusion: this is something that should be investigated in future work.*

Second comment (b): Finally, what is the impact of the assumptions of the values chosen for the innovation and imitation coefficients of the Bass Curve? Does increasing or decreasing these values change the results or are they relatively robust? A discussion of all of these items will take space, but there are several locations in the text that can be worded more judiciously to create space for a longer discussion and conclusion. Section 3.1 on pg. 7 is an example of a section that could be shortened to create more space.

Our response: *The values for innovation and imitation coefficients are taken from reference sources, which have calculated them to be a (relatively stable) average. The comment that these values will impact the results is of course relevant, but performing sensitivity analysis on the estimated parameters is not within the scope of this paper. A footnote indicating this was added to the discussion of the parameters though.*

Third comment: The third area of concern is the tree structure diagram included by the authors. While it is great that the authors included this, the Figure is not detailed enough to add any insight. On pg. 4 the authors refer to a first and second tree structure they constructed and used? Why not use these instead of the generic diagram added as Figure 1? These diagrams might be quite large but their addition is necessary to understand a key step in the analysis.

Our response: *The first and second diagram refer to the way the diagrams were being set up. The first tree diagram refers to input from literature review only, the second to the diagram checked by external experts. The actual process of* *defining the diagrams however was an iterative process, so it is not possible to show both diagrams separately. The paragraph (section 2.2) was adjusted towards the iterative process instead of step 1 and 2.*

To make figure 1 more clear, it was split up into two parts: one general tree diagram, and one example for teleworking. Reference was further made to tables 2 and 3, since they included a full tree structure. Some explaining sentences were added to the text as well. We hope this addition makes the followed methodology more clear now…

Specific Comments:

1. Is one of the issues with indirect benefits the fact that we underestimate the impact of broadband if they are not included? This is implied in the manuscript, but not stated directly.
   The impact of broadband definitely should be seen broader than only the absolute income from subscriptions. "In the paper we argue that indirect effects of broadband infrastructure should be taken into account in the evaluation of broadband deployment projects as these effects are responsible for economic growth as thus necessary to account for the full impact of broadband deployment and uptake" was added to the introduction paragraph.

2. The discussion of top-down and bottom up approaches is actually a literature review and should be moved to the front of the manuscript.
   This was moved. A short reference sentence was kept in the introduction of section 3.

3. The sentence on pg. 2 refers to low-speed broadband as dial-up. Broadband is an always-on connection whereas dialup is not. Therefore dial-up should not be referred to as broadband. This sentence should be revised accordingly.
   The sentence was adjusted as follows: "It is furthermore not always clear if the baseline for comparison is a low-speed connection (e.g. dial-up), broadband (e.g. ADSL) or no internet connection at all."

4. Pg. 3: Past and more recent work (Gordon, 2000; Kolko, 2010; Mack and Faggian, 2013) suggest that ICTs do not always lead to productive uses by people. This should perhaps be mentioned in a footnote on pg. 3 of the manuscript.
   A footnote with a reference to section 5.3 as well was added.

5. Pg. 4: Word dimension is perhaps better than axes. Axes imply something is being plotted, which is not the case here.
   This was adjusted: we now compare based on three dimensions rather than three axes.

6. Pg. 5: Citations are needed for the following statement: " In eBusiness, the most important services that create indirect benefits are teleworking and training of employees."
   Following literature review (e.g. Hayes, 2011) and interviews with experts, in eBusiness, the most important services that create indirect effects are teleworking and (distance) training of employees.

7. Do the authors have any citations for the assertion made on pg. 10 which reads as follows: ".in a lot of European countries where there is a lack of competition, the broadband subscription rates are kept arbitrarily high by incumbents."?
   The statement was specified into: "in a lot of European countries where there is a lack of competition, broadband subscription rates are sometimes said to be kept artificially high by incumbents, as regulatory authorities see the need for setting price caps and defining access regulation (Laffont & Tirole, 1994)".

8. Pg. 6: Citations are needed for the following statement: "A common critique on working at home is the transfer of electricity consumption from the employer to the employee."
   A reference to the article of Kenny & Kenny, 2011 was added. In that article, they state about teleworking: "it can reduce transportation requirements, but on the other hand it requires homes to be heated or air-conditioned that might otherwise be empty during the day."

9. Pg. 6: Another critique of working at home is that people make more intra-day trips for non-work items. This should be noted. For good references, see work by Patricia L. Mokhtarian:
   http://www.its.ucdavis.edu/?page_id=11690#21
   A statement was added to section 2.5: Although it has been stated that "households may redistribute nonwork travel among their members on workdays to take advantage of telecommuters' additional flexibility or location at home, [..] the net effect is still a reduction in trips per household on workdays" (Helling, Mokhtarian, 2001).

10. Table 7 is difficult to understand. It is also odd that the authors have compared a top-down study with a bottom-up study, which they stated previously are two very different approaches to the estimation of benefits associated with ICTs.
    The comparison was made to verify whether our results were in line with previous studies. The explanation of the table was rephrased: "Applying this percentage to the value found by Katz et al. (who calculated the effect for the entire economy, while this study focused only on eBusiness and eGovernment), leads us to the conclusion that these values are very similar".

11. Pg. 17: The authors should spell out the acronyms in the following sentence: "This methodology can be useful in specifying the four conditions for the applications of the SGEI principle with respect to NGA networks..."
    The abbreviations were written in full in that section: NGA=Next Generation Access in the first sentence, SGEI= Service of General Economic Interest in the sentence mentioned in the comment above.

***Highlights (for review)**

Highlights

- Currently, deployments of Next Generation Access networks lack investment.
- This paper indentifies, categorizes and quantifies indirect benefits in two sectors: eGovernment and eBusiness.
- The evaluation of these indirect benefits proves to be significant for individuals, companies and the government.
- Indirect benefits should be internalized in the investment decision for NGA network deployments.

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

Abstract

Recent developments of broadband infrastructure deployment and service development have shown the variety of applications it can entail, thereby affecting many, if not all, sectors of the economy and society. Despite an increasing growth of broadband networks combined with a rising number of studies calculating in great detail the direct costs and benefits of these deployments, less attention has been paid to the indirect effects resulting from those emerging applications. As these effects have proven to contribute to economic growth, this paper argues that that they should be taken into account when evaluating a cost-benefit analysis and proposes a model for conceptualization, measurement and quantification. It studies these indirect benefits in the area of eGovernment (related in particular to savings on travel and waiting time by introducing an e-counter) and eBusiness (related to reducing traffic jams by allowing employees to work at home). In a bottom up manner, the paper quantifies the indirect benefits in these two sectors by studying two cities: Ghent (Belgium) and Eindhoven (the Netherlands). By quantifying these benefits per actor, the paper shows that the indirect benefits would provide large business and local authorities additional incentives to stimulate investment in broadband networks. The model and results of the paper could be used by decision-makers to improve the business case for new investments in fibre networks and allows evaluating existing and future investment cases.

Keywords: *indirect effects; social benefits; broadband; FTTH; eGovernment; eBusiness*

1 Introduction and motivation

Conventionally, investment in broadband access networks has been evaluated using the narrow focus of cost-benefit analyses (CBAs), which indicate that investments needed to upgrade current networks are huge and can hardly be covered by customers' incremental monthly subscription fees (Casier et al., 2008b; Corning, 2009), but which insufficiently identify indirect effects generated by e-services emerging in sectors outside of telecom. Based on the Bresnahan and Trajtenberg's concept of general purpose technologies (1995), however, it has been shown that broadband infrastructure can act as an enabler supporting an endless variety of applications using the Internet as a platform (OECD, 2008). As such, broadband access networks are pervasive technologies affecting different sectors of the economy in providing opportunities for growth of new e-services in a complementary manner. If these complementarities are taken into account, CBAs have to focus in great detail on the conceptualization, measurement and quantification of indirect effects (OECD, 2009b). In investigating a number of sectors, the OECD (2009a) concluded that the cost savings in just four sectors of the economy (particularly transport, health, electricity and education) would justify the construction of a nationwide FTTH network. In focusing on the government and business sector, the paper is aimed at providing a clear identification, categorization and quantification of indirect benefits.

In the paper we argue that indirect effects of broadband infrastructure should be taken into account in the evaluation of broadband deployment projects as these effects are responsible for economic growth and thus necessary to account for the full impact of broadband deployment and uptake. Since Aschauer's original argument (1989), that there may be substantial discrepancies between the results of conventional CBAs and the ultimate effects of such investments on welfare, research in the public choice tradition has increasingly focused on the existence and the quantification of indirect effects. In a static Arrow-Debreu economy, the Pareto optimality criterion indicates whether or not there are welfare improvements generated from indirect effects. In a dynamic Schumpeterian world, in which general purpose technologies provide necessary inputs into different application sectors (such as health, education and energy), policy has a function in providing incentives to provide broadband infrastructure and to foster the adoption of new e-services. Furthermore, the "Guide to Cost Benefit Analysis of Investment Projects" (European Union, 2008) stresses the need for incorporating the socio-economic benefits in the project objective and evaluation, but acknowledges the difficulties in predicting and quantifying all impacts of the project[1].

Literature has just started to provide conceptual frameworks to examine these indirect benefits. In the discussion on the "real" benefits of broadband infrastructure for economic growth (Katz, 2010; Kenny & Kenny, 2011), rarely any agreement has been reached with respect to common methodologies and appropriate data sources to measure and evaluate these benefits. Although there have been a few studies focusing on the value of these indirect benefits, they have not been consistent and frequently not transparent in describing their methodologies. It is furthermore not always clear if the baseline for comparison is a low-speed connection (e.g. dial-up), broadband (e.g. ADSL) or no internet connection at all. The study performed by Columbia Telecommunications (2009) for example, claims to calculate additional social effects of FTTH

[1] It should be noted though that the context and historical developments strongly affect these effects. Recent work (e.g. Triplett, 1999; Gordon, 2000) suggests that ICTs do not always lead to productive uses by people. For more details, we refer to section 5.3.

on top of traditional broadband, but the meta-study by Hayes (2011) doubts this. 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 increases the risk of double-counting.

Having identified the clear need for the identification and quantification of these effects, as well as the discrepancy in previous evaluation studies, this paper investigates the indirect benefits using a bottom-up approach by concentrating on two specific sectors where most indirect benefits can be expected in the near future (Hayes, 2011): eBusiness and eGovernment. This bottom-up approach allows to more clearly link the monetary results to the individual effects (Damart & Roy, 2009), while top-down methods only evaluate the overall effect using aggregated macro-economic data. Even if a bottom-up approach is sensitive to input assumptions, it provides more detailed results compared to top-down approaches (Casier et al, 2009; Lannoo et al., 2008). Furthermore, since no macro-economic data comparing ante- and post-deployment situations are needed, our model allows forecasting the value of the effects whereas top-down models only allow for evaluating ex-post of deployment.

The model uses data from two cities: Ghent (Belgium) and Eindhoven (Netherlands), chosen based on comparability regarding number of inhabitants and information-intensive enterprises, size, presence of university, etc (Stad Gent, 2012; Eindhoven Buurtmonitor, 2012). Combining this comparability with the main diversity between the two cities (a well-established FTTH network in Eindhoven versus traditional xDSL and cable networks in Ghent), allows investigating the possible impact of a fibre network in terms of indirect effects.

After this motivational introduction paragraph, section 2 explains the identification and categorization process and applies it on both eGovernment and eBusiness. The quantification model is detailed in section 3, followed by a short comparison to previous studies. Section 4 describes the main results for Ghent and Eindhoven, which are benchmarked in section 5, and linked to regulations and investment decisions in section 6. Finally, section 7 concludes the paper and provides some recommendations for future work.

2 Identification and categorization of indirect benefits for eGovernment and eBusiness

As described above, this paper will focus on the bottom-up modelling of the indirect effects of two sectors: eGovernment and eBusiness, because these sectors conceal the most important effects for the near future (Hayes, 2011). 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 services and enhance the support of the government policy and the democratic process (Andersen & Henriksen, 2006; Layne & Lee; 2001; Lee, 2010). eBusiness on the other hand is typically defined as the application of ICT for the support of all kinds of business activities (Chaffey, 2007). Using ICT in the working environment improves the efficiency of employees, helps to improve the productivity of companies and allows flexibility in working hours and location (Bresnahan, Brynjolfsson & Hitt, 2002; Brynjolfsson & Hitt; 2000).

This section will describe the identification and categorization process, and apply it to the two sectors under study.

2.1 Identification process is defined in a tree structure, categorization is performed along three dimensions

The identification process takes the form of a tree structure, starting from the different sectors that can be influenced, to identifying specific services (and subservices) that are deployed, to finally arrive at the actual effects. Figure 1 gives a graphical representation of this identification tree structure, both in general (a), as well as applied to the concrete example of teleworking (b). Using this tree structure for the identification process allowed structuring the different effects, and ensured completeness.

Figure 1

The individual effects are subsequently categorized along three dimensions: measurability, term and actor (Table 1).

Table 1

The dimension 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 dimension is the term: here the effects are grouped on basis of the period in which the underlying services reaches the minimal adoption rate, meaning that 50% of the target audience uses the specific service and will therefore be impacted by the effect. An arbitrary distinction is made between short term (operational within 2 years after deployment) and long term (more than 2 years are needed to reach 50% adoption).

The third and last dimension of categorization refers to who benefits from the effects. The distinction is made between “government” (all local and national authorities), “companies” (all private entities, both SME’s 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 Practical approach and data gathering process

The process of building up the trees structure for both sectors was done iteratively, based on an intercommunion between desk research in literature and interviews with several experts in the field to validate and comment. The literature studied included publications in national and international journals, consultancy reports, presentations, press releases and websites (concrete references are referred to further in this paper). Interviews were conducted with representatives of the e-counter in both cities, ICT responsibles of the universities and some smaller companies, head of a telecom company, etc.). It should be noted that the list of identified effects is not exhaustive, but aims at capturing the most important ones.

Geographical, demographical and statistical data was gathered using national and regional databases, while sector-specific data was collected from measurements at the departments of the city and some companies, respectively.

2.3 eGovernment: from physical contact to electronic forms

Within eGovernment, the effects of two main services have been identified (Table 2), depicting all applications for which the citizen needs to contact the administrative centre (e.g. extraction of birth certificate, application for a driver’s license, etc.). The discussion on eGovernment services has been driven by the assumption that these services generate increasing and proportional cost-savings (Rorissa, Demissie & Pardo, 2011). In literature, there is some agreement (Layne & Lee, 2011; Lee, 2010) that the introduction of interactive services (like the e-counter in the Netherlands and Belgium) provides a major step in cost savings of government services. For example, transforming this physical contact into an electronic format, saves the citizens (at least some) travelling to the city hall. For (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 (FOD Financiën, 2013; Belastingsdienst, 2013).

Table 2

2.4 eBusiness: travel savings from teleworking and distance training

Following literature review (e.g. Hayes, 2011) and interviews with experts, in eBusiness, the most important services that create indirect effects are teleworking and (distance) training of employees, see Table 3. A high-speed broadband connection (preferably over fibre) will allow people to access their files at home as quickly as at 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 on their operational expenditures (e.g. rental fees for office space), while videoconferencing decreases the necessity of business travel (Vari et al., 2011).

Table 3

2.5 Not only positive effects

Although both tables above clearly focused on the identification of the benefits of broadband, the authors are well aware of possible negative sides. This paragraph will shortly describe some of the possible disadvantages (as for the positive effects, the list is not, and will most probably never be, exhaustive), but these will not be used further down in the actual calculations.

A common critique on working at home is the transfer of electricity consumption from the employer to the employee (Kenny & Kenny, 2011). This is of course true, but this part of the cost is small compared to the other operational savings (like office space rents and furniture). Furthermore, these operational savings free money at the employer's side to fund the employee's internet subscription. Secondly, there is the logical possibility that allowing people to work from home, will make them move further away from work (since commuting has no longer be done every day). It is however a question whether this effect is really negative, since it can also be looked at from the opposite side: working at home allows people to keep on living in remote or smaller villages, and liquidates the necessity to migrate to the larger cities (Forzati, Mattsson and Aal-E-Raza, 2012). Although it has been stated that "households may redistribute nonwork travel among their members on workdays to take advantage of telecommuters' additional flexibility or location at home, [..] the net effect is still a reduction in trips per household on workdays" (Helling and Mokhtarian, 2001).

On eGovernment, there has been less criticism, but there the main question deals with the necessity of all-fibre networks – does basic broadband not suffice to offer an e-counter? This is indeed true to some extent, as will be shown later.

3 Bottom-up quantification model for indirect effects

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. As mentioned in the introduction, the advantages of bottom-up modelling are a clearer link between results and individual effects, more detailed results and a possibility of forecasting. Despite some criticism of cost modelling exercises for infrastructure planning (Flyvbjerg, Holm & Buhl, 2002), an objective method for quantifying indirect social benefits of broadband networks should be used by decision-makers to think about "real" solutions to municipal problems, such as savings achieved by telecommuting or e-government services.

3.1 The quantification model in this paper

The quantification model, consisting of three calculation steps per effect, was developed by the authors. The first calculation step quantifies the Total Value Potential (TVP) per service, which indicates the maximum monetary value a certain service or effect could entail, independent of the market that adopts it. Secondly, since the goal of the paper is to allocate the right monetary benefit to the right actor, we calculate the Total Value per actor (TVP_a) per time period by taking into account the share of the actor and the adoption curve of the service. The actor's share represents the portion of the total effect that can be contributed to the respective actor, determined according to a statistical allocation key, while the adoption curve represents how fast the service is taken up by the customers. Finally, the effect of adoption of the technology, broadband or FTTH, is taken into account, resulting in the Total Value for all effects for broadband or FTTH, respectively. These different calculation steps are shortly explained and clarified by means of exemplary figures for the specific case of teleworking below. Note that all formulas detail the benefits per year, and that a multi-period analysis should include discounting before final summation.

As mentioned above, one should first calculate the TVP per service. This is a simple multiplication of four parameters: the *population group* experiencing influence of the effect (e.g. the labour force), the *benefit expressed in units U* (e.g. amount of km saved by avoiding commuting), the *conversion factor* (e.g. 1 km equals €0.5, taking into account the fuel and insurance costs of the vehicle (FOD Financiën, 2012; Travelcard, 2012), and the *occurrence* (in case of teleworking, we assume that people work 1 day per working week from home, which leads to 44 days a year).

Equation 1

To calculate the TVP per actor (TVP_a), the TVP for each service is multiplied with the *share* of the respective actor (e.g. about 90% of the cars are privately owned, so 90% of the benefits is assigned to "individuals") and the *Adoption Curve (AC)* of the specific service, which reflects how fast the service is adopted over time (e.g. a Bass adoption curve with innovation coefficient equal to 0.03, imitation coefficient equal to 0.38 and maximum market potential set to 32% (Bass, 1969; PWC, 2004)).

Equation 2

Finally, the Total Value (TV) for Broadband (BB) and Fibre-to-the-Home (FTTH) can then be calculated by summing all TVP_a, multiplied with the *adoption curves* and the *share* taken up by broadband (i.e. traditional broadband including wireless, up to 20 Mbps) and FTTH respectively. The adoption curves for broadband (consisting of DSL and DOCSIS technologies) and FTTH were determined using an extension of the model developed by Norton and Bass (1987), which allows for calculating the adoption of successive technologies in one market divided amongst three platforms (a DSL-based copper network, a DOCSIS-driven cable network and a FTTH network). The parameters for the model (model coefficients and technology introduction years) were derived according to Casier et al. (2008a). The shares taken up by broadband and FTTH were determined based on needed bandwidth per service[2].

Equation 3

Equation 4

3.2 Comparison with previous research models

The authors are aware of the fact that this study is not the first in its sort, but do however believe that the identification, categorization and quantification processes used in this paper overcome some pitfalls of previous research. This section will therefore shortly compare with previously published models. Although this paragraph will focus mostly on the benefits of our bottom-up model, we admit that both bottom-up and top-down models can be complementary in evaluating the value of indirect benefits.

3.2.1 Top-down

First of all, the comparison with top-down approaches should be made. Top-down approaches are models which use macro-economic input data in statistical evaluation models, such as regression or input-output analysis. Katz et al. (2009), for example, 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 fibre by 2020). Another recent study by Forzati et al (2012) calculates the effects of FTTH-FTTx on employment and population evolution in Sweden. They apply a multivariate regression analysis, but only use a limited number of time periods (2007-2010). Finally, we refer to the research of Ida et al. (2008), who use a mixed logic econometric model on the results of a large-scale survey to estimate the willingness to pay for services over FTTH in Japan. Here, the main drawback is, as mentioned in (PWC, 2004), that "people often don't know what their willingness to pay for a product is, until they are required to make a purchase".

The main advantage of using top-down approaches is the theoretical underpinning of the models themselves, which improves the reliability of the results. However, since most models experience a large degree of

[2] Note that the parameters for the Bass curve are based on reference values from literature (PWC, 2004; Casier et al, 2008), and that varying these parameters will undoubtedly affect results. This kind of sensitivity analysis however falls beyond the scope of this paper.

complexity, they are frequently misused and results are often wrongly interpreted. Furthermore, statistical models only indicate a correlation in between parameters, but do not procure causal insights of individual effects and benefits. A final, and perhaps most important, drawback of these types of methods is the use of macro-economic data, which allows only for ex-post evaluation. Of course, predictions of future behaviour can be asked for in surveys (as was partly done in the study by Ida et al. (2008)), but these data are rather subjective and can be biased.

3.2.2 Bottom-up

Following the argumentation described above, the authors here opted for a bottom-up quantification, because (i) the possibility of forecasting, (ii) the (causal) relationship of individual effects and their subsequently generated benefits. This paragraph will describe some previously published bottom-up studies and indicate where they are different from the methodology used in this paper.

The methodology of the New Zealand Institute (2007) is 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 each effect at once, and did not start from the value per individual or unit, as was done in this paper. The methodology is therefore less detailed, and risks double-counting effects by grouping them.

The study of Columbia Telecommunications (2009) 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. This study claims to evaluate the benefits of high-speed broadband on top of traditional broadband, but a meta-study by Hayes (2011) shows that these assumptions do not hold.

The study that matches best with our study in methodology used is the study by Price Waterhouse Coopers (PWC, 2004). They also investigated the effects of different specific applications using the bottom-up approach, and made the distinction between adoption of broadband in general and the adoption rate of the different applications. While in that study, only an overall economic benefit was calculated, this study adds the allocation of the benefits to the different actors. They furthermore included the quantification of subjective and large environmental effects (e.g. opportunity cost of time involved in commuting related to salary, the cost of traffic congestion and the effect on the climate change), which we did not consider. Finally, the willingness to pay (WTP), which was estimated as the current subscription revenues, was attributed direct benefits in the overall economic total. We however believe that this WTP of customers does not necessary equal the current average revenue per user (ARPU); in a lot of European countries where there is a lack of competition, broadband subscription rates are sometimes said to be kept artificially high by incumbents, as regulatory authorities see the need for setting price caps and defining access regulation (Laffont & Tirole, 1994).

The final study we want to mention The Guide to Cost Benefit Analysis of Investment Projects (European Union, 2008). This guide acknowledges the importance of including both direct and indirect effects, and applies quasi the same monetization methodology to reflect social opportunity and market value cost for indirect effects. The main difference with our study is that they do not attribute these costs to the actors.

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 xDSL and cable network (but no FTTH yet), and Eindhoven in 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, house a university with comparable number of students, as well as a business campus where lots of smaller high-tech enterprises are settled. Exactly this combination of a high degree of comparability with the difference in telecom offerings, will allow evaluating the impact of FTTH on the effects that have been identified.

Table 4

In order to fairly compare both cases, the economic parameters will be kept the same. The calculation period will be limited to 2012-2030, and the discount rate set at 10% (based on the rate of the Belgian incumbent, Belgacom (9.61%), (BIPT, 2010) and the Dutch incumbent, KPN (10%), (OPTA, 2008).

For similar reasons, the parameters determining the adoption curve for the services will be kept the same (which can be justified by the comparable economic and cultural background), only the introduction years of the services vary. The adoption curves of the technologies (traditional and FTTH) were based on existing data where possible, and extrapolated into the future. The penetration curves of traditional broadband could therefore be based on existing data for both cases. For FTTH, the introduction year for Eindhoven was set at 2007 (the year of the deployment of FTTH there (OnsNet Eindhoven, 2012)), 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.

Before we elaborate on the output of our model, we would like to discuss the significant difference in the penetration rates of both municipalities. The penetration of FTTH (homes connected) in the municipality of Eindhoven is about 17% (Poulus & Compter, 2012). The total internet penetration is 92%, which is in line with the Dutch average. The fibre 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 broadband penetration is similar to the Dutch situation though. In the outcomes, this will have a clear impact on the results, since the effects of fibre will be present from the start in the case of Eindhoven.

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

After having described the model, input parameters and identified effects, this section focuses 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.

4.2.1 Total value

The total value represents the addition of the effects due to current broadband and the effects of fibre, and sums to €930 million for Ghent and €1140 million for Eindhoven (discounted and cumulative up to 2030). 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).

Calculating this total value is of course relevant, but digging deeper down to the value per inhabitant (for eGovernment) or per company (eBusiness) might give a better insight. These values are shown in Figure 2 (cumulative and discounted over18 years), where a distinction is made between the value obtained by customers that have “normal” broadband, and those who are subscribed to fibre. It is clear that the portion taken up by fibre is much higher in Eindhoven than in Ghent, which can easily be explained by the fact that there are already more FTTH subscribers.

From this graph, it can be concluded 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 fibre is also significantly bigger. For eGovernment on the other hand, the additional value that fibre 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 18 years, so this value might not provide an incentive to invest in fibre infrastructure. The value of about €150 000 per company, on the other hand, is significant.

Figure 2

4.2.2 Most important effects

To identify the most important effects, we step away from the technology and its adoption, but only look into the maximum potential of the service itself, adjusted with its adoption curve (TVP_i x AC_i). We opted 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 3. We see similar results for both cases: the travel savings take up the largest part (88% for Ghent, 87% 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 3

The same analysis can be performed for the eBusiness sector (Figure 4). 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.).

Figure 4

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 centre 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 fibre infrastructure.

4.2.3 Value per actor

To conclude this results section, we give an overview of the results per actor (Figure 5). The spreading of the results do not differ much between Eindhoven and Ghent, and this can mainly be explained by the value of the shares contributed to each actor type, which were comparable for both cities.

Figure 5

Clearly, the largest part of the savings for eGovernment can be allocated to the individuals. This can be easily explained by comparing Figure 3 and Figure 5: 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; 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 meta-study 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). Note that these incremental effects are different from the results described in section 4, as that section also included the effects for “normal” broadband for the fibre customers (so that Ghent and Eindhoven could easily be compared). For a methodological analysis of all studies, we refer to section 3.2.

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 fibre adoption in Eindhoven (already 16.5% in 2012), but also in the higher benefits from fibre 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

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, but show some variation.

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 tripled, result is found for the eGovernment sector. Again, this value can be explained by the fact that our 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, we did not take this value into account because we started from the assumption of one administrative centre per city.

Table 6

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 (see section 3.2 for more information on the methodology). 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 does not 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 compared to other sectors (such as eHealth, eEntertainment etc.), and used this percentage to calculate the macro-economic value of eBusiness and eGovernment, as found by Katz et al. (2009).

Based on a more extensive, internal study including also other sectors, the combined share of eGovernment and eBusiness in the total share of possible indirect effects, is 59%. Applying this percentage to the value found by Katz et al. (who calculated the effect for the entire economy, while this study focused only on eBusiness and eGovernment), leads us to the conclusion that these values are very similar (Table 7). The value for Eindhoven is again higher due to the extra benefits already perceived for eBusiness on fibre.

Table 7

5.3 Impact of regional differences

The results of this and previous section show that indirect benefits are clearly present, but the comparison of studies however showed significant differences in order of magnitude. Part of this difference can of course be explained by the used methodology and included effects, but part can be allocated to the size of the region, population density, industry sector, etc.

Not only can we see a regional impact by comparing quantitative results of earlier studies, previous literature also indicates this. Mack and Faggian (2013), for instance, found that "broadband alone is not responsible for increased levels of productivity, but rather the availability of both broadband and high-quality human capital is key to broadband-related productivity increases" (p. 18). They also argue that faster broadband only proves its use when people are trained enough to apply it effectively to their daily work. Geographical location and population density are furthermore noteworthy characteristics to address in the future, as they not only affect the magnitude of the benefits, but can also induce extra costs (adopting a more complex internet technology can require significant co-invention costs (Forman, Goldfarb and Greenstein, 2005a)). Finally, linkages of companies within particular broadband regions have proven that there are industry effects of broadband (Forman, Goldfarb & Greenstein, 2003; 2005b) and agglomeration effects fostered by broadband (Mack, Anselin & Grubesic, 2011; Mack, 2012).

Although the goal of this paper was to compare the two regions under study (Ghent, Eindhoven), future work should account for these regional differences by extending this study towards including regions with other characteristics.

6 Impact on regulation and possible investment decisions

Within the discussion on Next Generation Access (NGA) networks in Europe (CEU, 2009; 2012), fibre technologies have been considered as the most future proof technology. Compared to other broadband technologies like xDSL and Cable Modem technologies, fibre infrastructure providers face high sunk costs and demand uncertainty (OECD, 2008). Based on current uptake predictions (Andres et al., 2010) and expected Willingness to Pay (Ofcom, 2011), investors face payback periods of 20 to 40 years (Verbrugge et al., 2012), which are too long to be justified in the current economic climate. However, these investments are necessary to reach the goals set out by the European Union in its Digital Agenda: “By 2020, all Europeans should have access to internet of above 30 Mbps and 50% or more of European households have subscriptions above 100 Mbps” (European Commission, 2010).

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, 2009b), the social benefits are not taken into account in most techno-economic analysis of investments in NGA infrastructures. This paper calculated that these indirect benefits are significant (in comparison to a deployment cost of €900-€1550 per home, depending on the type of infrastructure and the region (Corning, 2009)), especially for individuals and companies, and to a lesser extent for the government. If these indirect benefits could be internalized in the willingness to pay of the respective actors or externalized to other market parties in the business or government sector, they could provide a significant boost to the business case of broadband deployment. They can further prove useful in drafting national broadband plans (Jock, 2010).

If the indirect effects are included in conventional Cost-Benefit Analysis, a better case for local government involvement in municipal networks can be achieved. This methodology can be useful in specifying the four conditions for the application of the Service of General Economic Interest (SGEI) principle with respect to NGA networks (CEU, 2009), which allows addressing the “real” problems persisting in local communities such as digital inequality issues, restructuring of deprived areas and industrial parks to solutions provided by NGA networks and new broadband services.

Furthermore, there are other options to incentivize the right actors to help stimulating the investment. Authorities on all levels should promote the deployment of new and faster broadband networks. This can be done qualitatively, by making e.g. the companies aware of the potential savings that could be obtained in operational expenditures. These companies could then decide to compensate their employees by paying for their home internet subscription as an extra non-statuary benefit. On the other hand quantitative measures taken by the authorities are also possible, by using benefits in kind for targeted households (as is done in other sectors such as health, education, etc. (Barnard, 2009)). Past initiatives such as the Private PC initiative (a legislation that provided tax benefits for companies that equip their employees with a home computer and internet connection (Belgacom, 2003)), could be extended towards low-income households in the future. Concrete actions like this do not interfere with European State Aid regulations, as their primary goal is to reduce the digital divide by including those targeted households in the digital society. By indirectly increasing the willingness to pay of those specific households, however, those initiatives could stimulate investment at the same time.

7 Conclusions and future work

In the Digital Agenda, Europe has set clear goals regarding the broadband penetration in its Member States. These goals require the installation of new Next Generation Access (NGA) networks, or the upgrade of traditional networks. The needed investment project are however being postponed because of low forecasted willingness to pay of end-users and expected uptakes. On the other hand, savings in other sectors of the economy would justify the construction of a nationwide FTTH network. Investigating the indirect benefits of NGA networks and internalizing them in the investment decision of the involved actors, seems appropriate to improve the business case for NGA deployment.

This paper presented a bottom-up quantification model of these indirect benefits, for two sectors: eBusiness and eGovernment, and applied it to two cities: Ghent and Eindhoven. The authors opted for a bottom-up methodology because it allows modelling the effects separately, and in more detail. Although 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. Bottom-up models furthermore allow forecasting the effects, while top-down statistical calculations require ex-post macro-economic data.

Within the sectors eGovernment and eBusiness, the most important effects (leading to the highest monetary value), are travel gains from reduced physical contact in the administrative centre, and operational savings for companies by introducing teleworking. From the comparison of Ghent (without FTTH) and Eindhoven (with a well-established FTTH network), it became clear that some services, like teleworking, clearly benefit from the presence of fibre all the way to consumers' homes, while for others (e.g. the e-counter for eGovernment) traditional broadband through DSL suffices. 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.

Finally, the paper indicates how and where the quantification results could be used to improve the business case for NGA deployment. Two main recommendations focus on non-statuary benefits for employees in the form of broadband subscription fees, and benefits in kind for targeted households, granted by local authorities.

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 to include regional differences (size, population density, labour force, industry sector, etc), as indicated in section 5.3. 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. Finally, a full social cost benefit analysis should be calculated, based on methods as proposed in (European Union, 2008), so that effective quantitative results can be used in regulatory guidelines and State Aid decisions.

Appendix. Gathered input data for both cities

Table 8

Table 9

Table 10

Table 11

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Figure

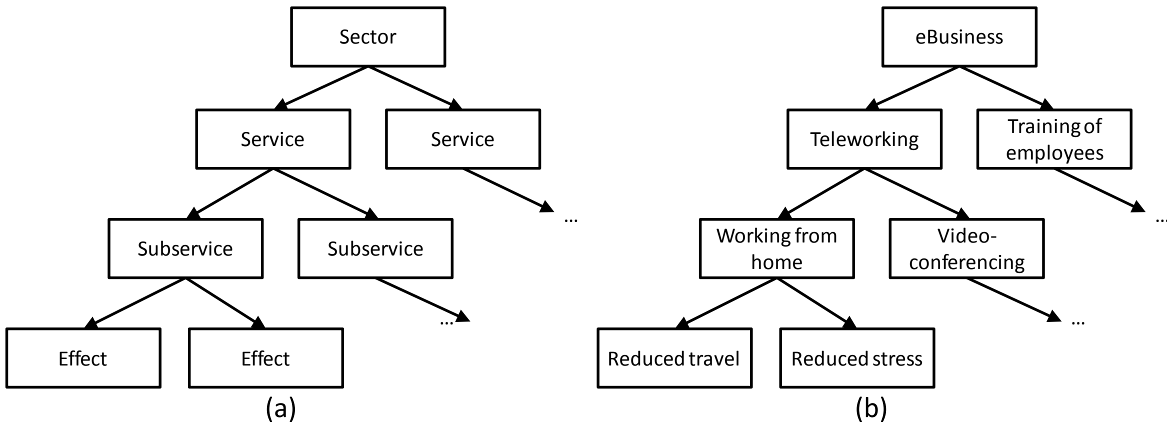

Figure 1: Generic example of identification tree

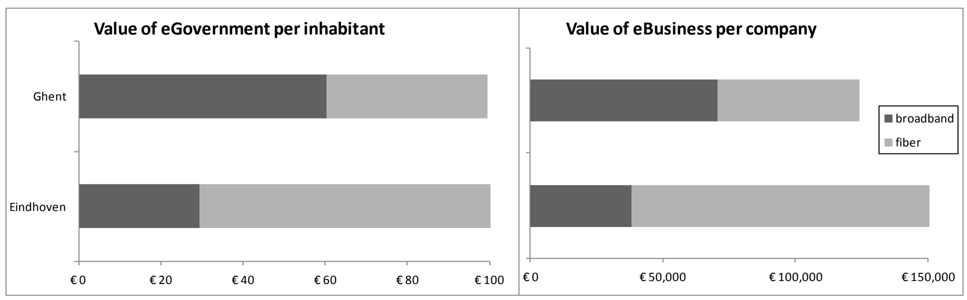

Figure 2: Value of the indirect effects for eGovernment per individual, and eBusiness per company

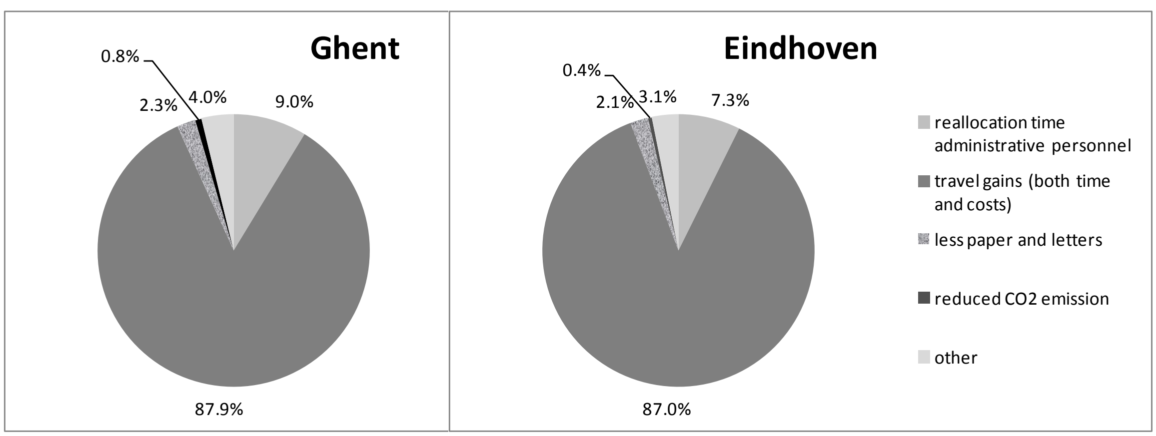

Figure 3: Indication of the most important effects for eGovernment

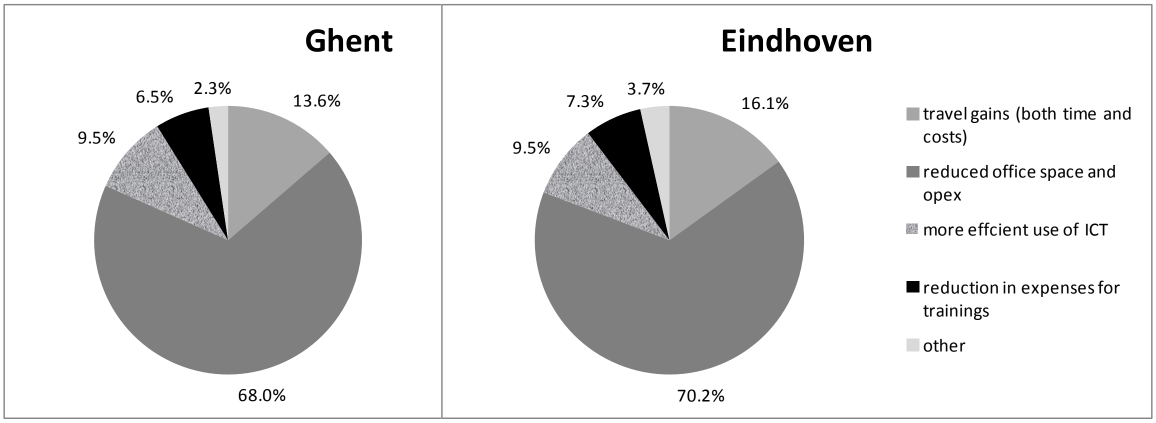

Figure 4: Indication of most important effects for eBusiness

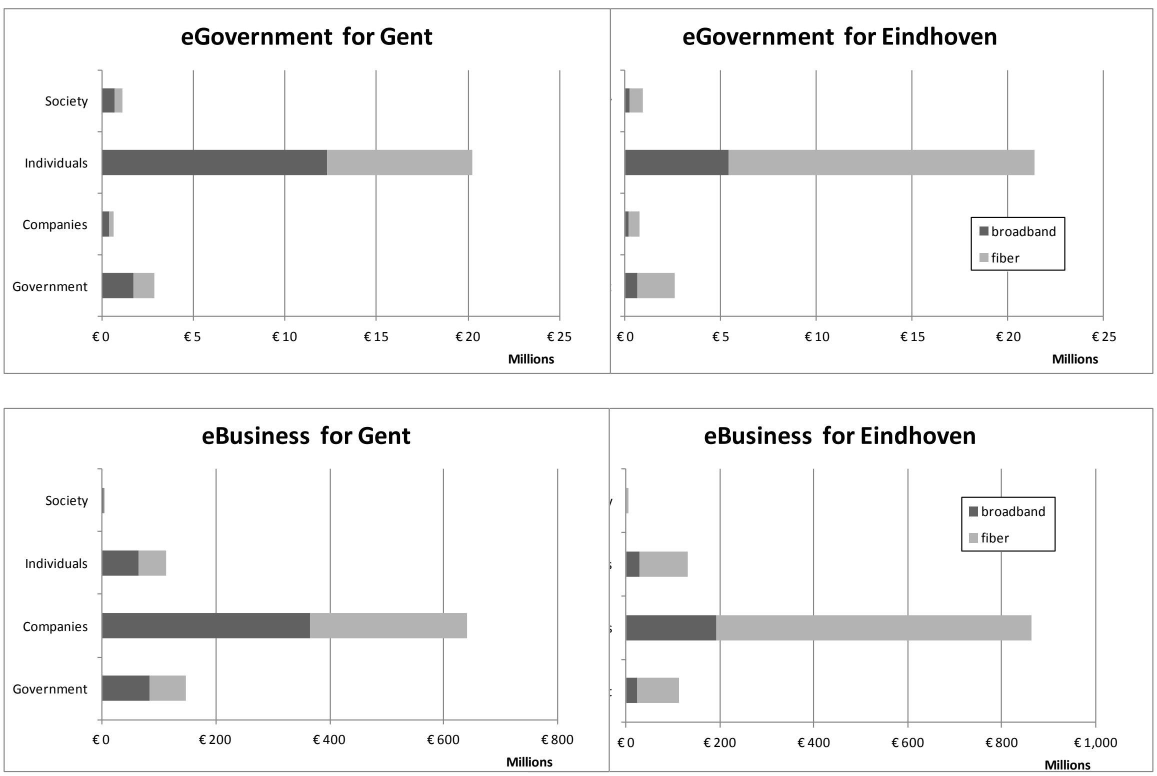

Figure 5: Overview of the value of the indirect effects per sector and per actor

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

Table 1: Abbreviations used for categorization

Service	Subservice	Effect	Meas.	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	Yes
		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

Table 2: Identified services and effects for eGovernment

Service	Subservice	Effect	Meas.	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	No
		Reduced training expenses	O	ST	G, C	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

Table 3: Identified services and effects for eBusiness

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

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

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

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	Seattle
eBusiness	€193	€270	€547
eGovernment	€5	€7	€15

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

	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)	€277	100%	€276
Katz et al. (Germany)	€333	59%	€196

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

Service	Subservice	Effect	Population group	Unit benefit [U]	Conversion [€/U]	Occurrence (x/year)	Actor's share (%) G	C	I	S
Government -citizen transactions	Switching from personal contact to electronic contact	Reallocation of the time of the administrative personnel	199174	10.4 minutes	0.0272 €/minute	12	100	0	0	0
		Time gain	199174	0.55 hours	10 €/hour	1.911	0	0	100	0
		Travel cost saving - fuel	199174	11.76 km	0.5 €/km	1.911	0	8.75	91.25	0
		Travel cost saving - parking	199174	1 hour	1.8 €/hour	1.911	0	8.75	91.25	0
		Decreased consumption of paper (e.g. sending letters)	199174	0.8114 €	1 €/€	0.50	100	0	0	0
		Decreased traffic jams and road accidents	199174	0.98 €	1 €/€	1.911	0	0	0	100
		Less stress	/	/	/	/	/	/	/	/
		Reduced CO_2 emission (and other harmful gasses)	199174	1.412 kg	0.135 €/kg	1.911	0	0	0	100
	Providing information and resources for citizens online	Time gain	/	/	/	/	/	/	/	/
		Reallocation of the time of the administrative personnel	199174	4.5 minutes	0.03 €/minute	4	100	0	0	0
		Travel cost saving	/	/	/	/	/	/	/	/
		Decreased consumption of paper (e.g. brochures)	/	/	/	/	/	/	/	/
		Retrieving information outside office hours	/	/	/	/	/	/	/	/

Table 8: Input data for eGovernment in Ghent

Service	Subservice	Effect	Population group	Unit benefit [U]	Conversion [€/U]	Occurrence (x/year)	Actor's share (%)			
							G	C	I	S
Government -citizen transactions	Switching from personal contact to electronic contact	Reallocation of the time of the administrative personnel	148118	10.4 minutes	0.0265 €/minute	12	100	0	0	0
		Time gain	148118	0.79 hours	10 €/hour	1.999	0	0	100	0
		Travel cost saving - fuel	148118	8.51 km	0.5 €/km	1.999	0	12.25	87.75	0
		Travel cost saving - parking	148118	1 hour	3 €/hour	1.999	0	12.25	87.75	0
		Decreased consumption of paper (e.g. sending letters)	148118	0.74 €	1 €/€	0.675	100	0	0	0
		Decreased traffic jams and road accidents	148118	0.98 €	1 €/€	1.999	0	0	0	100
		Less stress	/	/	/	/	/	/	/	/
		Reduced CO_2 emission (and other harmful gasses)	148118	1.021 kg	0.135 €/kg	1.999	0	0	0	100
	Providing information and resources for citizens online	Time gain	/	/	/	/	/	/	/	/
		Reallocation of the time of the administrative personnel	148118	4.5 minutes	0.0265 €/minute	4	100	0	0	0
		Travel cost saving	/	/	/	/	/	/	/	/
		Decreased consumption of paper (e.g. brochures)	/	/	/	/	/	/	/	/
		Retrieving information outside office hours	/	/	/	/	/	/	/	/

Table 9: Input data for eGovernment in Eindhoven

Service	Subservice	Effect	Population group	Unit benefit [U]	Conversion [€/U]	Occurrence (x/year)	Actor's share (%)			
							G	C	I	S
Teleworking	Working from home	Reduced travel time	138597	1 hour	10 €/hour	44	0	0	100	0
		Reduced travel costs	138597	37.6 km	0.5 €/km	44	0	8.75	91.25	0
		Decreased traffic jams and road accidents	138597	0.98 €	1 €/€	44	0	0	0	100
		Reduced emission of CO_2	138597	4.512 kg	0.135 €/kg	44	0	0	0	100
		Reduced stress	/	/	/	/	/	/	/	/
		Decreased number of absenteeism by illness	138597	0.67 days	68.99 €/day	1	21.61	78.39	0	0
		Reduced office space and opex	138597	357.85 €	1 €/€	12	21.61	78.39	0	0
		Higher independency and flexibility for the employee	/	/	/	/	/	/	/	/
		Reduced spending on human resources	138597	5.007 €	1 €/€	12	21.61	78.39	0	0
	Videoconferencing	Less business trips	7289	10 trips	150 €/trip	1	0	100	0	0
Training of employees	Grouped management of ICT infrastructure	Reallocation of the time of the support staff	/	/	/	/	/	/	/	/
		More efficient use of network- and ICT services	61934	429 €	1 €/€	1	0	100	0	0
	Online training	Reduced travel (time and costs)	/	/	/	/	/	/	/	/
		Reduced training expenses	138597	12.62 €	1 €/€	12	21.61	78.39	0	0
		Reduced stress	/	/	/	/	/	/	/	/
		Reduced emission of CO_2	/	/	/	/	/	/	/	/
		Decreased traffic jams and road accidents	/	/	/	/	/	/	/	/

Table 10: Input data for eBusiness in Ghent

	Subservice	Effect	Population group	Unit benefit [U]	Conversion [€/U]	Occurrence (x/year)	Actor's share (%) G	C	I	S
Teleworking	Working from home	Reduced travel time	143100	1 hour	10 €/hour	44	0	0	100	0
		Reduced travel costs	143100	27.8 km	0.5 €/km	44	0	12.25	87.75	0
		Decreased traffic jams and road accidents	143100	0.98 €	1 €/€	44	0	0	0	100
		Reduced emission of CO_2	143100	3.336 kg	0.135 €/kg	44	0	0	0	100
		Reduced stress	/	/	/	/	/	/	/	/
		Decreased number of absenteeism by illness	143100	0.8 days	160 €/day	1	13.46	86.54	0	0
		Reduced office space and opex	143100	357.85 €	1 €/€	12	13.46	86.54	0	0
		Higher independency and flexibility for the employee	/	/	/	/	/	/	/	/
		Reduced spending on human resources	143100	5.436 €	1 €/€	12	13.46	86.54	0	0
	Videoconferencing	Less business trips	6513	10 trips	150 €/trip	1	0	100	0	0
Training of employees	Grouped management of ICT infrastructure	Reallocation of the time of the support staff	/	/	/	/	/	/	/	/
		More efficient use of network- and ICT services	61882	429 €	1 €/€	1	0	100	0	0
	Online training	Reduced travel (time and costs)	/	/	/	/	/	/	/	/
		Reduced training expenses	143100	13.71 €	1 €/€	12	13.46	86.54	0	0
		Reduced stress	/	/	/	/	/	/	/	/
		Reduced emission of CO_2	/	/	/	/	/	/	/	/
		Decreased traffic jams and road accidents	/	/	/	/	/	/	/	/

Table 11: Input data for eBusiness in Eindhoven

$$TVP_i(t) = population\ group_i \times unit\ benefit\ [U] \times conversion\ [€/U] \times\ occurence\ (t)$$

Equation 1

$$TVP_a(t) = \sum\nolimits_i TVP_i(t) \times \frac{share_{ia}}{\sum_k share_{ik}} \times AC_i(t)$$

Equation 2

$$TV^{BB}(t) = \sum\nolimits_a share_a^{BB} \times AC^{BB}(t) \times TVP_a(t)$$

Equation 3

$$TV^{FTTH}(t) = \sum\nolimits_a share_a^{FTTH} \times AC^{BB}(t) \times TVP_a(t)$$

Equation 4