Industry-Insights BV

Research Report

Regulated access: a positive sum game

II-BV 201402 wl/wl ACM

Dr. Ir. Wolter Lemstra and Dr. Bart Voogt

First draft: 2014-05-28
Last revision: 2014-09-04
Released: 2014-09-04

Industry-Insights BV
in collaboration with Voogt Consultancy BV
Wakkerendijk 94A
NL-3755 DE EEMNES
The Netherlands

Corresponding author: Dr. Ir. W. Lemstra
w.lemstra@planet.nl
+31 653 216 736

Category: Research report
Publisher: NA
Keywords: Telecommunication; broadband; access regulation; performance

Table of Contents

Executive Summary

This report provides the outcome of research into the effects of broadband access regulation on broadband performance for the case of the Netherlands. This research builds upon two strands of ongoing research into the development of broadband markets in Europe, a quantitative and a qualitative strand. The quantitative strand involves the development of a broadband performance index (BPI) and a broadband market model (BMM), distinguishing fixed and mobile broadband. The qualitative strand is related to a collection of in-depth country case studies describing the development of broadband from 2000 onward in twelve EU Member States, exploring the commonalities and the unique features in these developments towards achieving the Digital Agenda targets set for 2020.

The broadband services market in the Netherlands is characterized by both infrastructure-based and access-based competition. Infrastructure-based competition takes place between incumbent operators exploiting the PSTN and the CATV networks respectively and access-based operators using PSTN-based wholesale inputs (e.g. bitstream, unbundled local loops) to provide broadband services to end-users.

The research investigates the impact of access regulation on broadband performance. Broadband performance is captured through a composite performance index (BPI) that captures the dimensions of uptake as proxy for volume, revenues as proxy for price and data rates as proxy for quality, and their weights have been derived from the broadband market data of the EU Member States. The Broadband Market Model has been developed by applying the Structure Conduct Performance paradigm. It is used to assess the effects of access regulation, considering in particular the price setting of unbundling as the independent variable, on the value of the broadband performance index (BPI), as the dependent variable. The mediating variable is a modified Herfindahl Hirschman Index (HHI*) reflecting the market shares of the competing technology platforms.

The impact of access regulation on the broadband market in the Netherlands is assessed by comparing its market performance with a hypothetical market that is in all respects identical to the Netherlands market except for the absence of access regulation. The results of the comparison showed that access regulation had a positive effect on broadband performance of approximately 5 points in the value of the broadband performance index.

If it is assumed that this performance difference is the result of a difference in broadband uptake only, i.e. assuming that price and quality as the other constituting components of the BPI are not affected, then for the Netherlands, access regulation has had a positive effect of 12-13% in broadband uptake.

From qualitative research into the development of broadband access modes in three other leading EU countries (UK, FR, DE) we have documented progression in the type of access mode being used by alternative operators, in line with the ‘ladder of investment’ concept. The data for the Netherlands corroborates with these findings.

The study results indicate that unbundling has provided a stepping stone encouraging alternative providers to consider moving up the ‘ladder of investment’ toward the final rung of facilities-based competition using fibre-based access. This increased potential for entrants to become the first movers has also played an positive role in stimulating incumbents to invest in fibre access.

The analysis suggest that by stimulating the demand for higher service levels, unbundling access regulation has tended to reduce the degree of risk related to the investment in fibre.

The quantitative and qualitative evidence and analysis in this study clearly indicate that continued access regulation is important to facilitate a progressive conversion of end-users from copper to fiber, and unbundling is an effective method for regulating access.

1 Introduction

There is an important debate in the telecom policy field around the policies that will best stimulate broadband network investment and new services development and applications. A focal point in this debate has been whether the regulation of access to dominant operator networks by competitors will provide a positive or negative effect on broadband rollout and innovative services development.

The central element of access regulation is the requirement for dominant operators to provide "unbundled" local loop access to their local networks that will provide competitors with direct control over the services they provide to their customers. Incumbent/dominant operators claim that with access regulation potential competitors will avoid investment in broadband rollout. Competitors claim that access regulation reduces the most significant barrier to market entry, increases competition in the services market, allows them to climb the ladder of investment to the point where it is economical to invest in broadband rollout. Research on the experience to date has not provided a definitive conclusion on this important broadband policy debate.[1]

This document reports on a research project aimed at assessing the impact of access regulation on fixed broadband performance for the case of the Netherlands, in particular on the dimensions of price and quality and where possible on investment and innovation. It presents new qualitative and quantitative research into broadband development, including a novel approach to measuring broadband performance and analysing broadband performance drivers. It has been applied to the case of the Netherlands, taking advantage of the detailed evidence available.

This research report builds on recently completed research by the authors and colleagues. The quantitative research strand includes the development of a composite broadband index and the exploration of the underlying broadband performance drivers using structural equations modelling. This research has been submitted for publication in Telecommunications Policy and will be reported at the Telecommunications Policy Research Conference (TPRC) in the USA in September 2014 (Voogt, Lemstra and Van Gorp, 2014).

The qualitative research strand builds on a collaborative effort among research institutes in twelve EU countries documenting the diversity in broadband developments at the Member State level from 2000-2013. This research will be published in the Fall of 2014 by Cambridge University Press (Lemstra and Melody, 2014).

A second qualitative source is a study into the effects of access regulation, in particular the applicability of the 'ladder of investment' concept. This has been a subject of case study research comparing the developments in the United Kingdom, Germany and France. This research has been reported in 2013 at the 2nd Conference on the Regulation of Infrastructures at the Florence School of Regulation (Lemstra and Van Gorp, 2013). In addition, use is made of a complementary working paper assessing the economic benefits of access regulation, in particular on investment and innovation (Lemstra, 2014). Finally, case study data on the Netherlands has been collected to allow for a comparison with the cases of the UK, Germany and France.

[1] For a discussion of the literature see Cawley (2014).

In this research report we will reflect the main findings of these research projects where they are relevant to the case of the Netherlands. For details we refer the reader to the publications referenced above.

Specifically for this research project the broadband market model and the broadband performance index have been updated to include 2012 and 2013. Moreover, the original EU-16 model is validated against new data for the EU-25, and against the cases of UK, France and Germany. For the case of the Netherlands the contribution of access regulation towards broadband performance is determined from the market model. Then, and the potential impact of removing access regulation is assessed in terms of broadband performance and its underlying components.

This report is structured as follows: Section 2 through 4 provide a description of the quantitative analysis and the outcomes. Section 5 provides the outcomes of the qualitative analysis. The conclusions are presented in Section 6.

Section 2 starts with an introduction to structural equations modelling as the main method used in the research. Section 3 summarizes the application of structural equations modelling in the development of the broadband market model and the broadband performance index for Europe. In Section 4 the results of the modelling are made specific to the Netherlands with the aim to respond to the research question on the effects of access regulation. The research outcomes are discussed and illustrated. In Section 5 three mini-case studies on broadband access development in the UK, Germany and France, are discussed providing evidence corroborating with the quantitative findings.

2 Methodology – quantitative analysis

The standard econometric approach to examining this research question would be the application of regression analysis, with regulatory parameter(s) as the independent variables and price and quality, as well as innovation and investment, as the dependent variables (individually or collectively), and a number of control variables to capture outside effects. Such an approach is subject to a number of difficulties, as in reality many variables are interdependent and have to be considered simultaneously.

For instance in reviewing the role of competition on price, we can observe that the introduction of competition has led to a convergence of prices, which was followed by a period, continuing until today, in which competition is focused on increasing data rates while prices stay relatively constant.[2] This reflection of reality implies that in considering broadband performance we need to capture the developments in price and in data rates simultaneously. The questions that remain are whether and to what degree data rates are a good metric to capture the notion of quality and whether price and quality together are sufficient to constitute broadband performance.

To address this issue in greater depth we begin by conceptualizing broadband performance as a latent, composite variable and need to determine the constituting parts and their respective weights.

[2] The case of Free/Iliad in France is a salient example. The company retained a price setting of €29.99 for broadband access using ADSL in 1999 until today, where the service is provided over fibre. Meanwhile, the download data rate has increased from 2 Mbit/s to 100 Mbit/s. See Lemstra & Van Gorp (2013).

Another issue with the use of regression analysis is its vulnerability to endogeneity, whereby an observed correlation between independent variable A and dependent variable B is in reality caused by variable C, which influences both A and B.

From earlier research into the development of the telephone network we know this to be the case for investment and the uptake of telephone service, whereby GDP per capita was the factor driving both. A similar effect may be expected for investment in broadband.[3]

To properly reflect this aspect of reality we need to model multiple relationships of dependent and independent variables simultaneously. The research methodology adopted here allows us to identify which relationships are statistically significant in explaining broadband performance and hence need to become part of the broadband market model. We perform exploratory factor analysis to test the hypotheses on relationships, which is followed by confirmatory factor analysis to determine the respective weights. Both types of factor analysis operate on the basis of co-variance analysis (see Section 2.1.1 for more detail).

Research questions involving multiple relationships of dependent and independent variables require the application of structural equations modelling (SEM), which includes exploratory and confirmatory factor analysis as steps in the analysis. See Hair, et.al (2010).[4] A summary explanation of the methodology applied follows in the next section 2.1. For a detailed discussion of our analysis we refer to Voogt, Lemstra & Van Gorp (2014).

Capturing innovation through econometric analysis has been shown to be notoriously difficult, as specific broadband innovation metrics are not available and the use of the typical innovation related variables such as number of patents, R&D spending, etc. is not applicable in this case. However, the effect of regulation on innovation can be captured through a qualitative analysis of new technology development and broadband uptake, and by analysing the differences in the opportunity for innovation associated with the various access modes being made available.[5]

2.1 Structural equations modelling

Although the most popular econometric tool, regression analysis, is not suited to deal with latent variables, to retain the ability to apply regression analysis, composite indicators are often constructed using additional assumptions, to provide a 'work around' the latent variable problem. In our case this would imply making assumptions about which specific variables are important in explaining performance and to make assumptions to which extent these variables affect performance, i.e. determining their weights – upfront. The disadvantage of such an approach is that the assumptions are rather arbitrary and not driven by empirical data. More importantly, it is not possible to test the validity of these assumptions.

[3] The analysis into the drivers of broadband development has shown that broadband performance is driven by investment, which in turn is driven by GDP per capita. See Voogt, Lemstra & Van Gorp (2014).

[4] See Chapter 1 for a discussion of the various multivariate methods, in particular Figure 1.1 providing a selection guide, and Chapters 12 and 14 on structural equations modelling.

[5] See the principled analysis of access modes vis-à-vis innovation in Lemstra (2014).

Therefore, we use an alternative, data-driven methodology that supports and actually revolves around the use of latent variables, namely, factor analysis. The idea behind factor analysis is that it detects patterns in a dataset based on the correlations (covariance) between the variables.

To illustrate the approach being applied a stylized model is used as an example.

2.1.1 Stylized model of a latent variable

Suppose the latent variable y represents performance. In this example we assume the variable consists of three components which are important for performance: x_1, x_2 and x_3, which may represent for example volume (e.g. uptake), price and quality. The model reflected is: $x_{ji} = \alpha_j + \lambda_j y_i + \varepsilon_{ji}$, whereby the index i represents a particular year. Figure 1 provides a representation of the model.

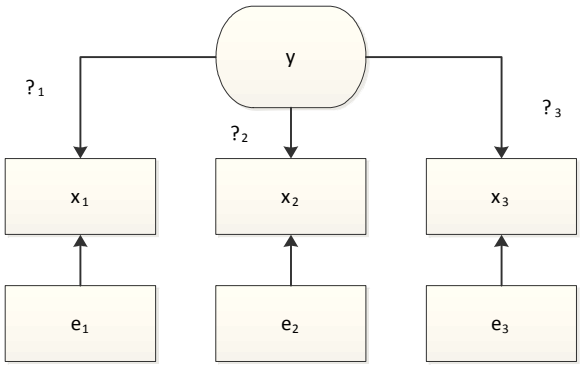

Figure 1. Stylized model latent variable with three components

The component x_1 is based on some constant (α_1), which is considered to be linearly dependent on performance ($\lambda_1 y_i$) and there is an error term (ε_{1i}) indicating that there are others factors besides y that affect x_1. Similarly the components x_2 and x_3 are defined.

In this model, we do not know what performance is. Nonetheless, given the theoretical model we can construct the theoretical covariance matrix, while the actual covariance matrix is derived from the data. The model then tries to find values for the weights (λ_1, λ_2 and λ_3) such that the theoretical covariance matrix is as close as possible to the actual covariance matrix. See Figure 2.

Theoretical covariance matrix	**X_1**	**X_2**	**X_3**
X_1	λ_1^2 + var(ε_1)		
X_2	$\lambda_1 \lambda_2$	λ_2^2 + var(ε_2)	
X_3	$\lambda_1 \lambda_3$	$\lambda_2 \lambda_3$	λ_3^2 + var(ε_3)

Figure 2. Covariance matrix

A few examples follow to illustrate the principle operation.

If for example, every country has the same level of uptake, then the actual variance of x_1 is 0. The model will then set $\lambda_1 = 0$ such that the theoretical variance of x_1 is also 0. This makes sense, as we cannot explain differences between countries in terms of a variable that the same value across all countries. Each component of the latent variable must have at least some variance.

Another example is when two variables are closely correlated. Suppose, that we have two components measuring prices: x_1 measures prices in Euros, while x_2 measures prices in Dollars. Obviously, the correlation between these components is very strong. Consequently, the model will set either $\lambda_1 = 0$ or $\lambda_2 = 0$, since including both components only restricts the model while not providing any additional 'value'.

If two variables, x_1 and x_2 have a very low level of correlation, the model is likely to drop one of them. The theoretical covariance is in this case $\lambda_1\lambda_2$, while the actual covariance is close to 0. If both components are kept in the model then both λ_1 and λ_2 are artificially forced to be very small. This is an undesirable restriction, as it can lead to underestimation of the weight of x_1 or x_2.

Basically, the model should include components which have: (1) a certain degree of variance; and (2) some degree of correlation, but not too little and not too much. Using statistical tests, the model is accepted if the fit is considered good enough.

In the next step, the individual significance of the components x_j is tested. If a statistical test shows that, for example, x_1 is not significant, we can rerun the model by eliminating this component, which is equivalent to setting $\lambda_1=0$. By comparing the 'goodness of fit' of multiple models with varying x_j, we can find a combination of components that provides the best indicator for the variable y, in our case performance.[6]

3 Broadband Market Model and Broadband Performance Index

The example discussed Section 2.1.1 reflects how a single latent variable is constructed. In the broadband market model (BMM) several latent variables (performance, competition, et cetera) are included, whereby the structure of the relationships between these variables has to be determined. The broadband market model hypothesized is that of the Structure-Conduct-Performance (SCP) paradigm.[7]

The SCP model provides the starting point for our analysis. It is elaborated and adjusted to reflect the specificities of the telecommunications industry; most importantly, to reflect that the industry is subject to regulation. A stylized version of the model is presented in Figure 3.

[6] If there are multiple latent variables in the model, then there can be an infinite amount of combinations of weights that lead to the same covariance matrix and therefore the same goodness of fit. Different rotation techniques are used to find a structure between the different factors that makes 'sense' in the light of our understanding of the broadband market.

[7] This paradigm originates from the discipline industrial organization and is a well-recognized stylized model of industry performance. The principal ideas were introduced by Mason in the 1930s, it has been formulated as a paradigm by Bain in the 1950s (1956, 1959) and has become the basis of Porter's Five Forces Model to analyse industry profitability in the 1980s (1980, 1985).

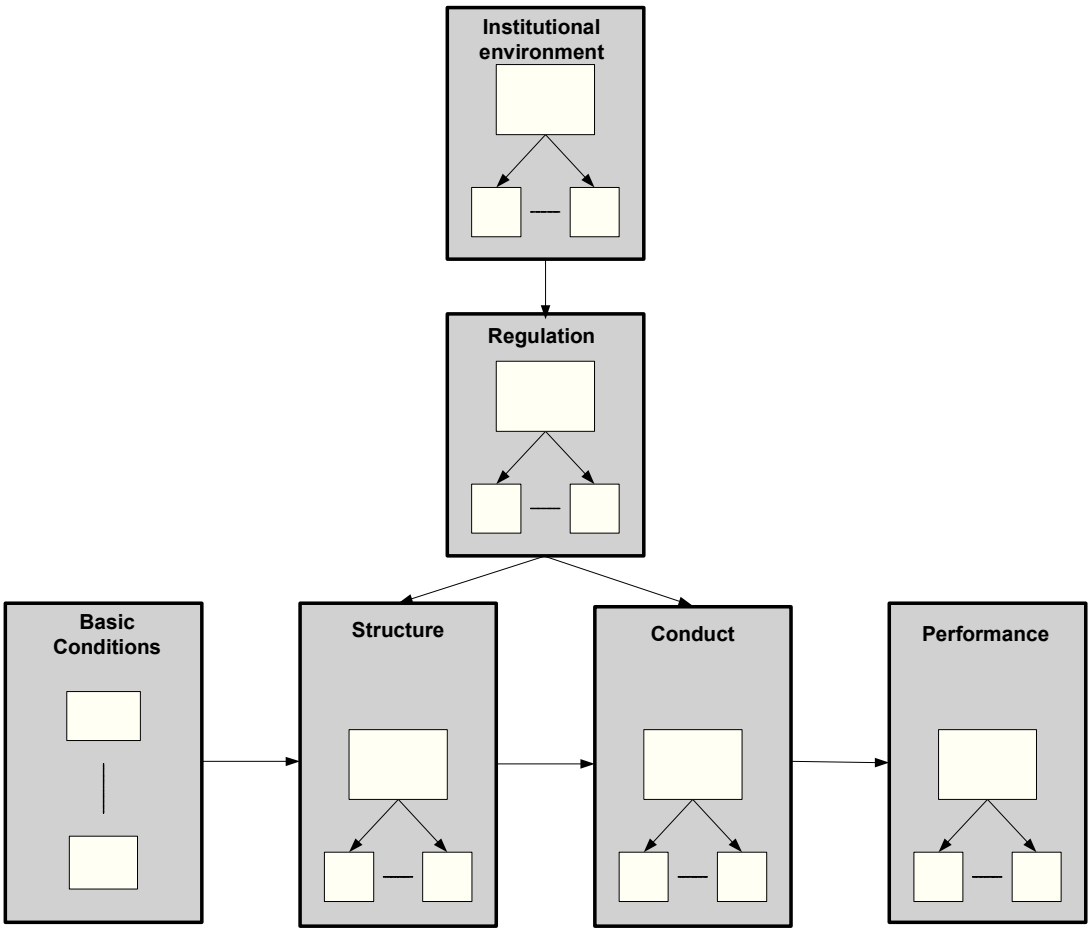

Figure 3. Stylized path model

In this path model five variables are identified as potentially being a composite variable (an index): the Institutional Environment in which regulation takes shape; the Regulations as they impact the market structure and the firm conduct; the Structure of the market; the firm Conduct; and the resulting broadband market Performance. Each composite variable is constituted by underlying components, which are to be identified on the basis of the factor analysis as being statistically significant. The Basic Conditions are assumed to be straight forward variables. Hence, as a result of the data analysis a composite variable, or index, may end up having only one component and thus 'collapse' into a singular, non-latent variable. The analysis may also show that no significant components can be identified and hence the variable does not show in the resulting path model.

As we provide structure to the relationships between the various variables and components, this type of modeling is called structural equations modeling (SEM). Sometimes this methodology is referred to as simultaneous equations modeling, as the relationships between the variables are calculated simultaneously.

The input of the researcher to the modelling effort is twofold. First, the researcher has to hypothesize which components should be assigned to which composite variable as the starting point for the exploratory factor analysis.[8] Secondly, the researcher imposes a

[8] Note that the factor analysis finally determines whether a component is actually included as part of the composite variable.

structure on the relationships between the variables for the confirmatory factor analysis.[9] In our case we performed a multitude of sensitivity checks by considering alternative structures and different assignments of components to the variables. The starting point for this process was a list of potential components of the SCP-paradigm being made specific for the telecommunications industry as reflected in Figure 4. This list was derived through literature research and inputs from industry experts.

Basic Conditions		
Demand	**Supply**	
GDP	Population, incl. density	
Income distribution	Households	
Purchasing power parity	Urbanization	
Regulatory Institutional Index		
Independence	**Accountability**	**Effectiveness**
Political	Procedural	Separate accounts
Operational	Informative	Rights to investigate
Organizational	Discovery	Penalties and fines
Financial	Evaluation	
Regulatory Outcome Indices		
Structure enablers	**Conduct enablers**	
Rights of way/ Infrastructure sharing	Porting of numbers	
Local loop access (unbundling)	Wholesale tariffs	
Spectrum auctions	Contract conditions	
Structure Index		
Market concentration		
Number of players		
Types of networks		
Conduct Index		
Pricing		
Product differentiation		
Infrastructure investments		
Numbers ported		
Performance Index		
Product volumes		
Prices		
Qualities		
Costs		

Figure 4. Potential attributes of the SCP-model

In developing a parsimonious model, an iterative process is applied, moving from exploratory factor analysis to confirmatory factor analysis and vice versa. This process starts with a rudimentary path model and a minimalistic definition of the constructs. Moreover, the analysis process runs from performance to its constituting parts, i.e., to conduct and structure and to regulation. In each iteration cycle a new variable is added and evaluated in terms of its effect on the particular construct and on the overall model. If the addition adds to the explanatory power and the statistical significance improves or remains the same, the variable is added to the construct and thereby to the model. Subsequently the construct and the model are re-evaluated by assessing the changes of leaving out a variable that was already part of the definition. Again, the deletion is

[9] The analysis tests whether the imposed structure is statistically significant.

evaluated in terms of its effect on the construct and on the model. If the deletion adds to the explanatory power and the statistical significance improves or remains the same, the variable is removed from the construct and thereby from the model. Otherwise, the variable remains part of the definition. This evaluation is done for all variables that constitute the construct to this point in the analysis. As the model extends beyond two layers the effects become smaller and hence the focus turns to the evaluation of first and secondary effects.[10]

For a detailed discussion of the various attributes and alternative structures that have been tested for their statistical significance in building the broadband performance index and broadband market model, see Voogt, Lemstra & Van Gorp (2014).

3.1 The Broadband Market Model: the outcome of the factor analysis

In this section we summarize the outcome of the structural equations modelling as introduced in the previous section.

Initially data was gathered on the EU27 + Switzerland for the period 2003-2012. As for certain key variables where relevant data was missing the analysis focused on the period 2008-2011, where 2010 is taken as the base year for the development of the broadband performance index. Due to further data limitations the model has been based on 16 EU countries: Austria, Belgium, Bulgaria, Czech Republic, Denmark, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Spain, and the United Kingdom.

3.1.1 The path model

The path model, the variables and their weights that resulted from the econometric analysis are reflected in Figure 5. The average of the variable for the 27 EU countries plus Switzerland in the year 2010 is shown between brackets in the box below the name of the particular variable. The direct effect of a particular variable on the next variable in the structure is presented as a number without brackets, while the indirect, i.e. the ultimate effect on performance, is presented as a number within brackets. Note that for ease of reference the BPI values have been calibrated to an average of 100 for the EU27+CH in 2010.

[10] Note that the first round of SEM analysis – used in this research – concerns an in-year and cross-country analysis. In potential subsequent rounds, the analysis could move to in-country and across-years, to be followed by a third round of in-country and across years based on an enhanced path model specification including lagged variables.

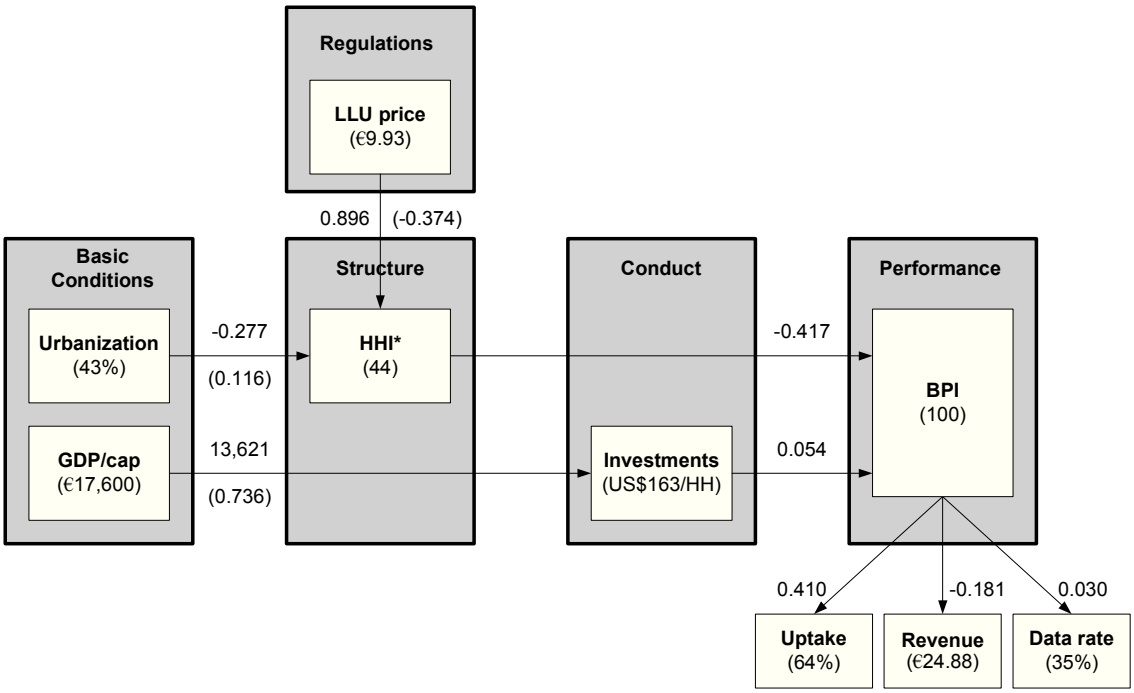

Figure 5. Broadband Market Model

A summary explanation of the variables included in the model follows.

Performance (BPI)

The composite broadband performance index (BPI) consists of three statistically significant components: (1) uptake; (2) revenues; and (3) data rates.

The SCP-dimension volume is reflected by component (1) the broadband uptake and is measured as a percentage of households served by broadband. It is the component with the highest weight. The interpretation of the weight is that an increase in uptake of 1% leads to an increase in the BPI with 0.410 points.

The dimension of price, component (2), is captured by the average revenue per user per month corrected for purchasing power. An increase in the revenue per subscriber connection (i.e. increase in money to be paid by the broadband user) by 1 Euro decreases the BPI by 0.181 points.

The dimension of quality, component (3), is reflected by the download data rate. It measures the percentage of households with a broadband connection with download data rates of at least 10 Mbit/s. The weight of this component with 0.03 is relatively low as a large part of the variation in performance is already explained by the combination of revenues and uptake. The additional effect of data rates is therefore limited.

Investments

The analysis resulted in a single variable to be representative for the dimension of conduct within the SCP-paradigm. In the broadband market model conduct is therefore represented by a singular variable. It represents the average investment per year per household over the period 2003-2011. An extra Dollar of investment per household

increases the BPI by 0.054 points.[11] The analysis showed that in turn the level of investments is dependent on the relative wealth of a country. More specifically, a €1,000 increase in GDP/capita (corrected for purchasing power) increases investments with 13.216. The indirect effect of GDP on performance is 0.7360 (13.621 x 0.054).

Competition Index

Initially, we tested the model with the Herfindahl Hirschman Index (HHI). For all calibrations the HHI was rejected as it was not statistically significant. Subsequently, we tested variations of other competition indices. The analysis showed that HHI* – the HHI of technology platform shares – was statistically significant. As a result the competition index consists of a modified form of the HHI and is in turn a singular indicator for the structure dimension in the SCP-paradigm.

While the classical HHI is based on the market share of individual operators, the HHI* reflects the combined market share of operators using a particular type of technology-base. More specifically, the HHI* represents the 'sum of squares' of: (1) the market share of the PSTN incumbent in broadband; (2) the combined market share of the cable operators; (3) the market share of operators using LLU (full and shared); (4) market share of operators using resale and bitstream; and (5) the market share of operators using FttH, excluding any share of the PSTN incumbent in FttH.[12] The HHI* is calibrated to a 0-100 scale. A one point increase in the HHI* reduces the BPI by 0.417, reflecting that a higher concentration of the technology platform market shares reduces performance. See the next section for an elaboration of the HHI*.

The analysis showed that market structure – and thereby the HHI* – is also influenced by the cost structure, largely as a 'basic condition of supply'. The variable 'degree of urbanization' has shown to have a significant effect. High urbanization rates are, for instance, consistent with a higher penetration of cable. An extra percent in the degree of urbanization leads to an decrease in the competition index of -0.277, and has an indirect positive effect on performance of 0.116 (-0.277 x -0.417).

Regulation

The only dimension in the context of regulation that has been identified as statistically significant is the price setting for unbundled local loops.[13] Hence, regulation is in the model captured by the price for an Unbundled Local Loop (corrected for purchasing power). An increase in the LLU price of 1 Euro increases the HHI* by 0.896, which in turn has a negative effect on performance with a factor -0.374.

3.1.2 Implications of the model

The broadband market model as presented in the previous sections reflects the results that are important to discuss and illustrate in the context of the specific research question on the impact of access regulation on performance.

---

[11] The source data is provided in USD. As the model is based on comparing relative differences between countries, the actual metric is not important.

[12] We also analysed the variant whereby the market share of resale is considered as part of the market share of the incumbent. Given the very small role of resale in the years being considered this resulted in a similar outcome.

[13] With a relatively uniform regulatory institutional environment across the EU Member States, the available data on the institutional environment in which regulation takes shape has not yielded any statistically significant inputs to construct an institutional environment index.

First, the analysis does not show a statistically significant relationship between competition and investments, or in the terms of the SCP-paradigm, between structure and conduct. This does not imply that such relationship does not exist.[14]

Secondly, the classical HHI appears not to be a good indicator for competition in the fixed broadband market.[15] This is a counter-intuitive result, suggesting that we either have to reject the premise that increased competition improves performance or explore alternatives to the HHI that better capture the role of competition in the broadband market. An assumption underlying the HHI is that the market shares are taken from a uniform product market. In the case of broadband this assumption is only partially valid. While the end-users may perceive broadband services as largely equivalent whether offered by the PSTN-incumbent, the CATV-incumbents or access-based operators, only differing in their attributes, in fact they are provided on the basis of different underlying infrastructure means and hence there are structural differences in the attributes of the broadband services offerings. These differences are a reflection of the underlying broadband platforms, the PSTN with xDSL, the CATV with DOCSIS Vx modems and for the access-players the type of PSTN-based wholesale offer they use (resale, bitstream, partial or fully unbundled local loop). Moreover, the cable sector is typically represented by multiple operators, but they do not compete against each other only with the PSTN-based operators. This is not properly captured in the classical HHI. The modified HHI – HHI* – reflects the resulting differences in the type of competition by using the technology platform market shares, rather than the operator market shares.

To illustrate the research results in applying the modified HHI we compare below the HHI with the HHI* in respect to certain key variables. Note that the figures presented below are not part of the analysis conducted to develop the BMM and BPI. They serve as an illustration to provide insights in the underlying reasons for our research findings.

Figure 6 presents a scatter plot of the HHI versus uptake, which is the main constituting component of the broadband performance index.[16] The scatter plot suggests that there is a slightly positive relationship, which would imply that less competition (equivalent to an increase in HHI) improves uptake, which to economists is counter-intuitive.[17]

[14] In the current model investments are captured at an aggregate level. To reflect the investment dynamics an extension of the model will be required with a multi-year cross-country data set and the inclusion of time lags.

[15] The HHI was rejected as being statistically insignificant in the model.

[16] After excluding outliers, 22 countries have been used to construct all the figures in this section. Namely, the EU27 minus Cyprus, Latvia, Lithuania, Luxemburg and Malta.

[17] We performed a regression analysis of the HHI on uptake, which showed that the relationship is positive but statistically not significant.

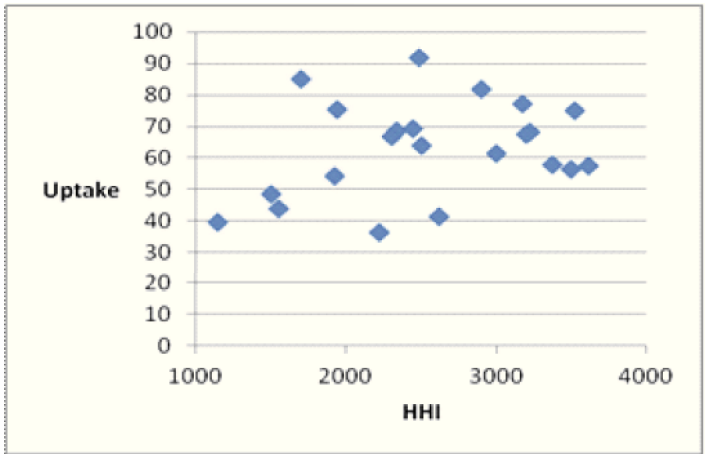

Figure 6. Uptake in relation to HHI, 2010

In Figure 7 uptake is reflected against HHI*. This plot shows a much more pronounced and negative relationship. Moreover, the relationship is in line with what we would expect, i.e. as competition increases (and the HHI* decreases) the uptake of broadband improves.

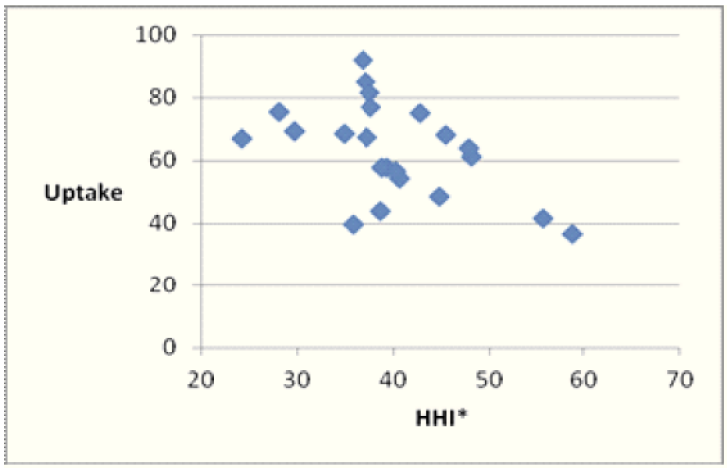

Figure 7. Uptake in relation to HHI*, 2010

Next, we consider the relationship between regulation, i.e. the price of LLU, and the HHI. The scatterplot in Figure 8 is not very pronounced in terms of the underlying relationship. Moreover, the plot suggests that the four countries with a relatively high LLU-price are more competitive than the other countries, which is again counter-intuitive.

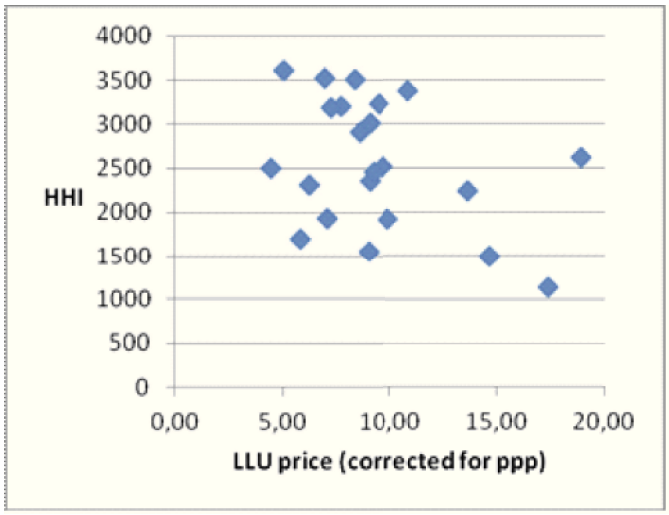

Figure 8. LLU price in relation to HHI, 2010

By contrast, reflecting the LLU price in relation to the HHI* shows a much more distinct and a negative relationship between the price of LLU and the degree of competition. See Figure 9.

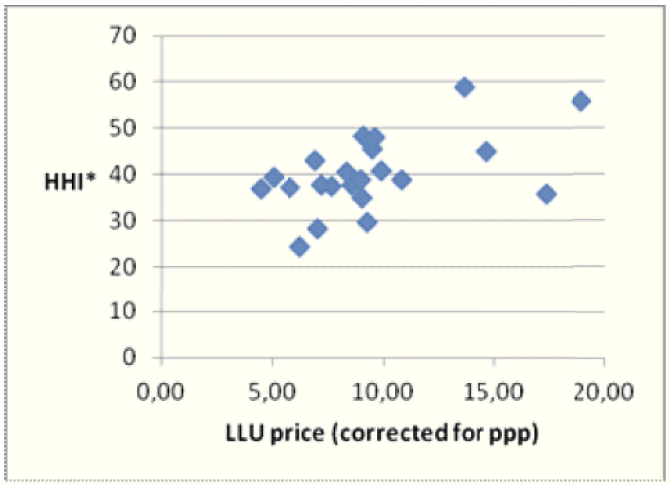

Figure 9. LLU price in relation to HHI*, 2010

Finally, the research suggests a significant positive effect of regulation on performance. However, this effect is not very evident when considering the effect of the LLU price on the market share of access players, as Figure 10 shows.

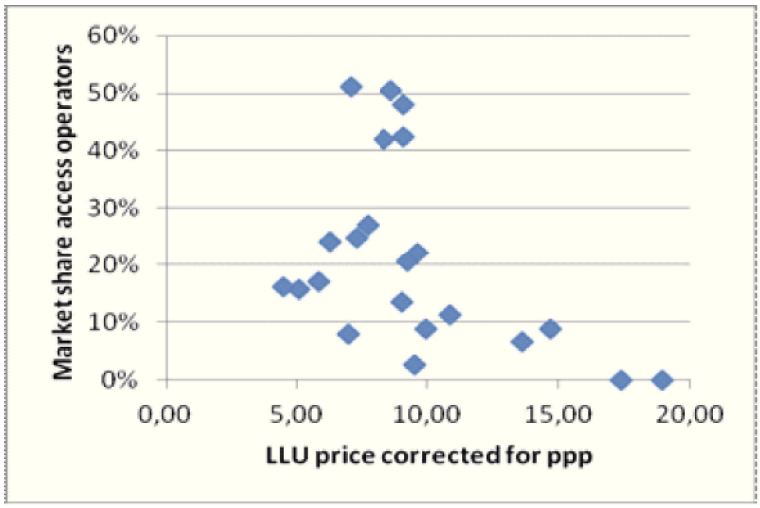

Figure 10. Market share of access operators in relation to LLU price, 2010

In the four countries with relatively high prices for LLU the access operators have a very low market share. However, for countries with prices closer to the average the relationship is less clear. Nonetheless, Figure 9 does suggest a positive effect of lower LLU prices on the degree of competition. Figure 11, reflecting uptake in relation to LLU prices, and Figure 12, reflecting the BPI in relation to LLU prices, provide a much more clear picture of the relationship between LLU prices and broadband performance.

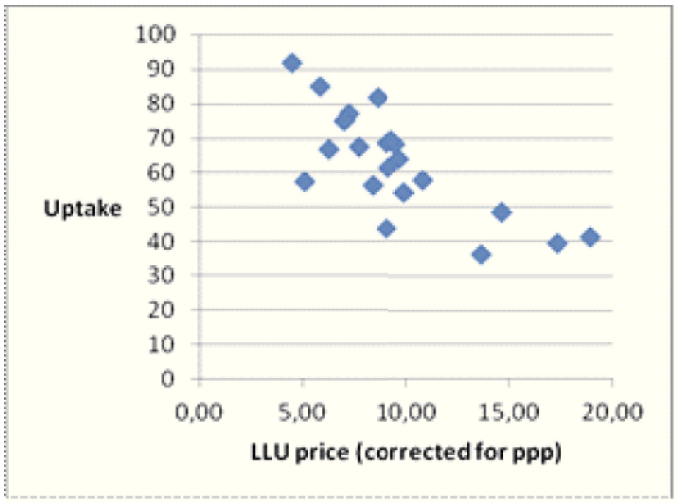

Figure 11. Uptake in relation to LLU price, 2010

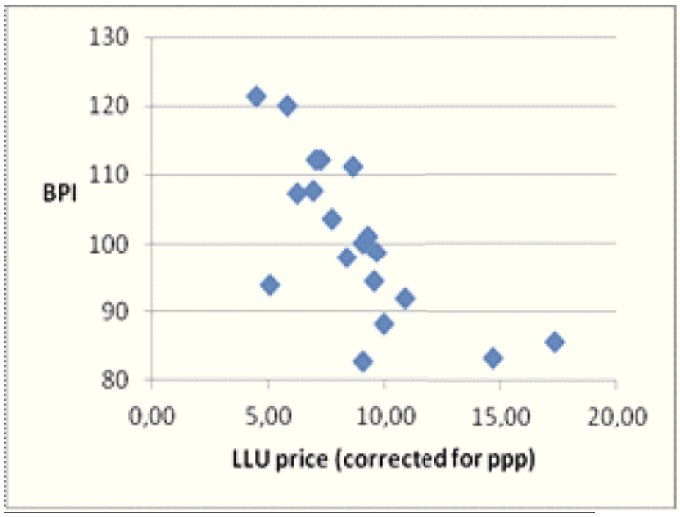

Figure 12. BPI in relation to LU prices, 2010

The reason for these results is that the market share of access operators does not reflect the competitive pressure access operators put on the market (or on the incumbent). If the LLU-price decreases, then access operators are able to compete more effectively. As a consequence the whole broadband market becomes more competitive. Typically the incumbent loses some share of the market, but not only to the access operators also to the CATV and FttH operators. The effect on performance is broader as reflected in the change of the BPI.

3.2 Outcomes of the model

The ranking for the Broadband Performance Index (BPI) is presented in Figure 13 for the year 2010. The scores have been rescaled such that a score of 100 represents the average score. This rescaling has no effect on the weights, but makes it easier to interpret the outcomes. Latvia and Malta are not included in the table due to missing certain relevant data.

Rank	Country	Score	Rank	Country	Score
1	NL*	121	14	FI*	99
2	DK	120	15	IT	98
3	LU	114	16	EE	94
4	UK*	112	17	CH**	94
5	IE	112	18	AT*	94
6	FR	111	19	PT*	92
7	BE	108	20	HU	88
8	SE	107	21	BG	86
9	ES	104	22	CZ	83
10	CY	102	23	PL*	83
11	SI	101	24	RO	79
12	EL	100	25	LT	75
13	DE	100	26	SK	73

*Missing one data point, which is estimated within the model.
**Very rough estimate due to missing data.

Figure 13. Country ranking based on broadband performance index values, 2010

With a score of 121 the Netherlands leads the broadband performance league table as measured by the Broadband Performance Index value. This is the result of a (in relative terms) very high score in terms of investment (NL 300 against average of 163; within a range 10-396), a very high score on uptake (92 against an average of 64; range 37-92), and a high score on data rates (57 against 36; range 5-74), a low score on revenues, below the average (21 against 25; range 9-40) and a low score on HHI*, below the average (37 against 43; range 24-69). See also Figure 14 for a quick overview, the values for NL are reflected at the left side of the bar, which reflects the lowest and highest values measured in the EU countries under consideration.

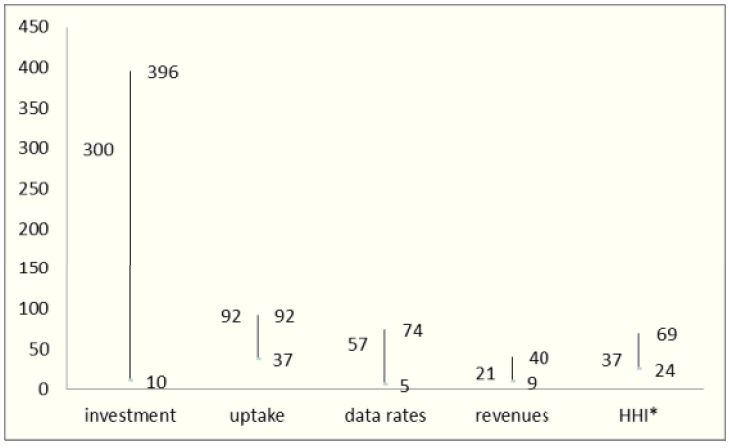

Figure 14. NL scores against the range of values for the EU countries

Over the period covered in the research, 2009-2011, the BPI value for The Netherlands has stayed high, improving slightly. See Figure 15.

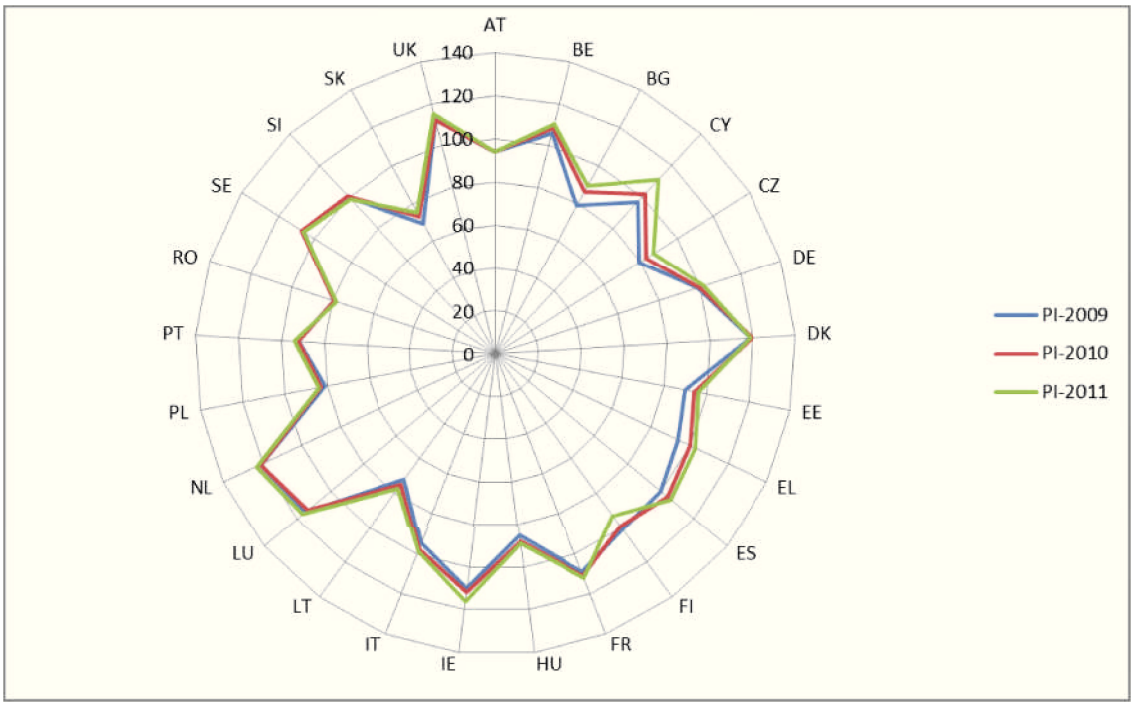

Figure 15. Broadband Performance Index values, EU Member States, 2009-2011

Based on the Broadband Market Model, with the weights for GDP/cap and the degree of urbanization being significant but outside the scope of telecommunications policy and regulation the BPI results can be corrected for these factors. The resulting values for The Netherlands are: 2009 - 116 (was 121); 2010 - 116 (121); 2011 - 117 (123).

3.3 Conclusions regarding BMM and BPI

The research into the broadband market model and the broadband performance index have identified as statistically significant the dimensions of: (1) price, in terms of revenue; (2) quality in terms of download data rates; and (3) investments, in terms of investment per line. The broadband market model – BMM – and broadband performance index – BPI – do not capture the dimension of innovation directly.

However, implied in the quality metric of download data rates is the notion of innovation, as higher data rates require more sophisticated infrastructure technology. At the PSTN side this is reflected in the successive generations of DSL equipment: from ADSL, through ADSL2 and ADSL2$^+$ to VDSL and VDSL2. At the CATV side this is reflected in the successive generations of DOCSIS modems: from DOCSIS-1 through DOCIS-3. Hence, higher data rates are an indication of a higher degree of innovation.[18]

Moreover, irrespective the choice of access mode, access-based competition provides for innovation in terms of the business models applied by the access seekers, including innovation in sales and marketing, and the response of the incumbent operators to these innovations. As access seekers move from resale through bitstream towards the use of unbundled local loops, the degree of innovation that is enabled in the broadband service being provided increases. (see e.g.: Lemstra, 2014).

[18] A secondary effect is that higher data rates enable enhanced innovation at the content and application level.

The research identified the weakness of HHI as the classical metric for market concentration and led to the alternative HHI*, reflecting the technology platform market shares as proxy for market concentration. In the HHI* regulated access is considered in two ways: (1) in the market share for shared and full unbundling; and (2) in the market share for bitstream and resale. With the HHI* having a strong linkage to performance, the model reflects a link between access mode and broadband performance. In the next section we elaborate this linkage and its strength for the case of the Netherlands.

Given (1) the present data set, with a lack of specificity in the investment data; (2) the period being investigated; and (3) the presence of a strong linkage between GDP/capita and investment, and subsequently from investment to performance, no statistical significant linkage between regulation and investment could be identified.

Nonetheless, we can infer an increase in investments by access seekers as they move up the 'ladder of investment' (Lemstra and Van Gorp, 2013; Lemstra, 2014). See Section 5 for the highlights.

The BMM and BPI reflect a strong linkage between the wholesale price of full unbundling and broadband performance. This represents a strong linkage between the role of access regulation and broadband performance. In the presence of this strong relationship, no other statistical significant linkages between regulation and performance could be identified, given the present data set and the period investigated.

4 Broadband model outcomes for the Netherlands

The original broadband market model provided outcomes for the period 2008-2011. However, the dataset for the Netherlands was incomplete for this period, as data on the investment levels of the fixed telecom operators in the Netherlands were lacking.[19] Using data made available by ACM, we first provide a revision of the model outcomes for the Netherlands. See Section 4.1. In Section 4.2 we provide the revised BPI outcomes for 2012 and 2013, based on additional data which has been acquired for this study.[20] In Section 4.3 we show which factors are responsible for the changes in the BPI over time. Finally, in Section 4.4, we consider to what degree the various factors have contributed to the high broadband market performance of the Netherlands in comparison to other EU countries.

4.1 Revision of the BPI for 2008-2011

The revision of the BPI is based on a new estimate of the investment levels of the fixed operators in the Netherlands. In the original model this data was lacking and an estimate was constructed using a statistical data imputation technique, based on the investment data available for the other countries. The estimate was an average investment level of 300 USD per household per year over the period 2003-2011.[21]

As new data has become available for 2012 and 2013 only, we can only improve the estimate, rather than recalculate the investment levels for the years 2003 through 2011.

[19] This is a typical problem in telecommunications as investment data is often reported on an aggregate level for fixed and mobile combined.

[20] We gathered data from several sources in addition to data received from ACM.

[21] The source data is provided in USD. As the model is based on comparing relative differences between countries, the actual metric is not important.

Based on the new data the average investment level is 259 USD per household per year. This implies that the investment levels were overestimated by around 15%. In Table 1 we show the effect on the BPI.

	BPI old estimate	BPI new estimate	Difference[22]	Old rank	New rank
2008	117.2	114.8	-2.4	2	2
2009	120.9	118.6	-2.4	1	2
2010	121.4	119.3	-2.1	1	2
2011	122.7	120.7	-2.0	1	1

Table 1. Effect of new estimate for investments.

Based on the new investment data, the BPI value of the Netherlands decreases on average a little more than 2 points. However, the effect on the ranking is rather small, in 2009 and 2010 Denmark now leads by a narrow margin.

Considering the strong effect of GDP on investment levels and recognizing the economic downturn in recent years, the investment levels in 2012 and 2013 are likely to be lower than in the period 2003-2011. Hence, the actual BPI is likely to be between the old and new estimate.

4.2 Update of BPI for 2012 and 2013

In Table 2, the revised BPI values for 2012 and 2013 are provided in the second column. The third column shows the year-over-year difference in the BPI values. The columns 4 through 7 indicate the differences in the components underlying the BPI.

Notice that broadband uptake is the main contributor to the increase in the BPI over time. This is not surprising as (1) uptake has a relatively high weight in comparison to data rates and revenues and (2) uptake naturally increases over time. The latter is something that is typical for indices; they have a positive trend.

The important question is whether the Netherlands reflects a 'better' improvement trend than other countries and whether this trend is stable. We come back to the first part of this question in more detail in Section 4.3. Trends, and more particularly, changes in trends are hard to assess for such a small time period. However, it is to be expected that the trend is declining, as uptake is approaching 100% of the households (98% in 2013), which allows little room for further improvement. Consequently, if the model will be recalibrated using more recent years, it is likely that the relative weight of uptake will decrease and shift to for example data rates or uptake of FttH (which was not yet significant in 2010).[23]

[22] These numbers are based on unrounded data. Therefore, the difference in 2009 is -2,4 rather than -2,3 as the table would suggest.

[23] A recalibration of the model falls outside the scope of this study.

Similar to uptake, data rates are also increasing over time. At first sight, the uptake of higher data rates is positive, but appears to slow down. This is somewhat surprising as usage patterns suggest continuously increasing data volumes.[24] In Section 4.3 we compare the Netherlands in this respect to other EU countries.

		Year over year change				
	BPI	**BPI**	**Uptake**	**Data rates**	**Revenues**	**HHI***
2008	114.8					
2009-2008	118.6	3.71	1.25	0.39	0.17	1.90
2010-2009	119.3	0.70	0.99	0.30	0.23	-0.82
2011-2010	120.7	1.43	1.02	0.11	-0.24	0.54
2012	121.2	0.50	0.91	0.17	0.15	-0.72
2013	121.5	0.34	0.63	0.09	0.14	-0.52
Total		**6.68**	**4.80**	**1.05**	**0.45**	**0.39**

Table 2. Development of BPI.

The effect of prices reflected by revenues is relatively small, as the changes in the prices have not been very substantial. On average revenues per user have decreased since 2008.

Competition in the form of the HHI* is subject to more fluctuation. From 2008 to 2009 there was a relatively large increase in the market share of the access players, having a large positive effect on the BPI through the HHI*. Notice that this change is accompanied by the largest positive effect of uptake and data rates and the second largest positive effect of revenues in the relevant period.[25] The negative changes in the HHI* are largely the result of an increase in the market share of cable. Whenever cable is gaining market share at the expense of the incumbent the effect is positive. By contrast, if cable is gaining market share at the expense of the access players the effect is negative.

As the model uses average investment levels, changes in investments are not captured. More detailed investment data over a longer period of time is required to assess the dynamic effects of investments.

[24] The data for the Netherlands tentatively suggests that the impact of data rates is becoming increasingly smaller relative to the impact of uptake. This could be an indication that uptake of data rates above 10 Mbit/s is starting to become less relevant in comparing performance across countries. It is to be expected that data rates above 30 Mbit/s will show up as a relevant factor in a newly calibrated model.

[25] In 2011, for example, the HHI* has a positive effect while the prices have a negative effect on revenues. The most likely reason for this is that the model is comparative static, i.e. time lags have not been included. In order to estimate a dynamic model a longer time period must be taken into consideration. In a static model one has to be careful to draw conclusions on a year by year basis.

Over the period 2008-2013, the Netherlands has gained almost 7 points in BPI value. This positive development result at large from the factors uptake and data rates, while revenues and HHI* (competition) also have had a positive effect.

Indirect effects

One of the main benefits of the broadband market model is that it also accounts for factors which are often considered to be exogenous to the broadband market, as well as changes in these factors. Moreover, the model captures the effect of changes in regulation on competition and in turn on performance. In Table 3 we provide an overview of the indirect effects underlying the model.

	Year over year change		
	Urbanization	**GDP/capita**	**LLU price**
2009-2008	0.01	-0.50	0.28
2010-2009	0.00	0.04	0.03
2011-2010	0.03	0.22	0.03
2012-2011	0.00	-0.34	-0.03
2013-2012	0.00	-0.17	-0.04
Total	**0.05**	**-0.74**	**0.28**

Table 3. Indirect effects on BPI.

Urbanization has a positive effect on competition as in urban areas the cost to roll-out infrastructure is lower. In the Netherlands there have only been relative small changes in the level of urbanization since 2008. Therefore, the effect of urbanization is, although positive, very small.

The economic downturn is noticeable as the total negative effect of -0,74 points more than negates the positive effect of for example, increased competition. Finally, the effect of the price of LLU is most prominent from 2008 to 2009. In this period the price of LLU dropped significantly and simultaneously competition increased and the Netherlands gained the largest boost in BPI over the period 2008-2013.[26]

4.3 Comparative analysis

In this section we compare the Netherlands with the other EU-27 countries. First, we compare the Netherlands with all other countries in the EU, with the exception of Malta and Latvia, which have been excluded due to missing data, see Table 4.

The table has been constructed as follows: For each year, the contribution of each component to the BPI across all countries is calculated and averaged.[27] Subsequently,

[26] The model does not fully attribute the increase in competition to the price of LLU, as the effect of LLU is 0.28 on performance, while competition has a total effect of 1.90. Nonetheless, the result is rather interesting.

[27] As we do not have data for the years 2012 and 2013 for the other EU countries, we can only make comparisons for the years 2008-2011.

for each year and for each component the average score of the countries for that year is subtracted from the score of the Netherlands.

As a result, the number 13.0 for uptake in 2008 implies that the Netherlands has gained on average 13 extra points in the BPI in 2008 relative to other countries by having a substantial higher level of uptake. The total direct effect of 21.85 in 2008 means that the Netherlands has a BPI that is 21.85 points higher than the EU-27 average.[28]

	Input/year	2008	2009	2010	2011
Direct effects	Uptake	13.0	12.2	11.7	11.1
	Data rates	0.5	0.6	0.6	0.4
	Revenues	1.1	0.8	0.8	0.7
	Investments	5.4	5.4	5.4	5.4
	HHI*	1.9	3.6	2.5	3.2
Total Direct		**21.85**	**22.64**	**21.00**	**20.83**
Indirect effects	GDP/cap in PPP	2.9	2.7	3.3	1.6
	Urbanization	2.6	2.8	2.7	2.7
	LLU price	1.7	2.0	1.9	1.8
Total Indirect		**7.23**	**7.46**	**7.93**	**6.14**

Table 4. Comparing Netherlands with EU 27 (excluding Malta and Latvia)

The table shows that the Netherlands performs above average on all fronts. The largest gain stems from the relatively high level of uptake in the Netherlands, which accounts for 53-60% of the total difference. As the points drop from 13.0 to 11.1, it suggests that other countries are (slowly) closing the gap, which nonetheless remains large.

The advantage gained in data rates is relatively small for two reasons. First, the relative weight of data rates is quite small in the BPI. Secondly, there are quite some countries which have relatively high data rates, but perform worse on other factors. Bulgaria, for example, has a relatively large uptake of FttH resulting in high data rates.[29]

The revenues are below average which leads to a gain of 0.7 to 1.1 points. However, the gap with the EU27 is becoming smaller.

The Netherlands gains a substantial number of points on investments, however, the investment level remains to be based on an estimate. Finally, there is a gain of around 3 points due to a higher level of competition.

[28] The observant reader might notice that the BPI of the Netherlands in 2008 is 114.8 and not 121.85 as the table would suggest. The reason for this deviation is that the base year of the index is 2010, i.e. the average score in 2010 is 100. Since we updated the figures for the Netherlands, the average score is now slightly lower than 100.

[29] The reason is that in many large cities in Bulgaria fibre is simply attached to the building façades. However, broadband in the rural areas, by contrast, remain far behind.

The indirect effects show the extent to which underlying factors explain the relative performance of the Netherlands. Around 12% (2 to 3 points) of the performance is solely caused by the Netherlands having a relatively high income (GDP/cap). Another 13% is to be attributed to the urbanization level of the Netherlands. Finally, a relatively low LLU price accounts for about 9% of the difference between the Netherlands and the EU-25.

Sensitivity check

As due to data limitations the original model is based on 16 EU countries, a sensitivity analysis has been performed by recalculating the figures on basis of these 16 countries.

	Input/year	**2008**	**2009**	**2010**	**2011**
Direct effects	Uptake	12.9	11.9	11.0	10.5
	Data rates	0.4	0.5	0.5	0.2
	Revenues	0.6	0.7	0.8	0.8
	Investments	5.4	5.4	5.4	5.4
	HHI*	0.2	1.8	0.8	1.0
Total Direct		**19.58**	**20.39**	**18.56**	**17.99**
Indirect effects	GDP/cap in PPP	2.6	2.3	2.1	2.2
	Urbanization	2.1	2.3	2.2	2.3
	LLU price	2.1	2.3	2.2	2.3
Total Indirect		**6.72**	**6.90**	**6.55**	**6.70**

Table 5. Comparing Netherlands with the 16 EU countries of the original model.

As can be seen, the differences between Table 4 and 5 are rather small. This suggests that the sample of 16 countries is fairly representative for the EU-25.

Comparing the Netherlands with the UK, Germany, France

In line with the mini-case studies on the effects of access regulation discussed in Section 5 (see Lemstra and Van Gorp, 2013), the sensitivity analysis has been repeated by comparing the Netherlands with the three countries covered by the case studies, the UK, Germany and France. The results are shown in Table 6.

Also in comparison with Germany, France and the UK, the Netherlands performs very well in terms of uptake, although, the other countries are catching up. This is not surprising as there is little room left to further increase of uptake in the Netherlands. In terms of data rates the Netherlands is still ahead, but only by a small margin. Interestingly, in terms of prices the advantage of 0.5 is quite close to the advantage of 0.7 in comparison to the EU-27. In terms of competition the Netherlands performs slightly worse. This is mainly caused by the relative high market share of access players in the UK.

	Input/year	2008	2009	2010	2011
Direct effects	Uptake	6.7	5.6	5.2	4.6
	Data rates	0.3	0.3	0.3	0.1
	Revenues	0.3	0.5	0.6	0.5
	Investments	3.5	3.5	3.5	3.5
	HHI*	-2.3	-0.6	-1.1	-0.5
Total Direct		**8.44**	**9.28**	**8.47**	**8.15**
Indirect effects	GDP/cap in PPP	-0.4	-0.5	-1.0	-1.1
	Urbanization	0.7	0.9	0.8	0.9
	LLU price	0.7	0.9	0.8	0.9
Total Indirect		**1.08**	**1.21**	**0.64**	**0.64**

Table 6. Comparing Netherlands with the UK, DE and FR

Table 7 reflects the developments at the BPI level over time for the four countries.

	NL	UK	GER	FR
2008	114.8	109.1	96.7	105.4
2009	118.6	111.5	98.8	108.8
2010	119.3	112.2	100.2	111.3
2011	120.7	115.0	101.5	112.3

Table7. BPI for NL, UK, Germany and France, 2008-2011.

4.4 Effect of access regulation on performance

In this section the effect of access regulation on the BPI is estimated and in turn the effect on its underlying components. Regulation is represented in the broadband market model by the price of LLU. In turn this price effects the level of competition in the market, measured by the HHI*. Next, the HHI* has an effect on the BPI, which then translates into an impact on the uptake, data rates and prices.

As said before, the model did not show a clear cut relationship between competition and the level of investments. This does not imply that the model rejects that such relationship exists. Given the limited amount of data available for the Netherlands it is undesirable to use the model as a basis for further quantitative analysis to determine the effect of regulation on investments. See for an alternative analysis Lemstra (2014) and Lemstra & Van Gorp (2013).

In the previous chapter we showed how the Netherlands performed with respect to regulation in comparison to other countries. As the Netherlands has a relatively low

LLU price, as a consequence the level of competition is increased, which is resulting in an increase in the BPI of around 2.1-2.3 points compared to the EU-25 average. However, the real question is how performance would be affected absent access regulation. As other countries also have access regulation in place we cannot directly conclude this from the model, which is in fact setup as a country comparison tool. Therefore, we must compare the Netherlands with a hypothetical country, similar to the Netherlands in all respects, but without access regulation. We can create such a country by using the NL data and artificially increasing the price of LLU, since absent regulation the price of LLU is no longer restricted. The effect of such an increase is that the market shares of the access players are likely to be crowded out, which implies that competition decreases, resulting in an increase of the HHI*. It is not very relevant to which extent the LLU price must be increased to establish this effect. What matters is how the market shares of the access players will be divided among the remaining market players, i.e. the PSTN incumbent, the CATV incumbents and FttH-based operators.[30]

Division of market shares

The first approach having been applied was to study how the changes in LLU prices in the period 2008-2011 affected the market shares in individual countries. Unfortunately, in most countries there was either not enough variation in the LLU price or other over-arching developments were present (like the roll-out of FttH in Bulgaria) to be able to filter out the effect of the LLU price on the division of markets shares underlying the HHI*.[31] The few countries, such as Spain, were such effects are clearly present are not enough to draw firm conclusions.

Another approach was to go back to a cross-country analysis, to consider how market shares in countries without access players are divided. However, in this approach we can only focus on countries which are in other aspects similar to the Netherlands, i.e. also have national coverage of cable. This becomes rather artificial and too dependent on specific factors of the few countries which have national cable coverage.

Therefore, the alternative approach is the use of scenarios. Three different scenarios are considered for the division of market shares absent access regulation. This allows a range of possible outcomes to be established. In the first scenario the assumption is that the incumbent PSTN operator manages to attract all customers from the access players. This scenario is likely if customers have a strong preference for service offerings that are enabled by xDSL technologies. On the other extreme we assume that the cable operators attract all customers from the access players using offerings enabled by DOCSIS. Some support for this particular scenario exists, as in our model revealed that the competitive pressure of cable operators and access players on the incumbent are to some extent substitutes. More specifically, the presence of a cable network improves competition, but it reduces the role that access players have in improving competition. Finally, we consider a 'medium' scenario in which the market shares are divided equally among the PSTN incumbent and the cable incumbents. The effect of these three scenarios on the HHI* is shown in Table 8. The last two columns present the range of changes in the HHI* resulting from the absence of regulation.

[30] As in the period considered the FttH market share is small, in the discussion that follows we concentrate on the market shares of the PSC and CATV incumbents.

[31] Note that most of the reduction in LLU prices has taken place before 2008.

	Currently	All to incumbent	All to cable	Equal division	Minimum change	Maximum change
2008	39.3	50.0	47.3	48.1	8.1	10.7
2009	34.7	49.2	47.5	47.1	12.4	14.5
2010	36.7	51.9	50.8	50.1	13.4	15.2
2011	35.4	47.6	48.4	47.0	11.6	13.0
2012	37.1	50.2	50.9	49.4	12.3	13.8
2013	38.4	49.6	50.5	49.2	10.8	12.1
Average	**36.9**	**49.8**	**49.2**	**48.5**	**11.4**	**13.2**

Table 8. Changes in HHI*

On average the HHI* increases by around 11 to around 13 points. Which of the three scenarios would apply in reality cannot be ascertained with certainty. The effect on competition depends on the market situation at the time the access regulation is abandoned. For example, in the period 2008-2010 the incumbent had a larger market share than the cable operators combined. Therefore, the scenario 'all to the incumbent' would have resulted in negative effect during this period, i.e. increasing the market shares of the PSTN incumbent further. As since 2011 the cable operators had a slightly larger market share than the incumbent, the scenario 'all to cable' would in this period have resulted in a negative effect, i.e. increasing further the market share of the cable incumbents. In the period 2009-2013 the market shares of the incumbent and cable are very close, hence, the scenario 'equal division' would not affect the balance in market power. Hence, the applicability of the scenario may (1) lead a higher market concentration; (2) have no effect on the distribution of market shares; or (3) compensate for an inequality in market shares.

Next, the effect of the changes in the HHI* on broadband performance (BPI) has been calculated. The results are reflected in Table 9.

From Table 9 we may conclude that access regulation has increased the BPI, on average, by around 5 points. The differences between the three scenarios is at most 1.1 points in 2008. As since 2008 the market shares of the CATV incumbents and the PSTN incumbent have converged, the differences between the scenarios decrease to only 0.5 points.

As the range of possible effects has become relatively narrow we may conclude that the exact division of the market shares of the access players is not of vital importance considering the current market division between CATV and PSTN incumbents. However, we would like to mention these are specific results for the Netherlands. In other countries, for example the UK, cable has a much smaller market share. In such a case the division of market shares has a much larger impact. Consequently, the potential gains from access regulation can also be much higher in those countries. This is not surprising, as in the case of lower market power from cable, other forms of competition become more important to put pressure on the incumbent.

	All to incumbent	All to cable	Equal division	Minimum change	Maximum change	Bandwidth
2008	-4.5	-3.3	-3.7	-3.4	-4.5	1.1
2009	-6.0	-5.3	-5.2	-5.2	-6.0	0.9
2010	-6.3	-5.9	-5.6	-5.6	-6.3	0.8
2011	-5.1	-5.4	-4.8	-4.8	-5.4	0.6
2012	-5.5	-5.8	-5.1	-5.1	-5.8	0.6
2013	-4.7	-5.0	-4.5	-4.5	-5.0	0.5
Average	**-5.3**	**-5.1**	**-4.8**	**-4.8**	**-5.5**	**0.7**

Table 9. Effect of changes in HHI* on BPI

Changes in the BPI: what does it imply?

The analysis showed that the expected effect of access regulation is around 5 points in the value of the BPI. The next question is how these points translate into effects on the underlying components of the BPI, namely uptake, prices (in terms of revenues) and data rates. As the BPI is a composite indicator, a particular combination of component values leads to a particular BPI outcome. However, given a certain BPI value there are an infinite amount of combinations of component values that could lead to that particular BPI outcome. Therefore, it is impossible to trace back an increase in the BPI to individual effects on the components.

As an alternative, we consider the maximum possible effect on uptake, i.e. we assume that the decrease in BPI is solely reflected in a decrease in uptake. This approach is used for several reasons. First, uptake is the factor with the highest relative weight. Second, uptake is the component with the most dynamic variation, making it the most likely candidate. Prices have remained relatively stable over the last years. Operators are mainly competing on higher data rates and in providing extra services (VoD, Spotify, et cetera). While data rates also feature dynamic variation, their relative weight is rather small. This reflects that data rates are highly correlated with uptake, such that most of the difference in performance is already captured within the component uptake. Consequently, it is difficult to assess to which extent an increase in the BPI is reflected Hence, considering the changes in uptake provides a good indication of the effect of changes in access regulation.

The maximum effect of not having access regulation on the percentage of households with a broadband connection is presented in Table 10.

	All to incumbent	All to cable	Equal division	Minimum change	Maximum change	Bandwidth
2008	-11	-8	-9	-8	-11	2.6
2009	-15	-13	-13	-13	-15	2.1
2010	-15	-14	-14	-14	-15	1.8
2011	-12	-13	-12	-12	-13	1.4
2012	-13	-14	-13	-13	-14	1.5
2013	-11	-12	-11	-11	-12	1.3
Average	**-13**	**-13**	**-12**	**-12**	**-13**	**1.8**

Table 10. Effect of changes in BPI on uptake (%).

Assuming that prices (revenues) and data rates are not affected, on average the uptake in the Netherlands has increased by around 12-13% due to access regulation.

5 Research outcome qualitative analysis

In general, but specifically in cases where the data set is limited in terms of the number of observations, it is advised that econometric analysis is accompanied by qualitative analysis as a means to validate the research findings. In this research project corroboration is derived from an investigation into the effects of access regulation on the deployment of the various access modes and on investments and innovation (Lemstra and Van Gorp, 2013). In this section the main findings are summarized, for a detailed discussion reference is made to the literature.

5.1 Three mini-case studies into access regulation

In the presence of a strong relationship between GDP/cap through investment onto broadband performance, the quantitative research did not reveal a statistically significant link between LLU access pricing and investment.[32] Nonetheless we can infer a relationship between access mode and investment from the changes in the composition of the access portfolio. This becomes evident from the research into the 'ladder of investment' concept, using the mini-case studies on the United Kingdom, France and Germany. (Lemstra and Van Gorp, 2013)

Access mode and investment

With respect to access mode and the degree of investment by the alternative operator it is important to recall the principle behind the so-called 'ladder of investment' concept (Cave, 2004, 2005, 2006): at the lowest rung of the ladder the market entry barrier is also the lowest, very little investment is required from the alternative operator to enter the market. Having established a customer base of sufficient size using a product such as resale or bitstream, the alternative operator will be enticed to decrease the

[32] Note that in the absence of more detailed investment data, the model has been based on total telecom investment on a country basis.

dependency on the incumbent and the fees to be paid to the incumbent by investing more in its own infrastructure.

Hence, if alternative operators change their mode of access, from resale and bitstream to partial and full unbundling their investments per end-user connected increases.

This shift in access mode is apparent in all three mini-cases studies. See Figure 16, Figure 17 and Figure 18. In all three cases we can observe that if the business conditions for unbundling are set appropriately the alternative operators 'move up the ladder of investment'.[33]

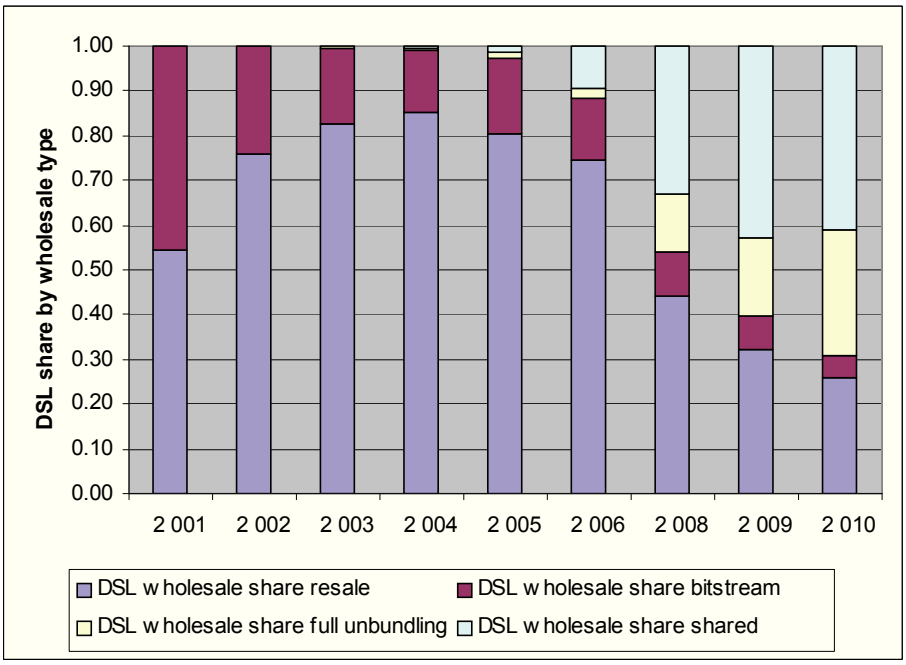

Figure 16. DSL share by wholesale type in the UK, 2001-2010

[33] It should be noted that bitstream is also a complementary service to unbundling in those areas where the density of the alternative operator's foot print does not economically justify the use of unbundled loops. Through the combination of unbundling and bitstream the alternative operator can still offer nationwide services, which is important for marketing and sales reasons.

The importance of bitstream increases with (1) the transition from ADSL to VDSL combined with FttC and (2) with the transition to All-IP, whereby the local exchange as point of aggregation disappears.

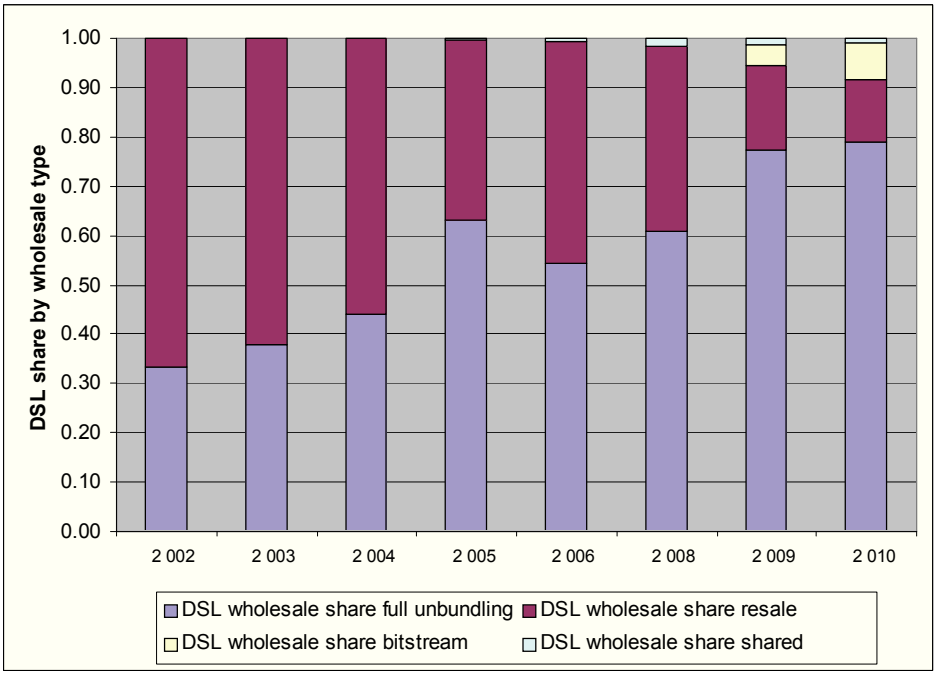

Figure 17. DSL share by wholesale type in Germany, 2002-2010

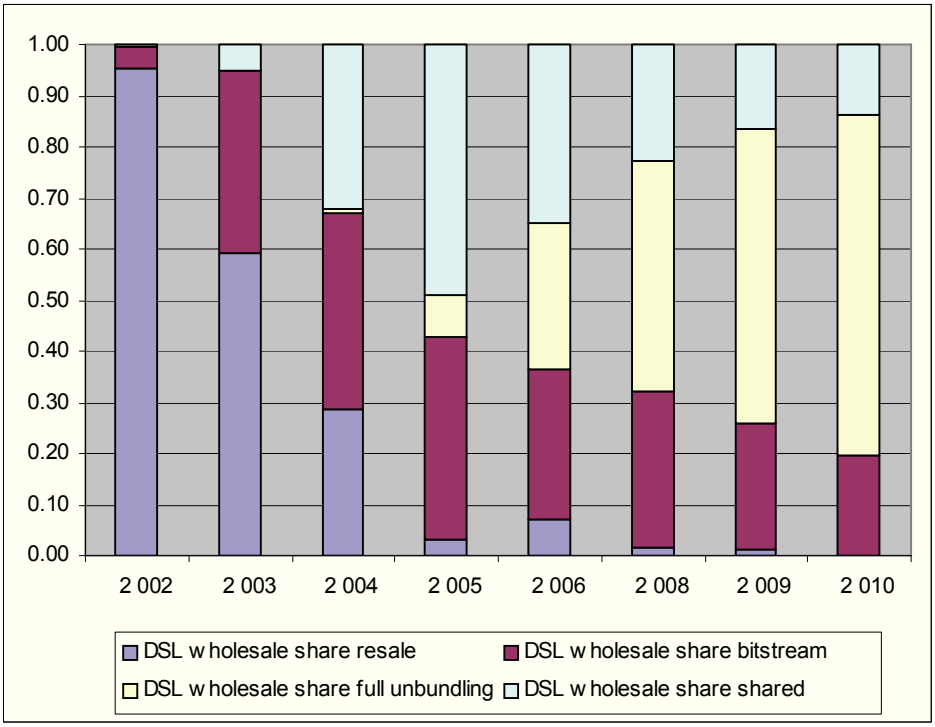

Figure 18. DSL share by wholesale type in France, 2002-2010

The equivalent chart for the Netherlands shows a much similar development in the evolution of access modes, see Figure 19 and Figure 20.

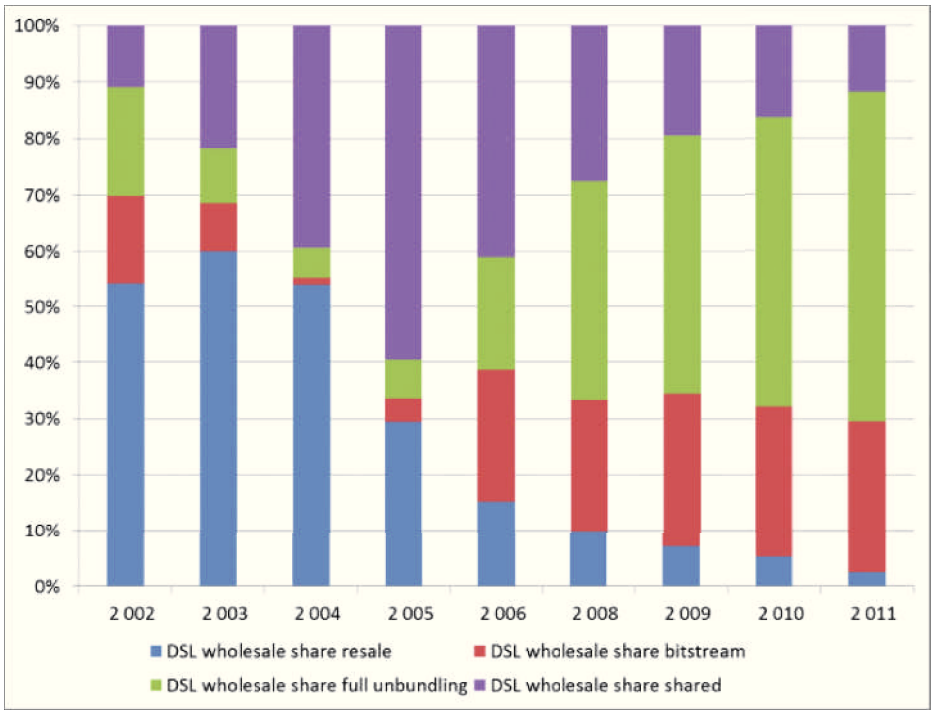

Figure 19. DSL share by wholesale type in the Netherlands, 2002-2011

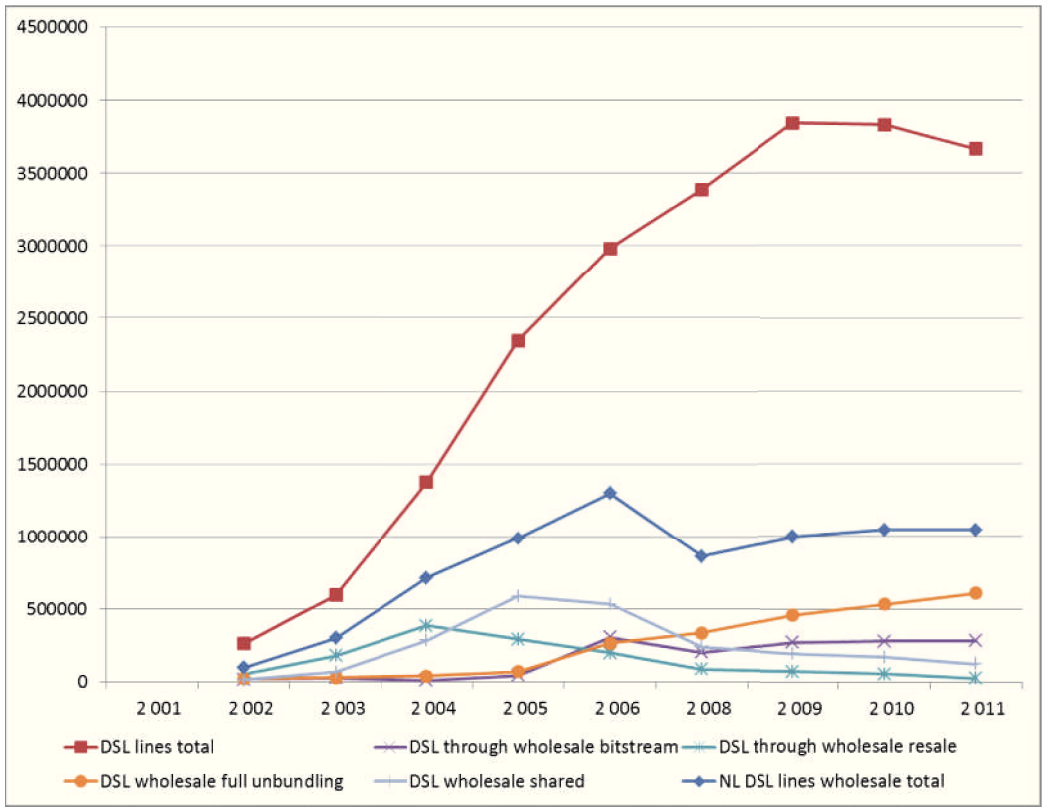

Figure 20. DSL developments in the Netherlands, 2002-2011

Note that this rather neat progression in access mode development may be hindered in later years as further progress in terms of higher data rates requires a shorter local loop and hence the introduction of fibre to the cabinet (FttC) and the application of VDSL on the sub-loop.[34]

Depending on the business case the alternative operator may follow the incumbent in the transition to VDSL and use sub-loop unbundling possibly combined with a backhaul service provided by the incumbent to increase the catchment area. Alternatively, the access seeker may have to climb down the 'ladder of investment' by using a virtual unbundled product, such as VULA, which is essentially a high data rate bitstream service. In the latter case the degree of investment by the alternative operator diminishes.

Access mode and innovation

In the most constrained situation, i.e. in the case of resale, the domain for innovation by the access seeker is limited to the business operations, marketing, innovative pricing plans and to any content related activity. Innovation in these areas by the access seeker may force the incumbent and other competitors to also innovate in these areas.

As alternative operators change their mode of access, from resale and bitstream to partial and full unbundling, they increase the degree to which product differentiation is possible and hence they increase their opportunities to innovate.

This shift in access mode is apparent in all three mini-cases studies and thus also the increasing opportunities to innovate.

The anecdotal evidence provided in the case studies suggest that alternative operators do use this increased opportunity to innovate. The case of Free/Illiad is probably the best example of both business model innovation and services innovation, being well ahead of the competition, including the incumbent.

Hence, as alternative operators change their mode of access, from resale and bitstream to partial and full unbundling the degree of innovation tends to increase.

When the alternative operator opts for sub-loop unbundling as part of the transition towards VDSL and FttC, the progression in terms of innovation continuous. However, if the alternative operator chooses to use VULA, this means a bitstream product and hence a lower degree of product differentiation being possible and thus a lower degree of service innovation opportunities.

Access mode and quality

The case of Free/Illiad also shows the progression in successive generations of DSL equipment being used – from ADSL, through ADSL2 to ADSL2^{+} – and ultimately the transition to FttH.[35] This represents a steady increase in the maximum data rates that can be offered and hence in the quality of service that is being provided. Free/Illiad chose to always provide the highest data rate made available by the technology being deployed.

---

[34] On relatively short loops the VDSL equipment can be located in the exchange building and VDSL unbundling can be applied, similar to ADSL.

[35] Other examples of access seekers reaching the 'final rung' are some of the Stadtwerke in Germany. (Lemstra and Van Gorp, 2013)

When the alternative operator opts for sub-loop unbundling as part of the transition towards VDSL and FttC, the progression in terms of higher data rates is continuous. This also applies in the case of VULA, assuming the wholesale product is not constrained relative to the retail product of the incumbent operator.

Hence, as successive generations of technology are deployed, the quality level increases as alternative operators follow this succession in technology, either through resale and bitstream or through shared and full unbundling. In the latter case they have the opportunity to differentiate their service offering relative to the incumbent towards higher quality levels. As the incumbent and the alternative operator typically use a similar type of technology, this argument holds only to a degree.

Nonetheless, an AnalysysMason study suggests that a higher degree of unbundling is related to higher data rates being offered. (AnalysysMason, 2010)

Access mode and prices

The mini-case studies provide ample evidence of the price pressure as a result of competition, both infrastructure-based competition and access-based competition. Again the AnalysysMason study is of particular interest as it reports higher data rates are provided for the same amount of money while being linked to higher proportion of unbundling.

5.2 Implications for the research question

While our research into the dynamics of broadband markets in Europe has shown that the diversity of broadband markets is large, the three mini-case studies can be considered as typical and representative for in particular leading West European countries. Hence, the research findings from the three mini-case studies may be considered as generally applicable for Western Europe.

The research based on the mini-case studies has shown that the progression in the mode of access by the alternative operators, from resale and bitstream to partial and full unbundling, leads to a higher level of infrastructure investment and a higher degree of service innovation by the alternative operators. Moreover, it shows that access-based competition provides for higher quality in terms of higher data rates and lower prices.

The case evidence shows that in practice all three access modes, resale, bitstream and unbundling, are important to alternative operators, albeit in different degrees.

In the analysis of the benefits of access regulation the welfare gains obtained through the alternative operators has to be judged against a potential welfare loss through the loss of business by the incumbents. The question is whether copper-based access regime provides for a negative, positive or zero sum game.

5.3 Moving beyond the research question

Based on the mini-case studies and our research into the dynamics of broadband markets in Europe we can recognize several positive effects from unbundling of copper on the investment in next generation fibre access.

Increased demand and take-up for higher data rates and services bundles

A crucial element for the viability of investments in next generation fibre access networks is the demand for the higher capabilities these networks offer. In all three countries that we examined, it has become clear that unbundling has increased the take-up of higher data rate Internet services and associated services bundles. As unbundling

is enabling these higher data rates, unbundling of copper is facilitating the business case for investments in fiber-based access.

Stepping stone to fibre roll-out for entrants

In cases where cable is absent and other supporting factors exist (such as strong localised market positions in Germany and the presence of legislative guarantees preventing duplication in France), unbundling has provided a stepping stone for the large(st) scale alternative providers to move up the 'ladder of investment' to reach the final rung of facilities-based competition using fibre-based access. The salient example are Free/Illiad in France and city carriers M'net and NetCologne in Germany.

Where the conditions were supportive, this potential for entrants to become the first movers has also played an important role in stimulating incumbents to invest in fibre access – where otherwise few incentives would exist.

Role of competition

The network economics of FttH suggest that, with few exceptions, economies of scale will persist leading to outcomes which would normally tend towards a monopoly or duopoly in the access network, in areas where roll-out is commercially viable. Depending on the existing presence and strength of cable networks, this could result in scenarios involving the cable operator(s) and the PSTN incumbent or a consortium of operators, or the incumbent and entrant, or indeed a single player, where 'first mover' privileges are granted as in France. Outside dense areas, a single player will be the most likely outcome.

Cost of fibre deployment

On the cost side the major element is trenching, where ever this can be avoided through sharing of facilities or using poles or façade mounting the business case will be improved significantly, the Free/Iliad case provides a salient example. Moreover, the coordination and facilitation of construction activities, such as by the City of Almere, and Stadtwerke München, provide for further cost and lead time reductions. The consultation by the European Commission, Directorate General for the Information Society and Media (now DG CNECT) may provide for (other) best practices to reduce costs.[36] However, in many cases it may be that the incumbent's own duct infrastructure, particularly where this has been depreciated, is the lowest cost route to installing fibre networks.[37]

Reducing investment risks

Irrespective of any potential benefits from cost reductions or increased spending by consumers on premium services, our analysis suggests that unbundling provides the stimulus for higher service levels and innovation, supporting the evolution of demand for ultra-fast broadband services and thereby reducing the degree of risk related to the investment in fibre.

---

[36] Study entitled "Support for the preparation of an impact assessment to accompany an EU initiative on reducing the costs of high-speed broadband infrastructure deployment", accessible at http://ec.europa.eu/information_society/policy/ecomm/library/calls_tenders/index_en.htm

[37] Note that in the Netherlands cables are directly burried, no use is made of ducts.

Regulatory implications

The analysis of unbundling and the transition from copper to fiber access identified a number of topics that deserve ongoing critical attention:

- the continued availability of cost-based copper loop unbundling to facilitate a progressive conversion of customers from copper to fiber;

To improve the effectiveness of the related regulation this may require:

- Vigilance in monitoring and resolving any price-based discrimination;
- The setting and tracking compliance with KPIs to reduce or avoid non-price discrimination; and
- The introduction of functional separation aimed at resolving non-price discrimination.

Improving the scenario for a fibre-based future

The experience with unbundling of the copper network has shown that prying open a monopolistic arrangement is not without problems, the regulatory accounts are full of examples of price and non-price discrimination. Moreover, getting the business conditions right for the 'ladder of investment' to work has been a cumbersome process, ultimately yielding success.

Recognizing that most fiber networks are likely to be single operator monopolies, an appropriate regulatory framework is essential in assuring a competitive outcome of the transition from copper to fiber. Open access networks should be the leading theme.

Given the greater diversity in fibre compared to copper, in terms of technology options and in the business cases for high density urban compared to the less urban areas, a more diversified regulatory approach may be required. The distinction between 'white', 'grey' and 'black' zones as used in the evaluation of the applicability of state aid reflects this diversification. A similar example is the approach taken by ARCEP in France in devising specific solutions for the different techno-economic circumstances, that span from the very high density urban to the deep rural areas. See Chapter 11 in the broadband book (Lemstra and Melody, 2014).

6 Conclusions and recommendations

The central issue addressed in the research which is summarized in this report is an assessment of the impact of access regulation on fixed broadband performance, in particular on the dimensions of price and quality and where possible on investment and innovation.

To respond to this research challenge use is made of the Broadband Market Model and Broadband Performance Index, having been development as part of prior research. The BMM and BPI are derived from the data on the broadband markets in the EU Member States.

The impact of access regulation on the broadband market in the Netherlands is assessed using a hypothetical country which is in all respect equal to the Netherlands except in the absence of access regulation. The impact of access regulation on broadband performance is approximately 5 points in the value of the broadband performance index (BPI=100 is the average score for the EU16 in 2010).

When assuming this performance difference is the result of a difference in broadband uptake only, i.e. assuming that price and quality as the other constituting components of the BPI are not affected, for the Netherlands access regulation has a positive effect of 12-13% in broadband uptake at the household level.

From the qualitative research into the development of broadband access modes in three countries (UK, FR, DE) we may conclude that unbundling the local loop has increased the take-up of higher data rate Internet services and associated services bundles.

Interpreting the research results, it means that unbundling has provided a stepping stone for alternative providers to move up the 'ladder of investment' and for the large(st) scale alternative operators to reach the final rung of facilities-based competition using fibre-based access. Where the conditions were supportive, this potential for entrants to become the first movers has also played an important role in stimulating incumbents to invest in fibre access – where otherwise few incentives would exist.

In stimulating the demand for higher service levels and for innovation, access regulation, in particular unbundling, is reducing the degree of risk related to the investment in fibre. Hence, continued access regulation is important to facilitate a progressive conversion of end-users from copper to fiber.

Annex: Data for the Netherlands

	Uptake	Data rates	Revenue	Investments	HHI*	Urbanization	GDP/capita	LLU price
2008	87	34	23.08	259	39	64.17	21,583	5.32
2009	90	47	22.12	259	35	64.25	20,910	4.56
2010	92	57	20.86	259	37	64.27	20,966	4.48
2011	94	60	22.18	259	35	64.55	21,264	4.39
2012	97	66	21.34	259	37	64.59	20,804	4.46
2013	98	69	20.58	259	38	64.63	20,573	4.58

Table 11. Input for model.

Glossary

Uptake, proxy for volume: % of households with a broadband connection.

Data rates, proxy for quality: % of households with a broadband connection with a data rate equal or higher than 10 Mbit/s.

Revenue, proxy for price: average revenue by consumers for broadband connection, corrected for purchasing power.

Investments: average investments per household per year over the period 2003-2011, in USD. Additionally, for the Netherlands only: 2012 and 2013.

HHI*: sum of the squares of: (1) market share PSTN incumbent in broadband; (2) market share of cable operators; (3) market share of LLU (full and shared); (4) market share of resale and bitstream; and (5) market share of FttH, excluding FttH incumbent. Converted to a 0-100 scale.

GDP/capita: Gross Domestic Product per inhabitant, corrected for purchasing power.

LLU price: monthly price for a full unbundled local loop, based on monthly rental fee and a three year depreciation of the connection fee, corrected for purchasing power.

References

AnalysysMason (2010). Europe's digital deficit: revitalising the market in electronic communications. London: AnalysysMason.

Bain, J. S. (1956). Barriers to new competition. Cambridge, MA: Harvard University Press.

Bain, J. S. (1959). Industrial organization. New York: Wiley.

Cave, M. (2004). Making the ladder of investment operational. Brussels: European Commission.

Cave, M. (2005). Encouraging infrastructure competition via the ladder of investment: Warwick University.

Cave, M. (2006). "Encouraging infrastructure competition via the ladder of investment." Telecommunications Policy *30*(3-4): 223-237.

Cawley, R. A. (2014). The influence of European Union policies and regulation The dynamics of broadband markets in Europe: Realizing the 2020 Digital Agenda. W. Lemstra and W. H. Melody. Cambridge: Cambridge University Press.

Hair Jr., J. F., W. C. Black, B. J. Babin & R. E. Anderson (2010). Multivariate data analysis. Upper Saddle River, NJ: Peasrson Prentice Hall.

Lemstra, W. (2014). The economic benefits of access regulation. Eemnes, the Netherlands: Industry-insight BV.

Lemstra, W. & W. H. Melody, Eds. (2014). The dynamics of broadband markets in Europe - Realizing the 2020 Digital Agenda. Cambridge, UK: Cambridge University Press.

Lemstra, W. & N. Van Gorp (2013). Unbundling: Regulation is a necessary, but not sufficient conditions to reach the final rung of the investment ladder. Second Annual Conference on the Regulation of Infrastructure Industries in an Age of Convergence. Florence, Italy: Florence School of Regulation.

Porter, M. E. (1980). Competitive strategy - Techniques for Analyzing Industries and Competitors. New York: The Free Press.

Porter, M. E. (1985). Competitive advantage - Creating and sustaining superior performance. New York: The Free Press.

Voogt, B., W. Lemstra & N. Van Gorp (2014). Research building the Broadband Performance Index and Broadband Market Model. TPRC, Arlington, VA: TPRC.