

# Exploring the rationale behind broadband roll out

## A quantitative analysis

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### 1. Introduction

Discussions on broadband rollout are a recurring phenomenon and take place almost every decade. In the 1970's they had to do with cable networks (Dutton et al., 1987), in the 1980's fibre to the home was considered to be the most promising option (Egan, 1996), while in the 1990's Internet Broadband was at top of the agenda and at the moment broadband in the local loop is the topic that attracts much of the attention (Han, 2003). The term 'broadband' has, of course, changed over time. Currently, end-users and operators consider 0.5 Mbps to be broadband, whereas in scientific literature it is defined as 10 Mbps symmetric, with discussions already moving towards 100 Mbps or even 1 Gbps. However, although the meaning of the concept itself changed over time, the issues being discussed have remained basically similar: Who is going to invest? What levels of investments are required? Are new technologies going to lead to a breakthrough as a result of which promising technologies will be by-passed? How will end-user demand develop? Is it possible for local governments to subsidize broadband projects? What will be the implications for health care, safety, education, SME's et cetera?

Although Broadband has been on the academic research agenda for quite some time now, as yet this has not produced a unifying theory, combining technical, economic and policy/regulatory factors, related to an evolutionary, flexible approach of network upgrading. There is no insight into the way technological, economic or regulatory factors affect broadband rollout in the local loop, let alone that the impacts of broadband on social and economic welfare are being studied. It is assumed that the economic benefits of broadband arise from both direct and indirect sources (Telecommunication Industry Association, 2003, p.6). The technology promises to open up significant economic and social opportunities (European Commission, 2002, p. 2), such as increased worker production, job creation, wage increases, efficiency gain, the creation of new or spin-off industries and an increasing demand for computer broadband equipment (a.o. OECD, 2003, 2004; Price Waterhouse Coopers, 2004). However, direct tests of these assumptions are seldom presented. Therefore it is the objective of this paper to analyse on basis of a small scale test among stakeholders and experts in the Netherlands what might explain the possible impact of broadband roll out on increased know how of operators and on more generic social benefits. This paper is part of a research project which tries to develop and test a conceptual framework with regard to develop a generic conceptual model that will help us gain insight into critical relationships between technical, economic and policy factors and the decision to broadband infrastructure investments, implementation and broadband rollout in the local loop. This paper will first discuss a meta-analysis approach and methodology to derive the model, and secondly present results from an initial small scale test of this model.

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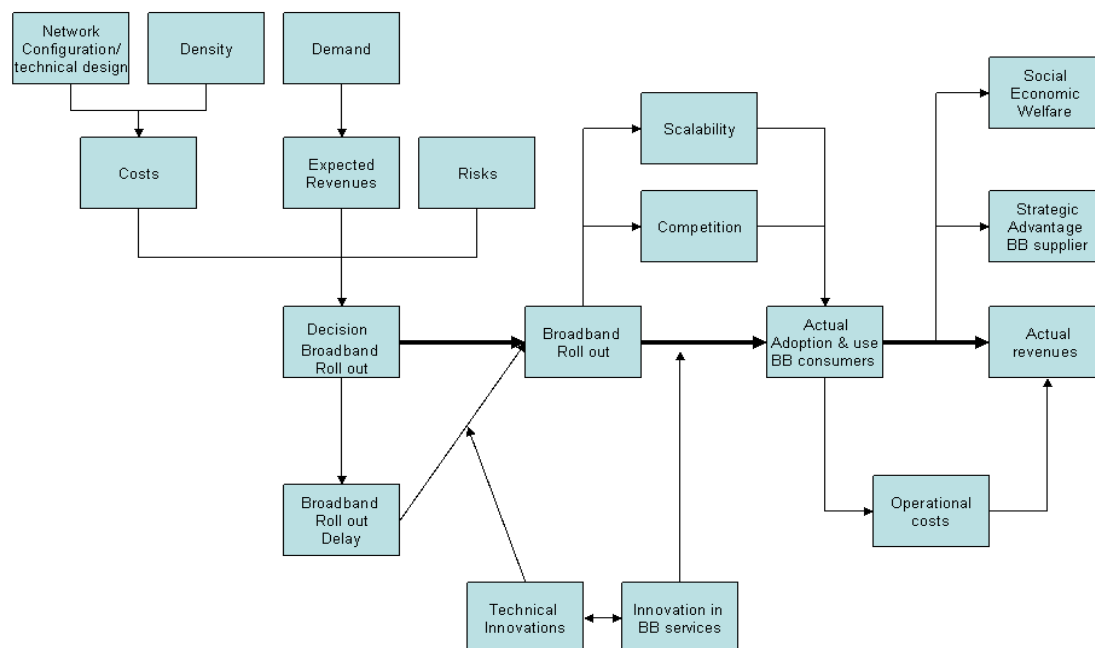
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## 2. Conceptual model

The research starts from the model as presented in figure 1. This model is based on an extensive meta-analysis (see Bouwman et al 2006). The meta-analysis approach nor the model will be discussed in detail. The Meta analysis is based on a combination of systematic literature research, content and network analysis (see for a detailed discussion Bouwman et al. 2006).



*Figure 1: Conceptual model as derived from the meta-analysis*

To test this model a questionnaire has been developed. This paper discusses the pre-test of this questionnaire. The results of the pre-test give some initial insights in the validity of the model. The measurement tools, the descriptive and causal results will be discussed. The model is characterized by four phases in which a specific variable play a core role. In the first phase the decision to roll out is key. In the second phase the actual roll out is central. In the third phase the actual adoption and use of broadband by consumers is key, and finally there is an assessment of the actual results, i.e. revenues, strategic benefits for the broadband supplier and social and economic benefits. This model is validated in two ways: based on qualitative research, i.e. interviews with executives of major telecommunication operators and network providers (see Fijnvandraat & Bouwman, forthcoming), and based on a small scale quantitative research among stakeholders and experts in the broadband domain. This paper reports the results of the small scale test.

## 3. Method

### 3.1 Questionnaire

The in this research developed questionnaire that contains about 19 questions, containing multiple items. The questionnaire was administered via the Internet, making use of Surveyworld.

### 3.2 Sample

As respondents persons were selected who are involved in advice, research or decision making with regard to broadband. There isn't a directory of decision makers, researchers and/or advisors. Therefore we had to rely on our own (perhaps some what biased) network. A number of potential respondents was approached via e-mail, asking for their corporation. If respondents agreed a link to the website where the questionnaire was published was sent to them. 60 people were invited to fill in the survey. Of the 40 persons who agreed on filling out the questionnaire 37 actually did. We are aware of the fact that this is not a random sample and we are therefore limited with regard to the external validity of the results. Nevertheless it is important to sketch the background of our respondents. Predominantly they are male: 92%. Respondents have on average 15 years experience in the telecommunication sectors. One person recently got involved in telecommunications, while another respondent has working experience of more over than 32 years. Most respondents have more than 10 years experience. Table 1 describes the functions of the respondents.

**Table 1: Functions of respondents**

1. Decision maker for a telecom infrastructure provider	3%
2. Decision maker for a cable provider	5%
3. Decision maker for another type of infrastructure provider	3%
4. Decision maker for a DSL provider	
5. Decision maker for a content provider	
6. Decision maker for a equipment supplier	8%
7. Advisor, consultant	60%
8. Regulator, or policy maker	
9. Researcher	16%
Other	5%
N= 37	100%

### 3.3 Scales

Based on the model we developed a questionnaire in which the concepts as used in the model were made operational. Due to the fact that no standard scales are available, we developed a number of new scales. We used in all scale analysis explanatory factor analysis, principal component analysis, and varimax rotation. We will first discuss a scale for technologies as such.

**Table 2: Factor Analysis relating technologies**

	I	II
1.6 New hybrid radio-optical technologies, like Hybrid Fiber Radio	.86	
1.5 New wireless optical based technologies, like free space optics	.74	
1.4 New radio based technologies, like WIMAX, or microwave or millimetre wave distribution systems	.65	
1.7 Development of new compression techniques	.62	
1.2 New coax based technologies, like Narad networks		.90
1.1 New copper based technologies, like xDSL, ethernet first mile over copper (EFMC)		.80
Eigen value	2.209	1.664
Explained Variance	37%	28%
KMO measure of sampling adequacy		.57
Cronbach's $\alpha$	.70	.71

It is striking that two scales for influence of emergent technology emerge. The first scale discusses all kind of new- mainly wireless and radio-optic- related technologies, while the second scale is more related to more familiar technologies: cable and copper. The first scale has a Cronbach's  $\alpha$  of .70. Scales with an  $\alpha$  between .70 and .80 are acceptable. The more traditional new broadband technologies load also on one factor and have an acceptable Cronbach's  $\alpha$ , even for the very small sample. Seen the fact that only a limited number of

items are included and the low number of observations, we might conclude, based on the factor analysis and the  $\alpha$ , that the items as used can be incorporated in a scale for importance of traditional technologies and a scale for the relevance of emerging technologies. The factor scores are saved using the Anderson-Rubin method (avoiding correlations between factor scores).

**Table 3: Factor Analysis technology items**

	<b>I</b>	<b>II</b>	<b>III</b>
2.8 Geographical scalability	.89		
2.9 Flexibility of technical solution	.82		
2.7 Technical scalability	.80		
2.6 Maturity of technology	.79		
2.3 Compatibility with existing network technologies	.53		
2.4 Standardization of technology or use of de facto standards		.88	
2.5 Openness of standard		.89	
2.1 Capacity: max number of Mbps			.82
2.2 Reach: maximum number of Mbps transmitted over a certain distance at a reasonable quality			.85
Eigen value	3.111	1.619	1.550
Explained Variance	34%	18%	17%
KMO measure of sampling adequacy			.66
Cronbach's $\alpha$	.83	.73	.63

Factor analysis of items discussing specific characteristics of technologies that might play an important role in the decision making result in a three factor solution. KMO is mediocre (.66). The first factor discusses scalability, flexibility, maturity, and compatibility issues, while the second scale discusses standardization and the third the trade-off between capacity and reach. Cronbach's  $\alpha$  is, with exception of the last scale (not in the .70 - .80 range), acceptable.

Based on analysis of the descriptive results (see next section) we had the strong impression that there is a mix of marketing, financial and organizational related items. Therefore we used these items originally being part of other intended scales in a factor analysis in order to see if this would result in factors, which are more eloquent. We decided to include 6.5 (marketing of new broadband services), 6.6 (marketing of end user services) and 6.9 (power of the holding/mother company), and to exclude 4.1 (Density) and 4.8 (broadband offer of competitors), in combination with items that are related to marketing issues.

**Table 4: Factor analysis market-related items**

		<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>
4.11	Expected CAPEX/OPEX	.85			
4.10	Expected revenues	.82			
6.9	Power of holding/mother company	.79			
6.6	Marketing of end user services		.91		
6.5	Marketing of new broadband access service		.89		
4.7	Marketing of broadband		.63		
4.9	Broadband offer of (local) governments			.82	
4.5	Role of lead users, for instance government			.70	
4.4	Demand aggregation			.69	
4.3	Market demand: consumers				.77
4.2	Reliability of market demand forecasts				.57
4.6	Availability of broadband services				.56
	Eigen value	2.434	2.354	1.835	1.523
	Explained Variance	20%	20%	15%	13%
	KMO measure of sampling adequacy				.57
	Cronbach's $\alpha$	.78	.79	.58	.44

If we give an interpretation of these scales, we see a trade-off between expenditures and revenues in combination with the power of the holding company cluster together, more or less suggesting that this combination deals with financial issues, in combination with a firm backing. The second scale deals with marketing issues. The third factor specifically deals with the role of lead users, demand aggregation and the role of the local government in offering broadband. The final factor deals with demand and supply of broadband end user services. Especially the two first factors and the reliability as calculated based on Cronbach's  $\alpha$  is promising. We will not include the last two scales in further analysis.

Due to the fact that we included the items 6.5, 6.6 and 6.9 in the previous factor analysis we excluded them in the next set of items. Strikingly, the factor analysis based on the remaining items show some interesting results: a factor dealing with strategy and a factor dealing with operational issues. We also excluded item 6.10 (Financial deep pockets).

**Table 5: Factor analysis organization-related items**

		<b>I</b>	<b>II</b>
6.4	(Effect on) internal processes for supplying additional equipment (set-top boxes) or services	.83	
6.7	Operations and maintenance of the network	.73	
6.3	(Effect on) internal business processes (billing, customer care)	.73	
6.11	Alternative/ competing projects within the company	.58	
6.1	Long term strategy		-.85
6.2	Impact of stakeholders on company decisions		.64
6.8	Company size		.53
	Eigen value	2.331	1.615
	Explained Variance	33%	23%
	KMO measure of sampling adequacy		.58
	Cronbach's $\alpha$	.71	.43

Noticeably is the negative loading on the second factor. Apparently, short term strategy goes together with impact of stakeholders and company size. We will not use the last scale.

The factor analysis on the risks and uncertainty items is a bit problematic, because the KMO indicator is low (.42). This is due to the limited number of observations in relation to high number of items. As a result we find a large number of factors, i.e. nine, in the first iteration. In

a second iteration we limited our analysis to four factors only, based on the decision that the Eigen Value initially is  $> 2$  (after rotation).

The first factor deals with uncertainties and risks that are related to operational and financial aspects. The second scale discusses uncertainties and risks that are related to government behaviour. The third factor deals with technology related uncertainties and risks. The last factor is not very clear. Cronbach's  $\alpha$  is low and the factor hard to interpret. We will not use this further in our analysis.

**Table 6: Factor analysis risk and uncertainty**

		<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>
9.16	Price of necessary supplies	.83			
9.14	Right timing of availability/ delivery of necessary supplies	.82			
9.15	Quality of necessary supplies	.74			
9.8	Availability of financial resources	.73			
9.9	Costs	.70			
9.3	Manageability of quality of service delivery and network	.68			
9.11	Availability of necessary human resources	.63			
9.6	Impact of new broadband networks for operational systems	.61			
9.5	Using non-standardized technologies	.53			
9.19	Unclear/ inconsistent regulation		.90		
9.20	Changes in regulation		.86		
9.21	Governmental behaviour		.83		
9.1	Broadband technology innovation and development			.80	
9.2	Availability of alternative technological solutions			.84	
9.7	Path dependency of technological choice			.59	
9.4	Future-proof-ness of technology			.56	
9.10	Revenues				.68
9.12	Effects of being first mover				.54
9.23	Development of broadband end user services				.54
9.22	Proper functioning of intelligence within the network				-.62
	Eigen value	5.078	2.726	2.522	2.153
	Explained Variance	22%	11%	11%	9%
	KMO measure of sampling adequacy				.42
	Cronbach's $\alpha$	.87	.87	.71	.56

Factor Analyses on items that might lead to a reconsideration of the decision of not rolling out broadband, didn't result in satisfactory results and are therefore excluded from further analysis.

The results of the factor and reliability analysis with regard to the actual adoption by consumers, only resulted in one factor that is meaningful and as well reaches an acceptable reliability level (see table 7). The first factor deals with competitive market offering and pricing. The second factor deals with customer satisfaction, while the third discusses critical mass. The fourth factor is hard to interpret in a sensible and coherent way.

**Table 7: Items influencing actual adoption and use of broadband.**

		<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>
12.2	Competitive offerings of other parties	.92			
12.1	Competitive pricing	.91			
12.3	Marketing campaigns focused on broadband	.60			
12.4	Satisfaction of lead users		.87		
12.5	Brand name (image)		.78		
12.6	Critical mass of available 'real' broadband services			.82	
12.7	Critical mass of consumers using broadband			.79	
12.8	Triple play concepts				.91
12.9	3rd party end user service promotion				.59
12.10	The time it takes to change to higher bandwidths (conversion rate)		.51		.52
	Eigen value	2.192	2.114	1.663	1.597
	Explained Variance	22%	21%	17%	16%
	KMO measure of sampling adequacy				.58
	Cronbach's $\alpha$	.78	.67	.55	.61

The last factor analysis discusses the dependent variables in our model. We deleted item 13.9 (Increased communication between people) from the analysis. This item originally loaded both on factor I and factor II. As a result the KMO increased from .53 to .61. Deleting item 13.11 (Decreased digital divide) would result in a slightly lower score for the KMO and a four factor-solution. The factor loadings hardly differ. Interpreting the factors, the first factor indicates increased know how and experience with broadband roll out, the second factor deals with more social-cultural consequences, including an increased digital divide. The third factor discusses improved customer attraction and satisfaction. While the last factor discusses economic benefits, direct as well as indirect benefits. With exception of the last factor: the economic benefits, we can include these scales in our analysis.

**Table 8: Factor analyses on items that can be considered to indicate dependent variables.**

		<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>	<b>V</b>
13.4	Know how on how to roll out/ upgrade broadband networks	.96				
13.5	Increased know how and learning on how to roll out, upgrade broadband networks	.94				
13.16	Stimulation for changed network configuration	.79				
13.3	Next step in broadband roll out achieved	.77				
13.6	Stimulation for further investments	.70				
13.8	Cultural consequences: high quality content		.89			
13.7	Social consequences: e-learning, distant working		.87			
13.15	Innovations in broadband services		.71			
13.10	INcreased digital divide		.58			
13.14	Expanded customer base			.81		
13.13	Image			.80		
13.12	Customer satisfaction			.59		
13.2	Strategic advantage over competitors				.84	
13.1	Clear revenues				.64	
13.11	DEcreased digital divide					.88
	Eigen value	3.800	2.627	2.188	1.549	1.272
	Explained Variance	25%	18%	15%	10%	8%
	KMO measure of sampling adequacy					.61
	Cronbach's $\alpha$	.89	.81	.70	.51	

In summary we will construct the following scales (see table 9). Scales numbers between brackets indicated that we will construct the scale but will them in further analysis for exploratory reasons.

**Table 9: Scales to be constructed for independent and dependent variables**

<b>Independent variables</b>			
<b>scale</b>	<b>label</b>	<b>items</b>	<b># of items</b>
1	New emerging broadband technology (NEBBT)	1.4-1.5-1.6-1.7	4
2	Familiar broadband technologies (FBBT)	1.1-1.2	2
3	Scalability/flexibility (Scaflex)	2.3-2.6-2.7-2.8-2.9	5
4	Standards (Standards)	2.4-2.5	2
(5)	Capacity-reach (Capreach)	2.1-2.2	2
6	Financials (finance)	4.10-4.11-6.9	3
7	Marketing (Marketing)	4.7-6.5-6.6	3
(8)	Demand (Demand)	4.4-4.5-4.9	3
9	Operations (OPS)	6.3-6.4-6.7	3
10	Risk Uncertainty Operations (RUOPS)	9.3-9.6--9.8-9.9-9.11-9.14-9.15-9.16	8
11	Risk Uncertainty government (RUGOV)	9.19-9.20-9.21	3
12	Risk Uncertainty technology (RUTECH)	9.1-9.2-9.4-9.7	4
13	Competition (Comp)	12.1-12.2-12.3	3
(14)	Customer satisfaction (CusSat)	12.4-12.5-12.10	3
(15)	Critical Mass (CriMass)	12.6-12.7	2
<b>Dependent variables</b>			
<b>scale</b>	<b>label</b>	<b>items</b>	<b># of items</b>
16	Know how BB roll out (KHBBRO)	13.3-13.4-13.5-13.6	4
17	Social Benefits (SocBen)	13.7-13.8-13.10-13.15	4
18	Commercial Benefits (ComBen)	13.12-13.13-13.14	3

Next to the computed scales we also used the factor scores from the factor analyses as an alternative in the analysis. We will discuss the results of the causal analysis after we have paid attention to the descriptive results.

#### **4. Results**

Before regression analysis will be discussed this paragraph first pays attention to the descriptive results.

##### **4.1 Descriptive data**

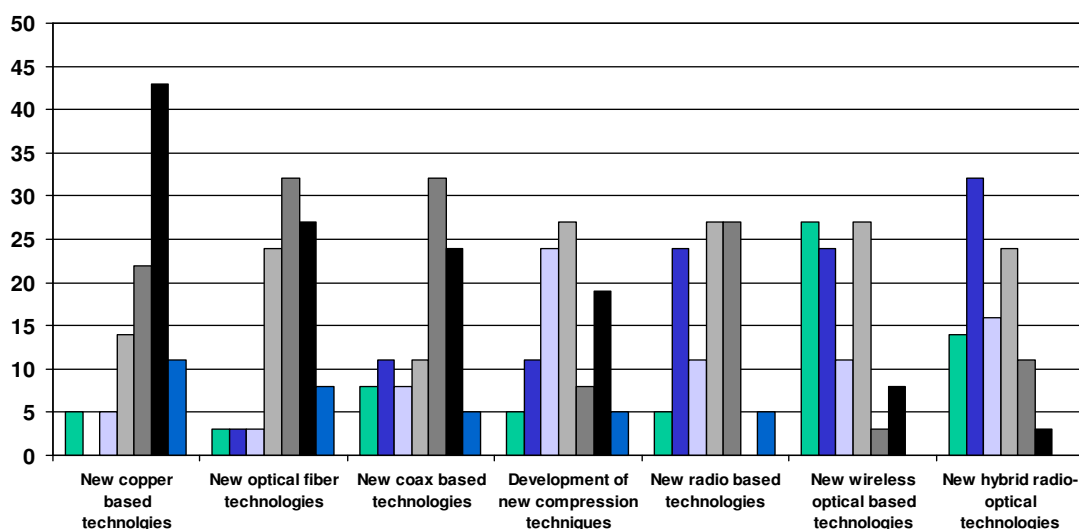
###### ***Emergent technologies***

In the first phase (the decision to roll out new broadband networks or to upgrade the current network) a number of issues play a role. In table 10 the relative importance of the impact of these issues on the actual decision to roll out or to upgrade the network is presented. The table discusses the role that emerging technologies play in the decision to roll out new broadband networks or to upgrade current networks

**Table 10: Relevance of Emergent technologies**

N =37		Mean	SD
1.1	New copper based technologies, like xDSL, etherloop, ethernet first mile over copper (EFMC)	5.19	1.450
1.3	New optical fiber technologies, like xPON ATM, Broadband, Ethernet, Gigabit (Passive Optical Networks )	4.95	1.29
1.2	New coax based technologies, like Narad networks	4.43	1.708
1.7	Development of new compression techniques	4.00	1.290
1.4	New radio based technologies, like WIMAX, or microwave or millimetre wave distribution systems	3.68	1.510
1.5	New wireless optical based technologies, like free space optics	2.78	1.566
1.6	New hybrid radio-optical technologies, like Hybrid Fiber Radio	2.95	1.353

The respondents have the highest expectations of the copper based technologies, and the least of new hybrid radio optical technologies. Next to copper based technologies, optical technologies and coax based technologies are considered to be highly relevant for decision making. It is striking that the cable based Narad networks has the highest standard deviation, indicating that the view on the impact of these technology is most controversial.



**Figure 2: Distribution of assessment of relative importance of new technologies**

Next to the network technologies compression techniques are expected to play an important role. New radio based technologies, like WIMAX or microwave or millimetre wave distribution systems, new wireless optical based technologies, like free space optics, and new hybrid radio-optical technologies, like Hybrid Fiber Radio, are controversial. In figure 2 we see that the distribution has a dip in the middle category (score 3, more precisely). These technologies are considered to be less influential, according to our respondents.

Next to the relevance of specific technologies the respondents were asked questions with regard to technology, market and policy characteristics.

**Technology characteristics**

It is important to establish the technology characteristics that play a role in the decision to roll out new broadband networks or to upgrade current networks. Clearly, characteristics like capacity and reach are considered to be the most important.

**Table 11: Relevant technological characteristics that play a role in decision to roll out**

N =37		Mean	SD
2.1	Capacity: max number of Mbps	5.89	1.048
2.2	Reach: maximum number of Mbps transmitted over a certain distance at a reasonable quality	5.65	1.136
2.7	Technical scalability	5.65	.978
2.6	Maturity of technology	5.35	1.033
2.4	Standardization of technology or use of de facto standards	5.27	1.146
2.2	Compatibility with existing network technologies	5.24	1.383
2.8	Geographical scalability	5.22	1.315
2.9	Flexibility of technical solution	4.92	1.211
2.5	Openness of standard	4.57	1.405

However some striking observations are

- The attention for compatibility and standardization,
- The limited standard deviation with regard to technical scalability, and
- The limited relevance of the flexibility of the technical solution and the openness of standards in the decision to roll out.

The last point is striking basically because one of the assumptions this research is based upon is the urge to search for flexibility, and that open standards, or at least compatibility of de facto standards is utmost relevant.

#### **Financial and market characteristics**

Which financial and market related characteristics play a role in the decision to roll out new broadband networks or to upgrade current networks? Financial arguments become very explicit: CAPEX and OPEX in relation to expected revenue have the most decisive influence (both indicated by the distribution of the variable as well as the mean). If we only observe decisive influence, expected CAPEX/OPEX is most relevant. 86% of the respondents consider, however, expected revenues to be crucial or almost crucial, while for expected CAPEX/OPEX this is 'only' 76%. The average for expected CAPEX/OPEX is higher than for expected revenues.

More market related issues like density, demand, competing offers, and availability of attractive broadband services are less relevant. What is striking is that expectations about demand aggregation, the role of local government in offering capacity, and of lead users, such as government institutions are higher than these from marketing efforts from network operators themselves. Apparently, expectations about the marketing effort and/or effectiveness of marketing from operators are not so high.

**Table 12: Relevant market characteristics that play a role in decision to roll out**

		Mean	SD
4.10	Expected revenues	6.35	.789
4.11	Expected CAPEX/OPEX	6.19	1.126
4.1	Density (number of -potential- customers per square km)	5.81	1.309
4.8	Broadband offer of competitors	5.78	.976
4.3	Market demand: consumers	5.76	1.011
4.6	Availability of broadband services	5.27	1.194
4.4	Demand aggregation	4.84	1.365
4.2	Reliability of market demand forecasts	4.65	1.274
4.9	Broadband offer of (local) governments	4.51	1.627
4.7	Marketing of broadband	4.33	1.434
4.5	Role of lead users, for instance government	4.14	1.512

There are different views on the leading role of the local government. The standard deviation is the highest for all the variables included to discuss market characteristics. It is remarkable that the mean is lower for these variables than for intention demand aggregation and reliability

of market demand. However, some respondents hold the opinion that the offer of the local government is rather decisive, as can be concluded from the high standard deviation.

### ***Organizational characteristics***

Next to technical, financial and market related characteristics we assume that also organizational issues are crucial. Basically we are interested in resources and capabilities, and the possible consequences for internal processes that might hinder the roll out of broadband. In this group of items the central question is: Which organizational factors play a role in the decision to roll out new broadband networks or to upgrade current networks? Again financial arguments are prominent. Deep pockets appear to be crucial: about 75% of the respondents consider this to be an almost crucial or a crucial influence. The average (5.84) is high for a 7-point scale. Strategy and the role of the holding of which operators might be a part, are also important factors.

Again marketing, in this case marketing of broadband services, is not considered to be an overly decisive factor.

Potential effects on internal processes either for internal logistics in order to provide customers with set top boxes, or the effects for billing and customer care are considered to be of a limited influence.

***Table 13: Relevant organizational issues that play a role in decision to roll out***

		<b>Mean</b>	<b>SD</b>
6.10	Financial deep pockets of company	5.84	1.118
6.1	Long term strategy	5.62	1.210
6.9	Power of holding/mother company	5.30	1.331
6.2	Impact of stakeholders on company decisions	5.11	1.195
6.7	Operations and maintenance of the network	4.59	1.257
6.11	Alternative/ competing projects within the company	4.51	1.677
6.5	Marketing of new broadband access service	4.41	1.423
6.6	Marketing of end user services	4.32	1.564
6.8	Company size	4.24	1.442
6.4	(Effect on) internal processes for supplying additional equipment (set-top boxes) or services	3.95	1.290
6.3	(Effect on) internal business processes (billing, customer care)	3.68	1.396

### ***Risks and Uncertainties***

An important issue in the decision making is the assessment of risks and the question how to deal with them. Risks and uncertainty can be divided into two groups: Risks and uncertainties due to imperfect knowledge (which can be reduced by gaining more knowledge on the subject) and risks and uncertainties which are inherent to characteristics of the environment (which cannot be reduced by gaining more knowledge about the subject). We asked respondents to indicate which risks and uncertainties are due to imperfect knowledge and which are inherent to the environment. Least uncertain is the way broadband is going to impact internal operating systems, and other issues that are under control of the provider of broadband, like quality of service, costs, quality of necessary supplies. Least certain are respondents about government behaviour. Even consumer behaviour is not as unpredictable as the behaviour of government.

**Table 14: Risk and uncertainties in perspective**

		Risks and uncertainties are due to imperfect knowledge	Risks and uncertainties are due to characteristics of the environment
8.6	Impact of new broadband networks for operational systems	78	22
8.3	Manageability of quality of service delivery and network	75	25
8.9	Costs	70	30
8.22	Proper functioning of intelligence within the network	70	30
8.15	Quality of necessary supplies	70	30
8.7	Path dependency of technological choice	65	35
8.16	Price of necessary supplies	65	35
8.2	Availability of alternative technological solutions	62	38
8.5	Using non-standardized technologies	57	43
8.14	Right timing of availability/ delivery of necessary supplies	57	43
8.1	Broadband technology innovation and development	54	46
8.11	Availability of necessary human resources	54	46
8.8	Availability of financial resources	49	51
8.4	Future-proof-ness of technology	46	54
8.10	Revenues	43	57
8.12	Effects of being first mover	38	62
8.23	Development of broadband end user services	38	62
8.17	Consumer preferences/ characteristics	35	65
8.13	Actions of potential or actual competitors	24	76
8.20	Changes in regulation	22	78
8.18	Development of demand	19	81
8.19	Unclear/ inconsistent regulation	16	84
8.21	Governmental behaviour	14	86

A second aspect of risks and uncertainty is their level of predictability. Risks and uncertainties can be predictable at several levels, varying from a predictable future to true ambiguity (completely unpredictable). Here it becomes clear that the level of unpredictability is higher for demand, as well as for competitor's behaviour. In terms of unpredictability it is interesting to look at the standard deviation: which indicates the lack of coherence in opinions. Strikingly it is availability of financial resources on which respondents agree the least. Apparently, finding the proper available financial resources is an important issue on which stakeholders tend to differ in opinion.

**Table 15: Degree of unpredictability for relevant topics**

		Mean	SD
9.18	Development of demand	2.89	.737
9.17	Consumer preferences/characteristics	2.70	.740
9.23	Development of broadband end user services	2.65	.716
9.13	Actions of potential or actual competitors	2.62	.639
9.10	Revenues	2.59	.725
9.20	Changes in regulation	2.59	.798
9.5	Using non-standardized technologies	2.57	.835
9.19	Unclear/ inconsistent regulation	2.54	.836
9.12	Effects of being first mover	2.51	.692
9.21	Governmental behaviour	2.49	.692
9.4	Future-proof-ness of technology	2.49	.692
9.7	Path dependency of technological choice	2.46	.691
9.2	Availability of alternative technological solutions	2.16	.727
9.8	Availability of financial resources	2.11	1.022
9.1	Broadband technology innovation and development	2.08	.759
9.22	Proper functioning of intelligence within the network	2.03	.687
9.14	Right timing of availability/ delivery of necessary supplies	2.03	.799
9.6	Impact of new broadband networks for operational systems	1.97	.726

9.11	Availability of necessary human resources	1.92	.894
9.16	Price of necessary supplies	1.92	.682
9.15	Quality of necessary supplies	1.89	.737
9.9	Costs	1.84	.834
9.3	Manageability of quality of service delivery and network	1.70	.777

### ***Investment methods***

Another important issue is which investment methods are most appropriate to support the decision to roll out a new broadband network or to upgrade the current network. Cost benefits and return on investment are considered to be suitable. The real options method is apparently a less familiar tool. We are wondering if the fact that people don't consider real options is due to lack of knowledge of this method. The fact that the neutral category is the modus for this variable is typical.

**Table 16: Appropriateness of investment methods**

		<b>Mean</b>	<b>SD</b>
10.1	Cost- benefit analysis (assessment of CAPEX (Capital expenditures) and OPEX (operational expenses) and revenues)	3.76	1.090
10.2	Return on investment (ROI)	3.81	.967
10.3	Net present value approach (NPV)	3.68	.973
10.4	Real options analysis approach (ROA)	3.41	.956
10.5	Other		

Cash flow methods are mentioned twice as a potential other method, other option methods as well as risk (venture) capital are mentioned only once.

### ***Reconsidering the decision to roll out***

The outcome of the first phase is the decision to roll out new broadband network / upgrade the current network, or to delay this network roll out/ upgrade. In case a decision for upgrading/ roll out has been delayed, a number of issues might play a roll in reconsidering this decision. We asked respondents to indicate to what degree the issues like changes in consumer demand, changes in competitor behaviour, et cetera have an impact on reconsidering the initial decision to delay.

**Table 17: Factors influencing the reconsidering of the decision to delay the roll out of broadband.**

		<b>Mean</b>	<b>SD</b>
11.3	Changing consumer demand	4.22	.854
11.4	Changing competitor behaviour	4.08	.862
11.2	Innovations in broadband services requiring high bandwidth	3.92	1.010
11.6	Disappointing revenues	3.81	1.101
11.7	Internal business strategy	3.76	0.925
11.1	Technical innovations	3.46	.989
	Changed government behaviour	3.35	1.006

It is remarkable that the factor that is considered to be the least predictable, i.e. government behaviour has also the least impact on reconsidering the decision to delay roll out of the network. Although the behaviour of the government isn't predictable, it has the least impact.

### ***From roll out to actual adoption and use***

Assuming that network roll out or upgrade is taking place, the real viability of the network depends on the decision to adopt and use broadband networks. The critical mass of consumers using broadband plays a very decisive role. The same goes for competitive pricing and offerings from competitors. The critical mass of real broadband services is another factor to be taken into account. Again the least is expected from marketing.

**Table 18: Factors influencing the viability of broadband roll out**

		<b>Mean</b>	<b>SD</b>
12.7	Critical mass of consumers using broadband	5.97	1.236
12.1	Competitive pricing	5.89	.994
12.2	Competitive offerings of other parties	5.78	.834
12.6	Critical mass of available 'real' broadband services	5.32	1.248
12.4	Satisfaction of lead users	4.86	1.294
12.8	Triple play concepts	4.57	1.501
12.3	Marketing campaigns focused on broadband	4.78	.976
12.10	The time it takes to change to higher bandwidths (conversion rate)	4.59	1.117
12.5	Brand name (image)	4.35	1.549
12.9	3rd party end user service promotion	4.16	1.323

### **The impact of broadband roll out**

In the final question on broadband roll out, we discussed the importance of the outcomes and effects of network upgrade/ broadband roll out. We asked questions about the tangible and intangible benefits and/or (social) effects that are a result of broadband roll out/network upgrade. It is clear that economic benefits play a crucial role. Directly or indirectly, as mediated by expanding customer base or customer satisfaction. Know how, experience and a next step, being achieved, are the least relevant. Experience and increased knowledge are not evaluated positively. Social outcomes take a middle position.

**Table 19: Outcomes of broadband roll out**

		<b>Mean</b>	<b>SD</b>
13.1	Clear revenues	6.16	.928
13.14	Expanded customer base	6.08	.937
13.2	Strategic advantage over competitors	6.00	.943
13.12	Customer satisfaction	5.51	1.121
13.15	Innovations in broadband services	5.30	.996
13.13	Image	5.22	1.058
13.3	Next step in broadband roll out achieved	4.59	1.189
13.11	DEcreased digital divide	3.38	1.800
13.6	Stimulation for further investments	4.49	1.446
13.8	Cultural consequences: high quality content	4.32	1.600
13.4	Know how on how to roll out/ upgrade broadband networks	4.03	1.554
13.7	Social consequences: e-learning, distant working	4.11	1.663
13.9	Increased communication between people	4.05	1.666
13.5	Increased know how and learning on how to roll out, upgrade broadband networks	3.95	1.413
13.16	Stimulation for changed network configuration	3.65	1.418
13.10	INcreased digital divide	3.19	1.664

## **4.2 Causal modelling**

In order to analyse the causality between our core concepts, we made use of step-wise regression analysis. Although we have a small sample (N = 37), and we therefore might assume that even on random data, we could expect an R of .5 and an R<sup>2</sup> of .25, our results shows significant better results. Operations is a very important predictor for learning effect with regard to Broadband roll out, i.e. one of the three dependent variables we could distinguish on bases of factor analyses of the 'results' items. Operations refer to effects on internal processes, billing customer care, supplying additional equipment. We achieve even better results, an additional 12 %, when we include new emerging technologies. New emerging technologies discuss other technologies than copper- or coaxial based technologies. The explained variance even increases to 59% in case we include marketing. Marketing is based on marketing of broadband, access and end-user services. Competition

deals with pricing, offering of other parties and marketing campaigns focussed on broadband. The last factor has a negative effect. Nevertheless the explained variance gains an additional 5% to 65%.

**Table 20: Step wise regression Dependent variable Increased Know how on Broad Band roll out, based on additive scale.**

	<b>Model 1</b>	<b>Model 2</b>	<b>Model 3</b>	<b>Model 4</b>
Operations (6.3-6.4-6.7)	.59***	.65***	.54***	.52***
New emerging broadband technology (NEBBT) (1.4-1.5-1.6-1.7)		.35*	.38**	.37**
Marketing (4.7-6.5-6.6)			.37**	.38**
Competition (12.1-12.2-12.3)				-.23*
R	.591	.683	.770	.805
R <sup>2</sup>	.349	.466	.594	.648
Model fit	F = 18.219	F = 14.419	F = 15.576	F = 14.862
	df 34,1	df 33,2	df 32,3	df 31,4
	p <.001	p<.001	p <.001	p<.001
Dobin Watson	1.685			
Collinearity statistics	1.000	.972.	.896	.891
Tolerance		.972	.962	.961
			.904	.904
				.993
VIF	1.00	1.029	1.115	1.123
		1.029	1.038	1.041
			1.106	1.106
				1.008

We repeated the analysis with the factor scores instead of the constructed additive scales. Nevertheless the results are similar. We only see two models, including operations and competition. The results for the additive scales are confirmed if we use factor scores. However, due to the finer granularity of factor scores, the effects of new emerging technologies and marketing are less explicit.

If we take a look at the excluded variables from the second model we find that familiarity of broadband technologies (FBBT) almost has a significant, but negative effect. Partial correlations = -.32, p = .063, and marketing has a positive effect: .298, p = .087.

**Table 21: Step wise regression Dependent variable Increased Know how on Broad Band roll out, based on factor scores**

	<b>Model 1</b>	<b>Model 2</b>
Operations (6.3-6.4-6.7)	.61***	.55***
Competition (12.1-12.2-12.3)		-.0.30*
R	.60	.674
R <sup>2</sup>	.369	.455
Model fit	F = 19.873, df 34,1, p <.001	F = 13.765, df 33,2, p <.001
Dobin Watson		1.698
Collinearity statistics	1.000	.963.
Tolerance		.963
VIF	1.00	1.038
		1.038

For the second dependent variable, social benefits of broadband roll out, we find two models for the additive scales. In this model we see the prominent presence of standards and demand as predictors for social benefits of broad band roll out. If we look at the excluded predictors than we see Risk and Uncertainty related to operations as a potential valuable

predictor (partial correlations = .30, p = .081), as well as competition: partial correlation .31, p =.075.

**Table 22: Step wise regression Dependent variable Social Benefits Broad Band roll out, based on additive scale.**

	<b>Model 1</b>	<b>Model 2</b>
Standards (2.4-2.5)	.61***	.55***
Demand (4.4-4.5-4.9)		-.0.30*
R	.488	.610
R2	.238	.372
Model fit	F = 10.648,df 34,1, p <.001	F = 9.765, df 33,2, p<.001
Dobin Watson		1.685
Collinearity statistics	1.000	.997.
Tolerance		.997
VIF	1.00	1.003
		1.003

The model for the factor scores is comparable. Explained variance ( $R^2$ ) is 27 %, the only predictor that has enough predictive power is standards (>53, p <.001). Customer satisfaction might be a potential predictor (partial correlations = .289, p = .092).

The last dependent variable, i.e. commercial benefits, cannot be predicted based on the additive scales as constructed. If we use factor score we find competition as the sole predictor for commercial benefits of broadband roll out (explained variance  $R^2 = 12$  %, F = 4.683, df 1, 34, p <.05). Competition has a Beta (standardized) of .35, p <.05. Operations is a predictor that comes close: partial correlations = .286, p = .096).

## 5. Conclusions and limitations

Although we have a very small sample we have some interesting and promising results. First of all experts and stakeholders see more future in copper-based technologies in an evolutionary approach. Modern advanced technologies are not appreciated, yet. With regard to the characteristics of technology capacity and reach are the two most relevant characteristics. Flexibility of the technological solution is considered the least relevant. This is striking, because the preference for innovations in copper technologies to revolutionary optical technologies like FttH implies an implicit choice for incremental upgrading and for that reason for flexibility and for an evolutionary upgrade strategy. The decision to roll out is primarily based on the expected revenues in combination with the expected CAPEX/OPEX. Deep pockets of the company who invest is also a relevant criterion, as well as a long term strategy. Operational issues are the least relevant. Investment assessment methods used are rather traditional. The lack of preference for Real Options, which are very suitable for infrastructure investments with high risks and high uncertainties, is striking. With regard to risks and uncertainty there is a difference between risks and uncertainties that are dependent on availability of proper knowledge. Information on government behaviour is the hardest to manage, followed by user demand. However, the level of ambiguity is the highest for user demand, and less for government behaviour. Changing user demand can trigger roll out of broadband or revitalize roll out projects, more than technological innovations. The viability of broadband projects is highly dependent on a critical mass of users, competitive pricing and the availability of a critical mass of real broadband services. The outcome of the decision to roll out broadband is assessed in terms of clear revenues, expanding customer base and strategic advantage.

Although the outcomes are clearly defined, it is hard to pinpoint the best way to achieve this outcome. It is striking that the causal analysis in which the economic benefits are the dependent variable can only be predicted on basis of competitor behaviour. This implies more

or less that stakeholders are more looking to each other than develop their own visions and approaches.

Our research has some important limitations. We used only a sample of Dutch stakeholders. The sample size is limited. Therefore we have to be careful in drawing conclusions. The external validity is limited, although we have to be aware that the population of knowledgeable stakeholders in itself isn't very large in itself. Furthermore during the analysis we weren't able to replicate the phasing more explicitly due to the fact that we didn't define a clear dependent variable for each phase. In future research we therefore will expand our sample to an international population and we will more clearly incorporate variables that allows us to test the causal model for each specific phase.

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