

THE IMPACT OF BROADBAND ON JOBS AND THE GERMAN ECONOMY

by

Prof. Dr. Raul L. Katz¹,
Dr. Stephan Vaterlaus, Patrick Zenhäusern,
Dr. Stephan Suter and Dr. Philippe Mahler²

Abstract

This study quantifies the macroeconomic impact of investment in broadband technology on employment and output of Germany's economy. Building on the "National Broadband Strategy" announced by the German government, two sequential investment scenarios (2014 and 2020) are defined. The economic impact of broadband development over a ten year period in Germany amounts to 968,000 additional jobs and EUR 170.9 billion in incremental output.

Keywords

Telecommunications, Broadband, Infrastructure, Growth, Employment, Input-Output Analysis, German Economics

¹ Dr. Raul Katz is Adjunct Professor in the Division of Finance and Economics at Columbia Business School, Director of Business Strategy Research at the Columbia Institute for Tele-Information, and President of Telecom Advisory Services, LLC.

² Dr. Stephan Vaterlaus is President of Polynomics AG. Patrick Zenhäusern, Dr. Stephan Suter and Dr. Philippe Mahler are also members of Polynomics AG.

EXECUTIVE SUMMARY

This study quantifies the macroeconomic impact of investment in broadband technology on employment and output of Germany's economy. In times of economic crisis, national governments are looking for immediate policy actions to deal with rising unemployment and declining output. Infrastructure investments have been singled out in the economic and policy debate as being tools of recovery. In this respect, broadband technology is key to providing one of the needed economic stimuli, not only in terms of construction, but also resulting in longer term externalities, such as accelerated innovation and new business creation.

Two sequential investment scenarios are analyzed: the first is based on the "National Broadband Strategy" announced by the German Government which aims at ensuring that 75 percent of German households have access to a broadband connection of at least 50Mbps by 2014. The second scenario (labeled "ultra-broadband" covering 2015-2020) defines the investment required to provide to 50 percent of households with at least 100 Mbps and another 30 percent with 50 Mbps by 2020.

It is estimated that fulfilling these targets will require an investment of 20.2 billion Euros up to 2014. This will allow covering all unserved households (730,000), upgrading households currently having sub-par access to download speeds up to 1 Mbps (2,8 million), provide 50 percent of German households with VDSL service and 25 percent of households with FTTH. Beyond these short-term objectives, the deployment of ultra-broadband fiber infrastructures in subsequent years (2015-2020) will entail making FTTH available to an additional 25 percent of households (an ambitious but realistic scenario), which will require an incremental 15.7 billion Euros of infrastructure investments.

These investments will generate both a substantial number of jobs and an incremental increase of the GDP. Based on input-output tables from the German Federal Statistical Office, and relying on input-output analysis, the network construction has been estimated to create 304,000 jobs (or 61,000 per year between 2010 and 2014), and additional 237,000 jobs (or 40,000 jobs annually between 2015 and 2020). Further, once the broadband infrastructure is deployed, additional job creation will be triggered by network externalities, such as enhanced innovation resulting in new services, additional business growth, and the attraction of jobs from other countries as a result of a recomposition of industrial value chains. Based on regression-based forecasting, it is estimated that 427,000 jobs will be created. As a result, the accumulated number of jobs over a ten year period (2010-2020) will reach 968,000 in Germany.

EMPLOYMENT IMPACT FOR GERMANY
(in thousand)

	Network Construction				Network externalities	Total
	Direct	Indirect	Induced	Total		
2010-14	158	71	75	304	103	407
2015-20	123	55	59	237	324	561
Total	281	126	134	541	427	968

In output terms, the construction of the broadband network will result in 18.8 billion Euros in additional GDP (2010-2014) and 14.6 billion Euros, in the subsequent phase of ultra-broadband rollout (2015-2020). The cumulative increase of GDP of 33.4 billion Euros between 2010 and 2020 means that for each Euro invested in constructing the broadband network, the value added amounts to 0.93 Euros. In addition, the resulting incremental broadband penetration will add 137.5 billion Euros to the GDP.³ Over a ten year period (2010-20), this results in 170.9 billion Euros of additional GDP (0.60 % annual GDP growth) in Germany. Of these, 108.8 billion Euros will be generated between 2015 and 2020.

GDP IMPACT ON THE GERMAN ECONOMY
(in billion Euros)

	Network Construction	Network Externalities	Total	Percentage Change
2010-14	18.8	43.3	62.1	0.49 %
2015-20	14.6	94.2	108.8	0.70 %
Total	33.4	137.5	170.9	0.60 %

Based on these results, it becomes obvious that the National Broadband Strategy and the subsequent ultra-broadband evolution significantly improve employment and economic growth in Germany. Broadband represents a high priority stimulus program the government needs to rely on to improve the current outlook and create a solid foundation for future growth. Since roll-out of broadband infrastructure is primarily based on private investment, the Government's commitment to a newly designed growth and innovation-gearred regulation is critical. In that sense, the formulation of a framework which allows for appropriate risk diversification between investors and non-investors as well as improved a-priori planning and legal certainty for investing companies represents a key element of the needed investment-friendly environment.

³ This number results from applying the calculated incremental GDP annual growth rate due to network externalities to Germany's 2008 estimated GDP of 2,489 billion Euros for the years between 2013 and 2020.

1. INTRODUCTION

In times of economic crisis, national governments look for policy actions that can rapidly deal with rising unemployment and declining output. Infrastructure investments have been identified as key tools in the economic and policy debate to fight the ongoing crisis. This is partly because of the direct and short-term labor effects in the building and construction industries, sectors that have been greatly affected by the economic crisis. On the other hand, construction of network based infrastructure, such as transportation routes and broadband networks carry substantial spillovers in terms of improving efficiencies and stimulating innovation in the production sector of the national economy. It is for these reasons that several governments (United States, Germany, Australia, Portugal, Singapore, and Ireland, among others) have decided to increase their investment in infrastructure, such as the construction of roads, bridges and telecommunications.

In particular, the economic benefits of deployment of broadband infrastructure are significant. In information-intensive economies, such as Germany where 54% of the economically active workforce is considered to be information-based (from IT professionals to content producers to clerks) (Katz, 2009a), the construction of infrastructure to facilitate the flow of information in the economy can have an impact on productivity, innovation and business growth. In fact, studies point out that rankings in national competitiveness and network readiness are directly correlated. If network readiness is a result of network technology investment, one could argue that an increase in broadband investment should impact Germany's overall competitiveness.

The objective of this study is to estimate the impact of broadband infrastructure investments on the German economy, in particular on employment and output. This study analyzes the potential effects of Germany's "National Broadband Strategy" which is expected to be completed by 2014 (BMWi 2009a). In addition, the study assesses the economic impact of a second phase of ultra-broadband evolution, which results in a more advanced broadband network and is assumed to be completed by 2020. Along these timelines, the study tackles the costs of deploying broadband due to the National Broadband Strategy and due to ultra-broadband evolution in Germany. It estimates the number of jobs created during the roll-out phase of the National Broadband Strategy and incremental employment effects thereafter. Furthermore, the economic effects of broadband deployment are estimated in terms of domestic value added resulting from network construction and incremental GDP growth.

The study relies on a three-step-approach. First, the total costs for broadband deployment in Germany by 2014 and 2020 are determined. Second, by relying on input-output tables generated by the German Statistical Office and utilizing input-output analysis, the workforce which will be created by the roll-out of modern broadband is estimated. Third, regression-based forecasting to estimate the externalities of broadband deployment is used.

The study begins with an assessment of the research literature on the economic impact of broadband. Based on the identification of what it is concluded to be the more rigorous theoretical frameworks and methodologies, it then presents the methodology and supporting data (see appendices). In the following section, an estimation of investment required to deploy broadband technology to meet the targets outlined in the National Broadband Strategy and in the ultra-broadband evolution long term view is made. With that basis, the estimates of economic impact, both in terms of jobs and output (value added growth), of implementing the Strategy are presented in the final section.

2. THE RESEARCH LITERATURE ON THE ECONOMIC IMPACT OF BROADBAND:

The study of the relationship between broadband and employment creation has produced few empirically driven pieces of research. Two types of studies have been conducted so far: a) national cross-sectional research focused on identifying employment and/or output effects on national economies, and b) regional studies oriented to the assessment of broadband economic effects at the regional level. Two methodologies are primarily used in these studies: input-output analysis and multivariate regression modeling (see figure 1).

Figure 1. Studies of the Employment Impact of Broadband

	National economies	Regional Economies
Input-Output analysis	<ul style="list-style-type: none"> • Crandall et al. (2003) • Katz et al. (2008) • Atkinson et al. (2009) • Katz et al. (2009) 	<ul style="list-style-type: none"> • Strategic Networks Group (2003)
Multivariate Regression Modeling	<ul style="list-style-type: none"> • Lehr et al. (2006) • Crandall et al. (2007) • Thompson et al. (2008) 	<ul style="list-style-type: none"> • Kelly (2003) • Ford and Koutsky (2005)

All studies conclude that, while it is difficult to measure and establish causality, broadband technology contributes to the creation of employment. Furthermore, some studies differentiate two types of employment impact of broadband:

- First impact: Jobs created to deploy the infrastructure, and
- Second impact: Employment generated as a result of network externalities on other sectors of the economy. The results of the research to date in these two areas will be reviewed in turn.

First, it is obvious that network construction will result in some level of job creation, in terms of direct effects. The four national studies that attempted to estimate this amount are Crandall et al. (2003), Katz et al. (2008), Atkinson et al.

(2009), and Katz et al. (2009). They all relied on input-output matrices⁴ and assumed an amount for capital investment: US-Dollars 63 billion (needed to reach ubiquitous broadband service) for Crandall et al. (2003), CHF 13 billion for Katz et al. (to build a national multi-fiber network for Switzerland), US-Dollars 10 billion for Atkinson et al. (2009) (as a US broadband stimulus), and US-Dollars 7.2 billion for Katz et al. (US Broadband stimulus plan approved by the US Congress in February 2009).

All studies that have relied on input-output analysis have calculated multipliers, which measure the total employment change throughout the economy resulting from the deployment of a broadband network. Beyond network construction (direct employment effects), broadband construction has an employment effect at two additional levels. Following the sector interrelationships of input-output matrices, network deployment will result in indirect job creation (incremental employment generated by businesses selling to those that are directly involved in network construction) and induced job creation (additional employment induced by household spending based on the income earned from the direct and indirect effects).

The interrelationship of these three effects is measured through multipliers, which quantify the total employment change throughout the economy from one unit change on the input side. Type I multipliers measure the direct and indirect effects (direct plus indirect divided by the direct effect), while Type II multipliers measure Type I plus induced effects (direct plus indirect plus induced divided by the direct effect). While multipliers from one economy cannot be applied to another one, it is useful to observe the summary results of multipliers of the four input-output studies:

⁴ From the Bureau of Economic Analysis for the US studies or the national statistics authorities of Switzerland for the Swiss study. In addition, the Strategic Networks Group (2003) also relied on input-output tables, although in this case they were the regional ones created by Canada's statistics agency, Statistics Canada.

Figure 2. Breakdown of Employment Multipliers of Studies relying on Input-Output Analysis

	Geography	Direct Effects	Indirect Effects	Induced Effects	Total
Crandall et al. (2003)	US	1.00	1.17		2.17
Strategic Analysis Group (2003)	Canadian county	1.00	1.03	1.4	3.42
Katz et al. (2008) (*)	Switzerland	1.00	0.38	N.A.	1.38
Atkinson et al. (2009) (**)	US	1.00	1.47	1.13	3.60
Katz et al. (2009)	US	1.00	0.83	1.59	3.42

(*) This study calculates only direct and indirect effects; induced effects were not calculated

(**) Atkinson et al. (2009) multipliers have been recalculated by relying on Bivens (2003), which the authors cite as their source.

Although multipliers from one economy should not be extrapolated to another, their comparison can be useful in terms of their wide variance. According to the sector interrelationships depicted above, a European economy appears to have lower indirect effects than the US economy. Furthermore, the decomposition also indicates that a relatively important job creation effect occurs as a result of household spending based on the income earned from the direct and indirect effects.

Beyond the employment and output impact of network deployment, researchers have been focusing on a set of network externalities variously categorized as "innovation", or "network effects" (Atkinson et al., 2009). In general, studies based on regression analysis do not differentiate between construction and spill-over effects. However, after examining the conclusions of the regression studies, the evidence regarding externalities appears to be quite conclusive. First, broadband spill-over employment effects are not uniform, they tend to concentrate in service industries (e.g., financial services, health care etc.), although Crandall et al. (2007) identified an effect in manufacturing as well. Second, two studies (e. g. Lehr et al., 2006; Thompson et al., 2008) point to the productivity impact of broadband, which can result in a net reduction in employment resulting from capital-labor substitution.

Beyond, what can be inferred as "network effects" from the regression studies, two types of approaches have been utilized to isolate this impact: 1) top-down based on "network effect" multipliers, and 2) bottom-up estimates based on extrapolating findings of microeconomic analysis of impact of broadband on efficiency and effectiveness at the firm level.

Within the first group, key studies are Pociak (2002) and Atkinson et al. (2009). Both studies relied on an estimated "network effect" multiplier, which is applied to

the network construction employment estimates.⁵ While the top-down approach allows to rapidly estimating a number, it does not have a strong theoretical support. Network effects are not built on interrelationships between sectors. They refer to the impact of the technology on productivity, employment and innovation by industrial sector.

On the other hand, only one bottom-up study of network effects has been identified (Fornefeld et al., 2008). This study identified three types of impact of broadband on employment: first, the acceleration of innovation resulting from the introduction of new applications and services (with the consequent creation of employment); second, the improvement of productivity as a result of the adoption of more efficient business processes enabled by broadband; and third, the possibility of attracting employment from other regions as a result of the ability to process information and provide services remotely. These three effects act simultaneously, resulting in contradictory impact on employment. The increase in broadband penetration can have a positive impact on productivity, contributing as a consequence to a negative effect on employment.⁶

However, this negative effect is compensated by the increase in the rate of innovation and services, thereby resulting in the creation of new jobs. Finally, the third effect may be comprised by two countervailing trends. On the one hand, a region that increases its broadband penetration can attract employment displaced from other regions by leveraging the ability to relocate functions remotely. On the other hand, by increasing broadband penetration, the same region can lose jobs by virtue of the outsourcing effect. While a better understanding of these combined "network effects" is being gained, the research is still at its initial stages of quantifying the combined impact. The study by Fornefeld et al. (2008) is probably the first attempt to build a causality chain applying ratios derived from micro-economic research to estimate the combined impact of all effects.

While the research of broadband impact on employment is somewhat limited, the literature regarding the impact on economic output of broadband (primarily of Information and Communications Technology (ICT) is quite extensive. As in the case of impact on employment, studies tend to point out the existence of a causal relationship.

A comparison study of OECD countries relating the impact of ICT capital accumulation on output growth reveals that ICT contributed between 0.2 and 0.5 percentage points between countries in the last two decades (Coleccia and

⁵ For example, Pociak relied on two multiplier estimates (an IT multiplier of 1.5 to 2.0 attributed to a think tank and another multiplier of 6.7, attributed to Microsoft) and calculated an average of 4.1. Similarly, Atkinson et al. (2009) derived a multiplier of 1.17 from Crandall et al. (2003).

⁶ This effect was alluded to by Lehr et al. (2006) when they said that "broadband might facilitate capital-labor substitution, resulting in slower job growth", and is also alluded to by Thompson et al. (2008) as they mention that "there may be a substitution effect between broadband and employment."

Schreyer, 2002). The authors show that in the second half of the 1990s the impact of ICT investments on economic growth rose to 0.3 to 0.9 percentage points. Among other results they find that not only in the US ICT investments have a strong impact on economic growth but that the possible effect of ICT investments depends largely on the industry framework in the respective country. In this study a big gap between the US and EU countries in the contribution of ICT investments to economic growth is identified. Based on this finding, a series of studies investigate the ICT different impact on economic growth between the US and EU countries. For example, a study relating labor productivity growth on ICT investments on an industry level shows that the faster productivity growth in the US compared to EU countries can be attributed to a larger employment share in the ICT producing sectors and a faster growth in industries that intensively use ICT (van Ark et al., 2003). The same authors show that the key difference between the growth impact of ICT in the US and the EU are the sectors heavily using ICT services. In the second half of the decade the US has a rapid increase in productivity growth whereas the growth in the EU countries stalled (van Ark et al., 2002).

To sum up, the literature on the economic impact of broadband provides solid grounding on the framework and methodology to estimate the impact on employment and output of network construction. Input-output analysis is analytically rigorous and its application to the issue under consideration has been sufficiently codified. With regard to the externalities estimations, it is necessary to develop a methodology that goes beyond the top-down multipliers and relies on econometric modeling. This approach will require handling relative large time series with a high level of disaggregation in order to establish regional effects and build bottom estimates of impact.

3. THEORETICAL FRAMEWORK, METHODOLOGY AND DATA

The study methodology comprises three modules: 1) an estimation of total investment required to meet the broadband targets, 2) an assessment of economic impact of construction of the broadband network required to meet those targets, and 3) an estimation of the economic impact to be achieved once the network is deployed.

3.1. Estimation of total investment for broadband deployment

The coverage and service targets established by the Broadband Strategy are used to estimate the costs of deploying the targeted broadband infrastructure. However, two sequential scenarios were defined: a 2014, built around the strategy targets (BMWi 2009a), and a 2020, defined on the basis of longer-term goals outlined in other government (see citation of the 2018 case in BMWi, 2009c)

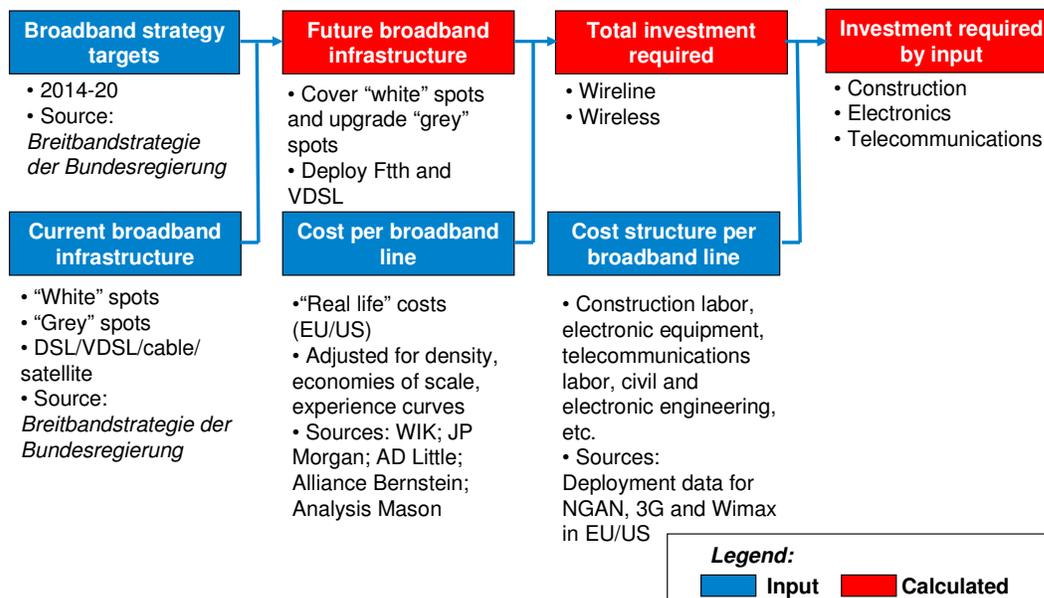
Once defined, the targets were compared against the current situation of broadband deployment. Data on current coverage was extracted from the National

Broadband Strategy and the Broadband Atlas produced by the Federal Ministry of Economics and Technology (BMWi 2009b). The comparison between the current situation and the targets allows estimating the deployment objectives in terms of number of lines to: 1) cover the "white" spots (unserved areas), 2) upgrade the "grey" spots (areas with inferior service measured by low access speeds), and 3) deploy VDSL and FTTH. Lines were estimated for different type of platforms (wireless, DSL, VDSL and FTTH).

Once the number of lines by service target is estimated, they are multiplied by the costs per broadband line by type of platform. In order to determine the costs per line, the costs from deployment experience in Europe and the United States were relied upon, adjusted for factors such as urban density, economies of scale, and experience curve⁷. This calculation yielded the total investment required for wireless and wireline technologies. The total investment was split according to three cost categories: 1) construction labor, 2) electronic equipment, and 3) telecommunications labor. These splits were based on cost allocations based on "real life" deployment data for NGAN (furnished by a European operator), and for 3G and Wimax for a US operator.

The resulting process yielded the amount of total investment by cost category (see figure 3):

Figure 3. Module for Estimating Deployment Costs



3.2. Assessment of economic impact of network construction

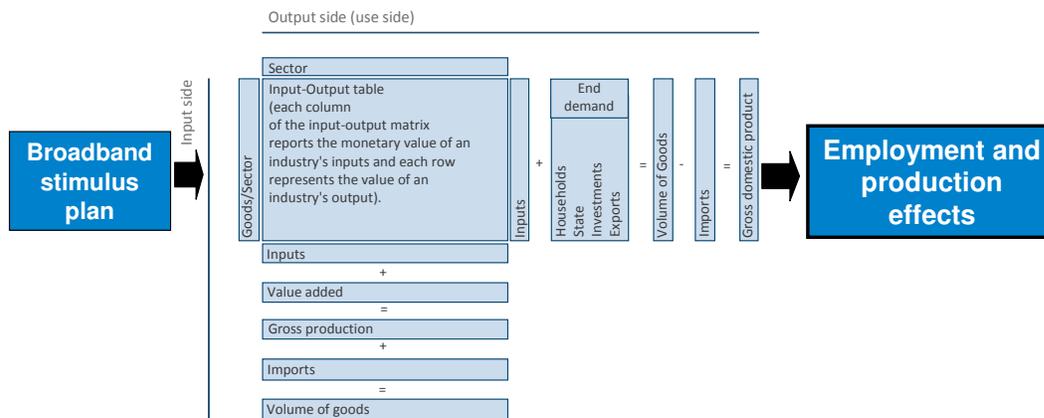
⁷ See, in particular, Elixman et al. (2008)

The assessment of economic impact of network construction comprised the estimation of jobs to be created to construct the network, as well as the impact on economic output.

There are three types of network construction effects on employment growth. In the first place, network construction requires the engagement of direct jobs. They typically comprise telecommunications technicians, construction workers, manufacturers of the required telecommunications equipment, and civil and Radio Frequency engineers. In addition, the creation of direct jobs has an impact on indirect employment, which refers to jobs created by indirect spending of businesses buying and selling to each other in support of direct spending. The industrial sectors more impacted indirectly comprise metal products workers, electrical equipment and professional services. Finally, the household spending based on the income earned from the direct and indirect effects leads to the creation of induced employment, primarily impacting consumer durables, retail trade, and consumer services.

To calculate the impact of broadband construction on employment and output input-output tables were utilized (see figure 4).

Figure 4. Structure of input-output table



Input-output tables calculate the direct, indirect, and induced employment and production effects of network construction. The interrelationship of these three effects can be measured through multipliers, which estimate total employment change throughout the economy from one unit change on the input side. Type I multipliers measure the direct and indirect effects (direct plus indirect divided by the direct effect), while Type II multipliers measure Type I plus induced effects (direct plus indirect plus induced divided by the direct effect). In this study, the German input-output matrix supplied by Eurostat (Eurostat 2009), and originally developed by the Federal Statistical Office (Destatis 2009) was utilized.

3.3. Estimation of the economic impact to be achieved after network deployment

Once deployed, the broadband infrastructure yields three types of economic impact labelled "network effects" or externalities. First, business firms might improve their productivity as a result of the adoption of more efficient business processes, themselves enabled by broadband services. Marketing of excess inventories and optimization of the supply chain are two of the effects that might be generated.⁸ Secondly, broadband deployment yields an acceleration of innovation resulting from the introduction of new broadband-enabled applications and services (for example, telemedicine, internet search, e-commerce, online education, video on demand and social networking). And, thirdly, broadband can have an impact on the composition and deployment of industry value chains. In other words, broadband can attract employment from other regions as a result of the ability to process information and provide services remotely. Among the likely businesses to be attracted, one should include outsourcing of services, and deployment of virtual call centers.

The estimation of economic impact achieved after network deployment was conducted through econometric modelling. This was performed in three steps. First, statistically significant causal models were specified for German historical data sets. Data included broadband adoption, GDP growth, population growth and other time series between 2000 and 2006 at the Landkreise level. Data was gathered from the Federal Statistical Office, the 'Bundesamt für Bauwesen und Raumordnung' and Deutsche Telekom AG. Once the models which held a high level of significance were specified, they were utilized to forecast economic and employment growth as a result of an increase in broadband penetration.

The increase in broadband penetration was estimated by inferring the net result of the broadband strategy. Once the estimates for employment and economic impact resulting from network deployment and externalities were generated, they were annualized and compiled to yield both aggregate and annual effects.

4. THE CURRENT STATE OF BROADBAND DEPLOYMENT IN GERMANY:

4.1. Current Situation of broadband deployment:

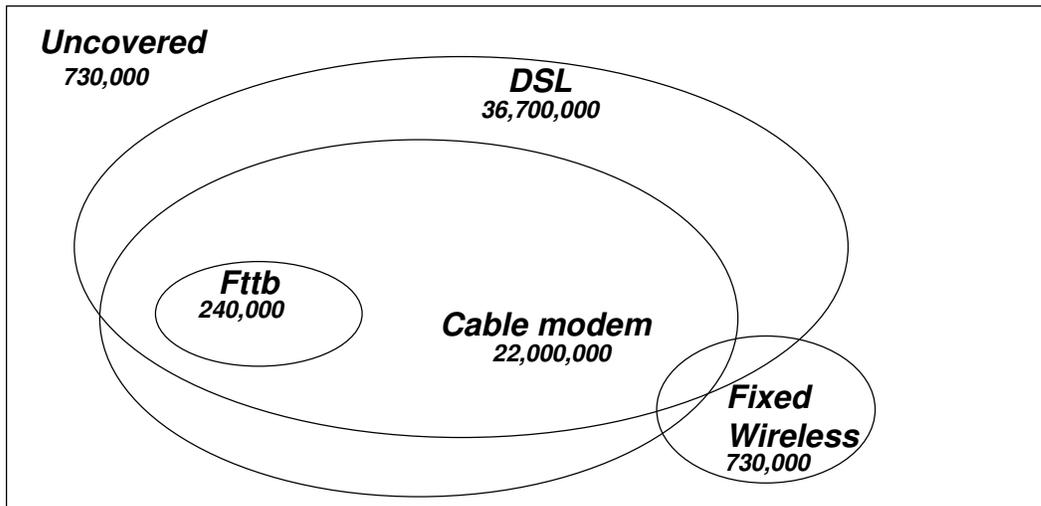
According to our estimates based on publicly available data published in the National Broadband Strategy, of all German households (total households: 39.7 million, Federal Statistical Office Germany 2006), 39 million have access to some type of broadband technology. Of these, 36.7 million can be served by DSL, 22.0

⁸ Efficient telecommunications have been pointed out as a critical enabler of business processes aimed at selling excess inventory of goods because they allow for a wider market reach. Similarly, telecommunications facilitate the optimization of pricing of components insofar that they allow wider search for the supplier with lower prices.

million are passed by cable TV networks (and, therefore potentially connected via a cable modem), and 730,000 can access the internet via fixed wireless or satellite technology. Furthermore, by compiling announcements of fiber optics technology being deployed by telecommunications operators and municipal networks, it is estimated that 10.9 million households are able to connect via VDSL, while only 240,000 could be based on FTTH.

Assuming that two or more technologies could be serving a group of households, the broadband supply side could be depicted as follows (see figure 5).

Figure 5. Technology Coverage Overlap



In addition to improving coverage, Germany has been making considerable strides in terms of raising the access speed of residential broadband users. The National Broadband Strategy reports that 98 percent of all German households have access to broadband internet with transmission rates of at a minimum 384 Kbps, while 92 percent of households are served by lines with at least 1 Mbps. About 2.8 million households are in “grey spots”, meaning that they have broadband access between 384 Kbps and 1 Mbps. The remaining "white spots", which comprise two percent of households (or 730,000), are either located in less densely populated areas or near the outer boundaries of already connected areas.

Furthermore, Germany is undergoing three levels of fiber deployment: 1) Fiber to the Main Distribution Frame for ADSL 2+ services for selected cities, 2) Fiber to the street cabinet for VDSL services, and 3) Fiber to the home (DTAG, NetCologne, M’net, and Stadtwerke Schwerte). In the case of VDSL, Deutsche Telekom has announced that 90 percent of households located in top 50 cities (which are estimated to be 10.9 million) can have access to VDSL. Simultaneously, the municipal networks have launched or are planning to deploy FTTB networks. Deployment in this case is focused on densely populated areas of their home markets (see figure B.1 in appendix B). Total coverage, based on these

targets which are already in construction, is 240,000 homes. Furthermore, with this presence, the city carriers would operate in cities containing approximately seven percent of the population of Germany (calculated as the population of each of cities metropolitan areas, see figure B.2 in appendix B).

The major cable players have all upgraded networks to two way Hybrid Fiber Coax generally relying on DTAG ducts. Kabel Deutschland’s acquisition of Orion in the first quarter of 2008 resulted in 7.6 million upgraded households passed (71 percent of homes passed). Unitymedia has 6.3 million upgraded households passed (72 percent of homes passed). Kabel BW has upgraded 91 percent of its network passing 3.3 million homes. All players are offering DOCSIS 2.0 and planning to roll out DOCSIS 3.0 by the end of 2010.

Turning to the demand side, as of the end of 2008, there were 22.6 million broadband lines in Germany (Source: Bundesnetzagentur Jahresbericht 2008, 2009). Based on this statistic, Germany has reached 58 percent household penetration, or 27 percent of its population. Assessing demand in light of the supply perspective indicates that 58 percent of households actually served by any combination of broadband technologies actually purchase service (see figure 6):

Figure 6. Households Passed by Broadband

Technology	Coverage <i>million</i>	Subscribers <i>million</i>	Connected/ passed in %
DSL	36.7	20.9	57
Cable Modem	22.0	1.6	7
Fixed Wireless, satellite	0.730	0.092	13
FTTB	0.240	0.043	18
Total (assuming overbuilds)	39.0	22.6	58

Sources: DT; Kabel Deutschland; Unitymedia; M-net; Bundesnetzagentur

4.2. The ‘National Broadband Strategy’ and a long-range scenario:

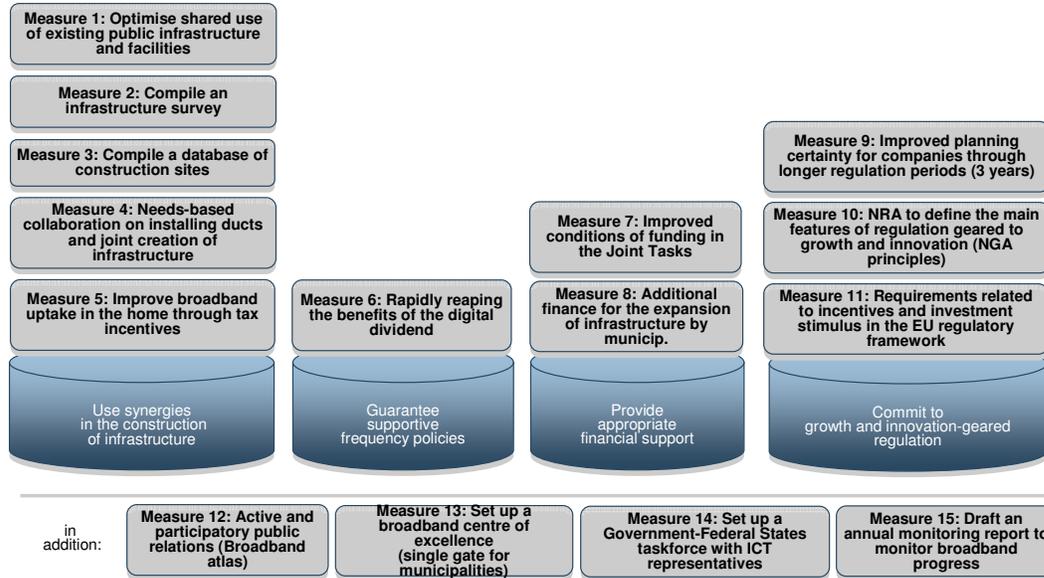
The Federal Government of Germany has agreed on the following two broadband strategy targets⁹:

- 1) The aim is to have nationwide capable broadband access (1 Mbps) no later than by the end of 2010.
- 2) By 2014, 75 percent of German households should have access to a broadband connection of at least 50Mbps, with the goal that such access lines should be available as soon as possible throughout the country

⁹ *Federal Government of Germany (2009) “Breitbandstrategie der Bundesregierung“, 3.*

For this purpose, the German Government derived a 4-pillar strategy consisting of no less than 15 measures, which are illustrated in the following figure:

Figure 7. German National Broadband Strategy



Source: Federal Government of Germany (2009); figure by the authors.

The deployment actions required to meet these targets are four-fold. First, the 730,000 unserved households (white spots) will be covered by a mix of wireless and wireline technology. It is assumed, following Deutsche Telekom's recent announcement that 250,000 unserved households will be covered by DSL technology, while the remainder will be covered by wireless technologies. The second action will be to upgrade the 2.8 million "grey spot" households to 1 Mbps.

Turning to the third target of the National Broadband Strategy, 75 percent of households will have to be served by at least 50 Mbps by 2014 and higher bandwidths beyond. This was structured in two stages:

- Upgrade to FTTH: It is assumed that 9.92 million households (representing 25 percent of the German households) will be upgraded to FTTH given that VDSL technology deployed in dense cities has limits to the capability of offering 50 Mbps. Since the current number of households served by VDSL is 10.9 million and that they are located in the major 50 German cities, it is assumed that the majority of them will be migrating from VDSL to FTTH
- Upgrade to VDSL: For this, it is assumed that the remaining 50 percent of households will be upgraded from DSL to VDSL and are calculated by subtracting from the target the coverage that has already been provided:

$$\text{Lines to be upgraded to VDSL} = \frac{29,791,000 \text{ households}}{(2014 \text{ coverage target})} - \frac{9,920,000 \text{ households}}{(FTTH \text{ covered})} - \left(\frac{10,900,000 \text{ households}}{(current VDSL coverage)} - \frac{9,920,000 \text{ households}}{(moved to FTTH)} \right)$$

According to this calculation, it is estimated the broadband lines to be connected as a result of this effort to be approximately 18.9 million.

To sum up, the broadband strategy will require the following investments to be completed by 2014:

- Unserved households (730,000) covered by a mix of wireless (480,000 lines) and wireline technologies (250,000 lines)
- "Grey zone" households (2.8 million) upgraded to 1 Mbps
- 9,930,500 households (or 25%) upgraded to FTTH: these will come from the 240,000 where FTTH has already been deployed (municipalities) and by upgrading the rest from the existing VDSL lines
- 18.9 million households (or 50%) upgraded to VDSL: this will be comprised by the remaining existing VDSL lines (980,000) and upgrading 17.9 million currently DSL lines

Longer term aspirations, as mentioned in other government reports (BMW, 2009c, 38) foresee to build a national ultra-broadband infrastructure by 2020. While this aim has not been underlined by clear policy objectives in the National Broadband Strategy, one can assume a set of "aspirational" targets for 2020:

- Deploy FTTH to 50 percent of households
- Deploy VDSL to the next 30 percent of households
- Offer broadband services under 50 Mbps to the remaining population (20%)

The action implied from these targets is to upgrade additional 25 percent of households to FTTH (which when added to the 25 percent upgraded by 2014 reach 50 percent).

4.3. Total investment required to meet policy targets

The calculation of total investment required has been conducted for each action by relying on costs per line. As such, the combined wireline and wireless costs required to cover the unserved households will require 924 million Euros, as depicted in figure 8:

Figure 8. Investment required to cover unserved households

Technology	Number of households	Cost per line Euros	Total Investment (Euro Mio)
DSL	250,000	1,200	300
Wireless	480,000	1,300	624
Total	730,000		924

The calculation of VDSL and FTTH deployment relies on cost per line gathered by a number of sources (see figure 9):

Figure 9. Cost per line estimates for VDSL and FTTH upgrade

Source	Cases	VDSL (Euro)	FTTH (Euro)
Analysis (2006)		300-400	1,000
Analysis (2008)	Netherlands		1,566
ADL (2009)	Generic	300-450	1,150-1,700
AT Kearney (2008)	Greece		1,206-1,525
WIK (2008)		475	
JP Morgan (2006)	Iliad		1,000-1,500
	Net Cologne		1,000
	Fastweb		1,200
	Hillegon (NL)		1,200

The cost calculation relies on the ADL figures with an increase of cost per household resulting from further deployment of the technology in the network. For example, in the case of FTTH the initial 10 percent of households (3,972,000) will cost 1,150 Euros per household to deploy, the next 10 percent will require 1,287 Euros, and the next 10 percent, 1,425 Euros. In the case of VDSL, the first 10 percent, will cost 300 Euros, while deploying beyond 50 percent, will require 450 Euros. Based on these figures and the number of lines to be deployed calculated in 5.2, the investment required to meet the FTTH target is 12,236 million Euros, while the investment required to meet the VDSL target would reach 6,747 million. To sum up, the total investment required to fulfill the 2014 National Broadband Strategy will be 20,243 million Euros (see figure 10).

Figure 10. Total Investment required to achieve objectives for 2014

Target	Amount (Euros Mio)
Address the unserved "white spots"	924
Upgrade the "grey spots"	336
Deploy FTTH to 25% of households	12,236
Deploy VDSL to 50% of households	6,747
Total	20,243

The incremental investment required to meet the FTTH target of 50 percent households served by 2020 will be 15,690 million Euros.¹⁰

¹⁰ The difference between the first 25%, achieved in 2014 (12,236 million Euros) and the second 25% tranche achieved in 2020 (15,690 million Euros) is due to two factors: 1) the first tranche benefits from the 240,000 households already served by municipal networks roll-out and, more importantly, 2) the cost per line in the second phase rises from 1,150-1,425 Euros to 1,500-1,700 Euros.

5. JOB CREATION AND ECONOMIC IMPACT OF GERMANY'S BROADBAND STRATEGY

5.1 Employment and economic impact of broadband network construction

In order to estimate the impact of the construction of broadband accesses required to meet the strategy targets, the investment is broken down in three primary sectors of the economy to receive the benefits: manufacturing of electronic equipment, construction and telecommunications. As mentioned above, the breakdown was done based on deployment numbers of NGAN of a European carrier (for wireline) and of Wimax/3G US carrier¹¹ (for wireless).

According to this categorization, the breakdown of investment funds for 2014 is estimated to be as follows (see figure 11):

Figure 11. Breakdown of broadband investment to fulfill 2014 Broadband Strategy

Inputs	Wireline		Wireless		Total
	%	Euros (Mio)	%	Euros (Mio)	Euros (Mio)
Electronics	12	2,354	45	281	2,635
Construction	67	13,145	34	212	13,357
Telecommunications	21	4,120	21	131	4,251
Total		19,619		624	20,243

A similar breakdown was completed for the investments required for completion of the 2020 scenarios, although in this case all the investment was assigned to wireline technology (FTTH).¹²

Figure 12. Breakdown of broadband investment to fulfill 2020 ultra-broadband evolution

Inputs	Wireline		Wireless		Total
	%	Euros (Mio)	%	Euros (Mio)	Euros (Mio)
Electronics	12	1,883	45	0	1,883
Construction	67	10,512	34	0	10,512
Telecommunications	21	3,295	21	0	3,295
Total		15,690		0	15,690

¹¹Interview at Spectrum Management Consulting regarding cost modeling of 3G/Wimax US deployment

¹²Some coverage could be assigned to LTE but the lack of reliable economic estimates due to recent deployment activity prompted to consider FttH only.

These estimates were entered into the input/output matrix for the German economy, in each of the following industry categories:

- Manufacture of radio, television and communication equipment and apparatus
- Site preparation, Building of complete constructions or parts thereof; civil engineering
- Building installation, Building completion, Renting of construction or demolition equipment with operator
- Post and telecommunications

This is the basis to estimate the impact on jobs and the economy of investment in network construction. Fulfilling the 2014 objectives of the National Broadband Strategy is estimated to generate 304,000 jobs over five years (between 2010 and 2014).¹³ Following the breakdown of construction effects, 158,000 jobs will be created in equipment manufacturing, construction and telecommunications. The primary sector benefited in terms of job creation will be construction with 125,000, followed by telecommunications (28,400) and electronics equipment manufacturing (4,700).

Total indirect jobs generated by sector interrelationships measured in the input/output matrix will be 71,000. The key sectors benefited from the indirect effects are distribution (10,700), other services (17,000) and metal products (3,200). Finally, household spending generated directly and indirectly, will result in 75,000 induced jobs. Based on these estimates, the Type I multiplier for employment is 1.45 and Type II is 1.92.

Additionally, the implementation of the expected ultra-broadband evolution would generate 237,000 incremental jobs between 2015 and 2020. Similar to the breakdown shown above, this figure comprises 123,000 in direct jobs, 55,000 indirect jobs and 59,000 in induced jobs. As expected, multipliers will be similar, the Type I multiplier for employment is 1.45 and Type II is 1.93.

Figure 13 presents all the employment effects reviewed above:

¹³ Given the static nature of I/O-matrix it is not possible to project job creation over time. This could be done, however, if yearly investment data is available.

Figure 13. Total Employment impact of Broadband Network Construction

Type of Impact	2014 National Broadband Strategy	2020 Ultra-broadband evolution	Total
Direct effect	158,000	123,000	281,000
Indirect effect	71,000	55,000	126,000
Induced effect	75,000	59,000	134,000
Total	304,000	237,000	541,000
Type I multiplier	1.45	1.45	
Type II multiplier	1.92	1.93	

The sector impact of direct and indirect effects is included in figure 14:

Figure 14. Sector impact of direct and indirect job creation

	2014 National Broadband Strategy	2020 Ultra-broadband evolution	Total
Construction	125,000	99,000	224,000
Telecommunications	28,400	21,000	49,400
Other services	17,000	13,000	30,000
Distribution	10,700	8,400	19,100
Metal products	4,800	3,700	8,500
Electronics equipment	4,700	3,400	8,100
Electrical equipment	3,200	2,500	5,700
Financial services	3,000	2,000	5,000
Other	32,200	25,000	57,200
Total	229,000	178,000	407,000

As figure 15 indicates, the labor intensive nature of broadband deployment determines that the construction jobs to be created are significant and, despite the high technology nature of the ultimate product, broadband is to be seen as economically meaningful as conventional infrastructure investment such as roads and bridges.

In addition to estimating employment effects, industrial output and GDP impact are to be derived by the input-output matrices. The investment in meeting the targets of the 2014 Broadband strategy (20,243 million Euros) will generate additional production of 52,324 million Euros in total. This means that for each Euro invested in broadband deployment, 2.58 Euros will be generated in output. Of this, 4,146 million Euros (8% of total output) will be based on imported goods. This indicates a relatively low level of output "leakage" to other national economies. Of the remaining production, 18,733 million Euros would be additional GDP (+0.15 %). Again, for each Euro invested in broadband

deployment, it would trigger 0.93 Euros in additional value added, or incremental GDP. Figure 15 compiles the economic impact of the 2014 and 2020 targets:

**Figure 15. Industrial output of Broadband Construction
(in millions)**

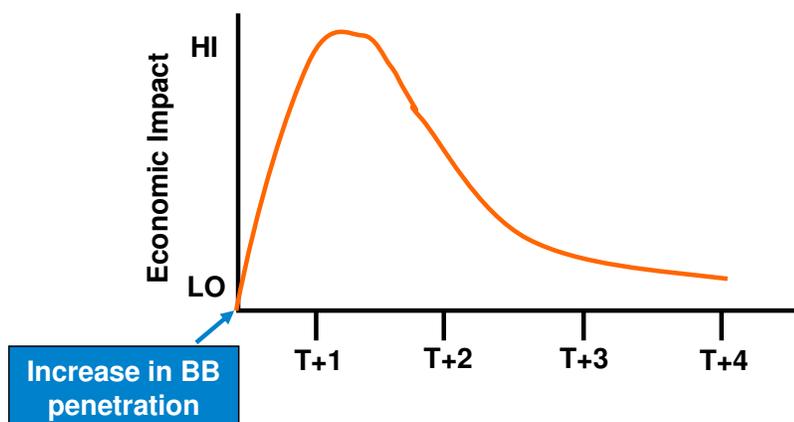
	2014 National Broadband Strategy	2020 Ultra- broadband evolution	Total
Investment	20,243	15,690	35,933
Total additional production	52,324	40,749	93,073
• Domestic	48,178	37,609	85,787
<i>Additional Value added</i>	18,733	14,631	33,364
<i>Intermediate outputs</i>	29,466	22,978	52,444
• Imported	4,146	3,148	7,294

To sum up, the incremental GDP growth achieved by investing in broadband deployment would amount to 33,364 million Euros (which represents +0.12% of the German GDP). This amount does not include the additional impact to be achieved once the network construction is completed. This is the subject of the next section.

5.2 Employment and economic impact of externalities

Economic impact of broadband in terms of network externalities (that is to say, positive effects in employment and economic output resulting from enhanced productivity, innovation and value chain decomposition) have been found to be significant throughout Germany. The analysis of these effects focused on the impact of increased broadband penetration on economic growth and job creation, has found that the economic stimulus impact of broadband is highest in the first year after deployment and tends to diminish over time (see figure 16).

Figure 16. Conceptual depiction of Broadband externalities



Results of the regression analysis for national time series between 2000 and 2006 indicates, with high significance levels, a strong impact of increased broadband penetration on GDP growth, although the degree of impact tends to diminish over time. On the other hand, results regarding the impact of broadband penetration on employment creation carry a low level of significance and, therefore, do not allow us to indicate, with certainty the existence of causality.

However, consistent with the results of Lehr et al. (2005) for the US, which is the only other econometric study of the relationship between broadband and employment, the impact can be identified once the analysis is disaggregated and models are specified at the Landkreise¹⁴ level. By splitting the national territory into two groups, Landkreise with 2008 average broadband penetration of 31 percent of population and Landkreise with average broadband penetration of 24.8 percent, the analysis determined, with high level of significance for the advanced territories, that the type of network effects of broadband varies by region.

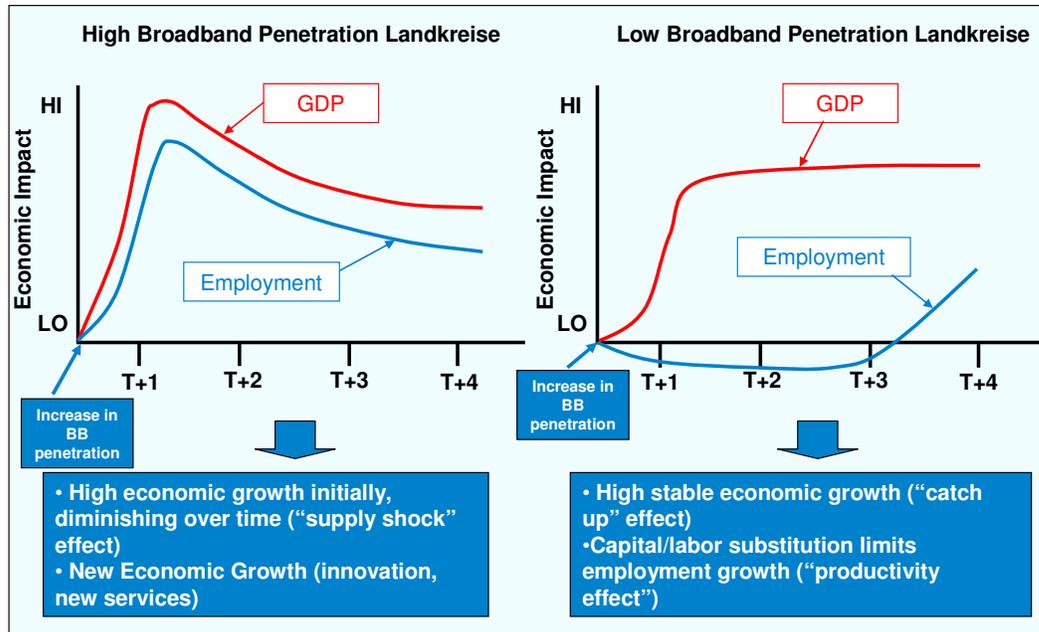
In high broadband penetrated Landkreise, the impact of the technology is very high both on GDP and employment in the short term, but declines over time. This "supply shock" is believed to occur because the economy can immediately utilize the new deployed technology. Furthermore, the fact that employment and GDP grow in parallel indicate that broadband is having a significant impact on innovation and business growth, thereby overcoming any employment reduction resulting from productivity effects.

On the other hand, in Landkreise with low broadband penetration, the impact on GDP of broadband penetration is lower than in high penetrated areas in the short term but "catching up" to comparable levels over time. With regards to employment, the impact of broadband at least in the initial years is slightly negative. This would indicate that the impact of broadband in low penetrated areas is more complex than in the high penetrated areas. Regarding economic growth, the increase in broadband penetration in low penetrated areas takes longer to materialize because the economy requires a longer period of time to develop and fully utilize the technology. However, after three years the level of impact of broadband in low penetrated regions is as high as in the more developed areas. This is consistent with Jorgeson's findings of lagged effect of ICT investment in productivity (Jorgeson et al., 2007). On the other hand, the fact that employment growth is initially negative would appear to indicate that productivity increase resulting from the introduction of new technology is the most important network effect at work resulting in employment reduction. However, once the economy develops, the other network effects (innovation, value chain recomposition) start to play a more important role, resulting in job creation. However, the data sets do not enable to test this last point at this time. Therefore broadband deployment in low penetrated areas will likely generate high stable economic growth ("catch up" effect) combined capital/labor substitution which initially limits employment

¹⁴ Landkreise is the administrative unit in Germany corresponding to a county.

growth ("productivity" effect). Figure 17 presents in conceptual fashion a comparison of impact in both regions.

Figure 17. Conceptual view of comparative broadband regional effects¹⁵



Based on these differentiated effects, the impact of broadband on economic growth and employment are estimated. However, in order to do that, it is necessary to assume how broadband penetration would evolve over time in both regions as a result of the broadband strategy. Accordingly, the following forecast was defined based on the expected impact (see figure 18).

Figure 18. Forecast of Broadband penetration (percent of population)

		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
High Penetration Landkreise	Basic Trend	14.3	20.8	26.6	31.0	34.0	36.1	37.8	39.3	40.7	41.9
	Incremental impact							1.0	2.0	3.0	4.0
	Total				31.0	34.0	36.1	38.8	41.3	43.7	45.9
Low Penetration Landkreise	Basic trend	10.3	16.6	21.2	24.8	27.2	28.9	30.1	31.4	32.5	33.4
	Incremental Impact in White/gray areas							1.0	2.0	3.0	4.0
	Total				24.8	27.2	28.9	31.1	33.4	35.5	37.4

¹⁵ Only effects up to t + 3 are estimated.

It was stipulated that broadband penetration in advanced areas would increase from 31 percent in 2008 to 45.9 percent in 2014, while the low penetrated areas would increase from 24.8 percent to 37.4 percent. This last trend is largely driven by the coverage of "white spots" and an improvement of service in "grey spots". These trends reflect an incremental increase in penetration of approximately 25 percent in both regions between 2008 and 2011.¹⁶

The percent increase was inputted in the regression models specified for the time series 2000-2006.¹⁷ The regression models estimate an incremental annual GDP growth rate of 0.61 pp for low penetrated Landkreise and 0.64 pp for high penetrated Landkreise, which over three years amounts to 1.93 percent and 1.82 percent respectively. This incremental percentage point increases were applied to the GDP of both regions (estimated to be 1,698 billion Euros for high penetrated Landkreise and 791 billion for low penetrated Landkreise). This resulted in an incremental GDP of 32,809 million Euros for high penetrated Landkreise and 14,375 million Euros for low penetrated Landkreise. When added, the total incremental GDP is 47,184 million Euros (+0.62 %) in three years.

Regarding the impact on employment, following the same methodology, creation of a total of 162,000 jobs is expected, whereby the more developed broadband areas would contribute 132,000 and the low penetrated regions 30,000.¹⁸ The differentials across regions are driven by the divergent effects discussed above. Having estimated the three year (2009-11) employment and economic impact of incremental broadband penetration, the prorated annual increments were applied to the period 2012-2020 (54,000 jobs, and 15.7 billion Euros of GDP per year). However, in doing so, the impact during the years 2012-2014 was adjusted downward. For example, network externalities employment effects between 2012 and 2014 were reduced from 162,000 jobs to 103,000. It was assumed that the difference was already accounted for in the construction effects since regression models do not differentiate between construction and externalities. After 2014, no adjustments were made because with the construction of the National Broadband Strategy being finished, the regression models were primarily forecasting externalities. A similar adjustment was made to the GDP impact.

¹⁶ A cautionary note should be made that in order to translate infrastructure deployment programs into increased broadband penetration, network construction should be complemented with very targeted demand promotion programs (be it community aggregation programs such as the ones of the Dutch government, tax deductions such as the ones implemented in Sweden, and, potentially, subsidies) that stimulate adopters to sign up for service.

¹⁷ $g_gdp_03_06 = \beta_1 * gdp_pc_2000 + \beta_2 * g_pop_00_06 + \beta_3 * g_bbpen_02_03$
 $g_emp_03_06 = \beta_1 * gdp_pc_2000 + \beta_2 * g_pop_00_06 + \beta_3 * g_bbpen_02_03$
See models in appendix C.

¹⁸ While it is not possible to determine, as in the case of network construction, what type of sectors would be mostly impacted by network externalities, experience indicates that higher developed areas will generate knowledge-intensive occupations such as R&D and product development, while less developed regions will attract low-end information intensive jobs, such as virtual call centers.

These numbers prompt the question of why to invest in the low penetrated areas if externalities are greater in more advanced regions? The answer is threefold: first, the impact in more advanced areas tends to decrease over time, which requires that in order to continue creating jobs the emphasis is shifted to the less penetrated regions; second, based on the "catch up" described above, it is expected that less penetrated areas will become engines of job creation in the long run; third, the social intangible benefits of addressing the "digital divide" problem remains an overriding imperative, regardless of the short term employment effects.

5.3. Combining construction effects and externalities

As discussed throughout the review of the study projections, the estimates were generated for several years and dependent of stages of network deployment. For example, the 541,000 jobs to be generated by network construction do not occur all in one year but over a ten year period. To understand the yearly impact of the estimates, a table that displays the yearly impact over time was constructed (see figure 19).

Figure 19. Employment and Economic Impact per annum

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
EMPLOYMENT (in thousands)													
Network Construction	National Strategy	60.8	60.8	60.8	60.8	60.8							304.0
	Ultra Broadband						39.5	39.5	39.5	39.5	39.5	39.5	237.0
	Total	60.8	60.8	60.8	60.8	60.8	39.5	39.5	39.5	39.5	39.5	39.5	541.0
Network externalities				24.0*	35.0*	44.0*	54.0	54.0	54.0	54.0	54.0	54.0	427.0
Total		60.8	60.8	84.8	95.8	104.8	93.5	93.5	93.5	93.5	93.5	93.5	968.0
GROSS DOMESTIC PRODUCT (in Billion Euros)													
Network Construction	National Strategy	3.8	3.8	3.8	3.8	3.8							18.8
	Ultra Broadband						2.4	2.4	2.4	2.4	2.4	2.4	14.6
	Total	3.8	3.8	3.8	3.8	3.8	2.4	2.4	2.4	2.4	2.4	2.4	33.4
Network externalities				13.9*	14.5*	14.9*	15.7	15.7	15.7	15.7	15.7	15.7	137.5
Total		3.8	3.8	17.7	18.3	18.7	18.1	18.1	18.1	18.1	18.1	18.1	170.9

** Some overlapping of effects assumed*

Based on these figures, the net employment effects over time periods were calculated (see figure 20).

**Figure 20. Employment effect over time
(in thousand)**

	Network Construction				Network externalities	Total
	Direct	Indirect	Induced	Total		
2010-14	158	71	75	304	103	407
2015-20	123	55	59	237	324	561
Total	281	126	134	541	427	968

Between 2010 and 2014, 407,000 jobs will be created while job creation between 2015 and 2020 will reach 561,000.

Three remarks are noteworthy: First, it is obvious that, while total projections have been split evenly over time, one would expect yearly projections to change. For example, more jobs are generated in the beginning of network deployment than in the back-end. This would require further refinement of these projections in light of construction plans. Second, as mentioned above, to avoid double counting with respect to network construction effects in the first years and to assure a conservative calculation some of the totals have been reduced. Third, the regression model is capable to project economic impact over a three year period which has been extended throughout 2020, which is believed to be a reasonable assumption.

6. CONCLUSIONS:

The National Broadband Strategy and the expected evolution of ultra-broadband through 2020 will have a significant impact on jobs and the German economy.

It is estimated that a total investment of close to 36 billion Euros would generate a total of 968,000 incremental jobs, of which 541,000 are derived from construction of the network to meet the stipulated targets and 427,000 will be generated after the network is progressively deployed, resulting from enhance innovation and new business creation. From an incremental economic growth standpoint, network construction would yield additional value added of 33.4 billion Euros, while network externalities will result in additional 137.5 billion Euros.

These economic returns on the broadband investment amply justify the need to move ahead with the announced plans, in particular to assure a growth and innovation-gearred political and regulatory framework.

A. BIBLIOGRAPHY

- Abramovsky, L. and Griffith, R. (2006). Outsourcing and off shoring of business services: how important is ICT? Advanced Institute for Management Research London. Working paper Nr. 1744-009.
- Analysis Mason (2008). The business case for fiber-based access in the Netherlands. Final Report for OPTA, Public Version, Ref. 12885-226. Cambridge,
- Arthur D. Little (2009). The moment of truth, www.adl.com/The_Moment_of_Truth.
- AT Kearney (2008). Preliminary results on development of strategy for Electronic Communications industry in Greece. May 2008, Athens.
- Atkinson, R., Castro, D. and Ezell, S.J. (2009). The Digital Road to Recovery: A Stimulus Plan to Create Jobs, Boost Productivity and Revitalize America, Washington, DC, The Information Technology and Innovation Foundation.
- Atrostic, B.K. and Nguyen, S.V. (2006). How businesses use information technology: insights for measuring technology and productivity. U.S. Bureau of Census, Washington, DC.
- BMWi (2009a). Breitbandstrategie der Bundesregierung, Stand Feburar 2009, <http://www.bmwi.de/Dateien/BBA/PDF/breitbandstrategie-der-bundesregierung,property=pdf,bereich=bmwi,sprache=de,rwb=true.pdf>.
- BMWi (2009b). Der Breitbandatlas des BMWi, <http://www.zukunft-breitband.de/BBA/Navigation/breitbandatlas.html>.
- BMWi (2009c). Konjunkturgerechte Wachstumspolitik Jahreswirtschaftsbericht 2009, <http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/jahreswirtschaftsbericht-2009,property=pdf,bereich=bmwi,sprache=de,rwb=true.pdf>.
- Bresnahan, T. F. and Trajtenberg, M. (1995). General Purpose Technologies, Engines of Growth? *Journal of Econometrics*, 65/1, 83-108.
- Brynjolfsson, E. and Hitt, L.M. (2000). Beyond Computation: Information Technology, Organizational Transformation and Business Performance, *Journal of Economic Perspectives*, 14/4, 23-48.
- Colecchia, A. and P. Schreyer, P. (2002). ICT Investments and Economic Growth in the 1990s: Is the United States a Unique Case? A Comparative Study of Nine OECD Countries, *Review of Economic Dynamics*, 5/2, 408-442.
- Crandall, R., Lehr, W. and Litan, R. (2007). The effects of broadband deployment on output and employment: A cross-sectional analysis of U.S. data. Working paper Brookings Institution.
- Crandall, R.W., Jackson, C.L. and Singer, H.J. (2003). The effect of ubiquitous broadband adoption on Investments, Jobs and the U.S. Economy. Washington, D.C.: Criterion Economics.

- DESTATIS (2009). VGR des Bundes - Input-Output-Rechnung - Fachserie 18 Reihe 2 – 2005, <https://www-ec.destatis.de/csp/shop/sfg/bpm.html.cms.cBroker.cls?cmspath=struktur,vollanzeige.csp&ID=1022527>.
- Dixon, K. (2009) Broadband link to U.S. jobs exaggerated: experts Reuters, <http://www.reuters.com/article/technologyNews/idUSTRE50T6IP2009010>.
- Elixman, D., Ilic, D., Neumann, K-H., Pluckebaum, T. (2008). The economics of Next Generation Access, Final Report. Study for the European Competitive Telecommunication Association (ECTA), WIK Consult. Bad Honnef.
- Federal Government of Germany (2009) "Breitbandstrategie der Bundesregierung", <http://www.bmwi.de/Dateien/BBA/PDF/breitbandstrategie-der-bundesregierung,property=pdf,bereich=bmwi,sprache=de,rwb=true.pdf>.
- Ford, G.S. and Koutsky, T.M. (2005). Broadband and economic development: a municipal case study from Florida, *Review of urban & regional development studies*, 17/3, 216-229.
- Fornefeld, M., Delaunay, G. and Elixmann, D. (2008). The impact of broadband on growth and productivity. A study on behalf of the European Commission (DG Information Society and media), MICUS.
- Inklaar, R., O'Mahony, M. and Timmer, M.P. (2005). ICT and Europe's Productivity Performance: Industry-level Growth Account Comparisons with the United States, *Review of Income and Wealth*, 51/4, 505-536.
- Bundesnetzagentur (2009). Jahresbericht 2008, <http://www.bundesnetzagentur.de/media/archive/15901.pdf>.
- Jorgenson, D. (2001) Information technology and the U.S. Economy, *American Economic Review*, 91/1, 1-33.
- Jorgenson, D. W., Ho, M.S. and Stroh, K.J. (2003). Lessons for Europe from the US Growth Resurgence, *CESifo Economic Studies*, 49, 27-48.
- Jorgenson, D.W. (2001). Information technology and the US Economy, *American Economic Review*, 91/1, 1-32.
- Jorgenson, D., Ho, M, Samuels, J., Stroh, K. (2007), Productivity growth in the new millennium and its industry origins, Presentation to the Sloan Industry Studies Conference, Boston.
- J.P. Morgan Securities (2006): The fibre battle – Changing dynamics in European wireline. European Equity Research.
- Katz, R.L. (2009). La Contribución de las tecnologías de la información y las comunicaciones al desarrollo económico: propuestas de América Latina a los retos económicos actuales. Madrid, España: Ariel.
- Katz, R.L. and Suter, S. (2009). Estimating the economic impact of the broadband stimulus plan. Columbia Institute for Tele-Information Working Paper.

- Katz, R.L., Zenhäusern, P. and Suter, S. (2008). An evaluation of socio-economic impact of a fiber network in Switzerland, mimeo, Polynomics and Telecom Advisory Services, LLC.
- Kelley, D. (2004). A study of the economic and community benefits of Cedar Falls, Iowa's Municipal telecommunications Network. Iowa Association of Municipal utilities,
http://www.baller.com/pdfs/cedarfalls_white_paper.pdf.
- Lehr, W., Osorio, C., Gillett, S. and Sirbu, M. (2006). Measuring broadband economic impact. Paper presented at the 33rd Research Conference on Communications, Information and Internet Policy. September 23-25, Arlington, Va.
- McGuckin, R.H., Spiegelman, M. and van der Ark, B. (2005). The Retail Revolution: Can Europe Match the U.S. Productivity Performance? Perspectives on a Global Economy.
- Nicoletti, G. and Scarpetta, S. (2003). Regulation Productivity and Growth: OECD Evidence, Economic Policy, Vol 18/36, 9-72.
- OECD (2004). The Economic Impact of ITC, Measurement, evidence and implications, OECD, Paris.
- O'Mahony, M. and Vecchi, M. (2003). Is there an ICT impact on TFP? A heterogeneous dynamic panel approach, NIESR Discussion Paper, Nr. 21.
- Pociask, S.B. (2002). Building a nationwide broadband: speeding job growth. TeleNomic Research, LLC, Herndon, VA. February 25.
- Rincon-Aznar, A., Robinson, C., and Vecchi, M. (2006). The productivity impact of e-commerce in the UK, 2001: Evidence from microdata. The National Institute of Economic and Social Research, United Kingdom.
- Roeller, L-E, and Waverman, L. (2001). Telecommunications infrastructure and economic development: a simultaneous approach, The American Economic Review, 91/4, 909-923.
- Shiu, A. and Lam, P-L. (2008). Causal relationship between telecommunications and economic growth: a study of 105 countries. Paper presented at the 17th Biennial Conference of the International Telecommunications Society (ITS). Montreal, June 24-27.
- Strategic Networks Group (2003). Economic Impact Study of the South Dundas Township Fiber Network. Report prepared for the UK Department of Trade and Industry, Ontario, Canada.
- Thompson, H.G. and Garbacz, C. (2008). Broadband impacts on State GDP: Direct and Indirect Impacts. Paper presented at the 17th Biennial Conference of the International Telecommunications Society (ITS). Montreal, June 24-27.
- Timmer, M., P., Ypma, G. and van der Ark, B. (2003). IT in the European Union: Driving Productivity Divergence? GGDC Research Memorandum Nr. 67.

- van der Ark, B. and Inklaar, R. (2006). Catching Up or Getting Stuck? Europe's Problems to Exploit ICT's Productivity Potential, EU KLEMS, Working Paper Nr. 7.
- van der Ark, B., Inklaar, R. and McGuckin, R. (2002). 'Changing Gear' Productivity, ICT and Services: Europe and the United States, GGDC Research Memorandum Nr. 60.
- van der Ark, B., Inklaar, R. and McGuckin, R. (2003): ICT and Productivity in Europe and the United States, Where Do the Differences Come From? CESifo Economic Studies, 49/3, 295-318.
- van der Ark, B., Melka, J., Mulder, N., Timmer, M.P. and Ypma, G. (2002b). ICT Investments and Growth Accounts for the European Union 1980-2000, GGDC Research Memorandum Nr. 56.

B. DATA ON CURRENT BROADBAND DEPLOYMENT IN GERMANY

Figure B.1. Planned Fiber deployment of Regional/City Networks

Carrier	FTTB deployment focus
NetCologne (muni)	Cologne (55,000 buildings/110,000 homes)
	Aachen
M'net (muni)	Munich (10,000 buildings/110,000 homes)
	Augsburg (450 buildings/5000 homes)
Hansenet (Telecom Italia)	Hamburg (15,000 homes)
Stadtwerke (muni and RWE)	Norderstedt, parts of Hamburg, Schwerte

Figure B.2. Population in cities served by municipal networks deploying fiber

City	Population	Percentage for the population
Munich	1,280,000	1.6 %
Aachen	259,030	0.3 %
Hamburg	1,776,156	2.2 %
Norderstedt	71,653	0.1 %
Augsburg	267,836	0.3 %
Schwerte	49,221	0.1 %
Cologne	995,397	1.2 %
Subtotal	5,724,387	7.0 %
Germany	82,218,000	

C. REGRESSION MODELS

Growth of GDP

Dependent Variable: Growth of GDP between 2003 and 2006

$$G_GDP (03-06) = \beta_1 * GDP_Capita_2000 + \beta_2 * G_POP (00-06) + \beta_3 * G_BBPEN (02-03)$$

	Total	Low Penetration	High Penetration
GDP per Capita 2000 (* 1'000'000)	0.0261 (0.041)	0.0627 (0.121)	0.0185 (0.050)
Population growth (2000 - 2006)	0.6318 *** (0.075)	0.5311 *** (0.102)	0.7731 *** (0.116)
Broadband penetration growth (2002 - 2003)	0.0255 *** (0.002)	0.0238 *** (0.005)	0.0256 *** (0.003)
R ² adjusted	0.6317	0.6321	0.6305
Number of Observations	424	210	214

Note: ***, ** and * indicate a significance level of 1%, 10% and 15%.

Standard errors in parentheses.

Growth of Employment

Dependent Variable: Growth of Employment between 2003 and 2006

$$G_EMP (03-06) = \beta_1 * GDP_Capita_2000 + \beta_2 * G_POP (00-06) + \beta_3 * G_BBPEN (02-03)$$

	Total	Low Penetration	High Penetration
GDP per Capita 2000 (* 1'000'000)	0.0362 * (0.024)	-0.0066 (0.072)	0.0030 (0.029)
Population growth (2000 - 2006)	1.0481 *** (0.044)	1.1265 *** (0.061)	0.9072 *** (0.066)
Broadband penetration growth (2002 - 2003)	0.0020 * (0.001)	0.0027 (0.003)	0.0061 *** (0.002)
R ² adjusted	0.6065	0.6597	0.5557
Number of Observations	424	210	214

Note: ***, ** and * indicate a significance level of 1%, 10% and 15%.

Standard errors in parentheses.

D. LIST OF ABBREVIATIONS

FTTB: Fiber to the building

FTTH: Fiber to the home

NGAN. New Generation Access Network

VDSL: Very High Rate Digital Subscriber Line