Cooperative value creation and cost reduction strategies in a disintegrated telecommunications value chain

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Abstract

The telecommunications industry is exposed to fundamental drivers of change that foster the emergence of cooperation. Increasing intra- and inter-industry competition requires telecommunication companies to explore cooperation strategies to compensate for revenue losses in their core markets. Furthermore, political impulses for market-driven broadband deployment require telecommunication companies to reorganize traditional value chains and to explore cooperation as a strategic means for value creation and cost reduction.

This cumulative dissertation assesses cooperative value creation and cost reduction strategies in a disintegrated telecommunications value chain. In a collection of six articles, a pluralist set of research methods is employed to explore cooperation strategies in different value-added steps. All publications can be grouped into two chapters, which explore cooperative value creation and cost reduction strategies.

The research section on cooperative value creation systemizes intra- and inter-industry cooperation and identifies major contingency factors that influence cooperation profitability and sustainability. The results show that inter-industry cooperation can enable telecommunication companies to differentiate existing customer solutions and extend the availability of core services beyond the scope of physical infrastructures. Moreover, evidence is provided that cooperation sustainability in broadband deployment can be improved with advanced knowledge sharing routines, casual ambiguity, time compression diseconomies and a supportive regulatory environment. Profitability of cooperative broadband deployment is primarily ensured in inter-industry cooperation with utility companies.

The second research focus analyzes the preconditions for cooperative cost reduction strategies and quantifies their effect for different cooperation scenarios. The analyses indicate that cooperation profitability with utility companies is primarily achieved in an environment with high local business customer broadband demand and an above average appreciation of the telecommunication company's marketing-related activities. The results of further analyses indicate that public authorities should aggregate customer demand in larger broadband tender areas to improve cost reduction potential between multiple fixed fiber infrastructures in rural broadband deployment. Under this precondition, co-investment savings of up to 13% can be achieved if a competitive market for metro-aggregation, backbone and co-location services is ensured. A content delivery network topology analysis demonstrates that a potential coalition of telecommunication companies can replicate the infrastructure properties that are associated with market success. The complementarity of the partner's resources contributes to cooperation stability.

Kurzbeschreibung

Die Telekommunikationsbranche durchläuft zurzeit einen grundlegenden Wandel in dem Kooperationen als strategische Handlungsoption an Bedeutung gewinnen. So führt der zunehmende brancheninterne und -externe Wettbewerb dazu, dass Telekommunikationsunternehmen Kooperationen mit dem Ziel eingehen, Einnahmeverluste in ihrem Kerngeschäft zu kompensieren. Zudem verlangen politische Impulse für einen marktgetriebenen Breitbandausbau die Entwicklung kooperativer Wertschöpfungs- und Kostenreduzierungsstrategien.

Diese kumulative Dissertation untersucht unter dem Titel *Kooperative Wertschöpfungs- und Kostenreduzierungsstrategien in einer disintegrierten Telekommunikationswertschöpfungskette* die Erfolgsfaktoren und Eigenschaften von Kooperationen in der Telekommunikationsbranche. In sechs ausgewählten Aufsätzen werden unter Zuhilfenahme verschiedenartiger Forschungsmethoden Kooperationsstrategien auf unterschiedlichen Wertschöpfungsstufen untersucht. Die Aufsatzsammlung ist in zwei Abschnitte unterteilt, die sich mit den Forschungsschwerpunkten kooperative Wertschöpfungsstrategien und kooperative Kostenreduzierungsstrategien befassen.

Der Forschungsschwerpunkt zu kooperativen Wertschöpfungsstrategien systematisiert brancheninterne und -externe Kooperationen und identifiziert Einflussfaktoren, welche die Kooperationsprofitabilität und -nachhaltigkeit beeinflussen. Die Ergebnisse der Arbeit zeigen, dass branchenübergreifende Kooperationen Telekommunikationsunternehmen dazu befähigen ihre bestehenden Angebote zu differenzieren und Dienste über die physische Reichweite ihre Netze hinaus anzubieten. Des Weiteren belegt diese Arbeit, dass die Nachhaltigkeit von Kooperationen im Breitbandausbau durch fortschrittliche Verfahren des Wissensaustauschs, kausale Ambiguität, Zeitvorteile bei der Akkumulation von Ressourcen und eine unterstützende Regulierung gefördert wird. Die Profitabilität des kooperativen Breitbandausbaus lässt sich vor allem in branchenübergreifenden Kooperationen mit Stadtwerken gewährleisten.

Der zweite Forschungsschwerpunkt analysiert die Voraussetzungen für kooperative Kostenreduzierungsstrategien und quantifiziert deren Effekt in verschiedenen Kooperationsszenarien. Die durchgeführten Analysen zeigen, dass die Profitabilität von Kooperationen mit Stadtwerken besonders in einem Umfeld mit hoher lokaler Geschäftskundennachfrage und einer überdurchschnittlichen Wertschätzung für die marketingbezogenen Fähigkeiten von Telekommunikationsunternehmen gegeben ist. Weitere Untersuchungen belegen, dass die öffentliche Hand die Breitbandnachfrage der Kunden in größeren Ausschreibungsgebieten zusammenfassen sollte, um die Nutzung von Kosteneinsparungspotentialen mit alternativen Glasfaserinfrastrukturen im ländlichen Raum zu fördern. Unter dieser Voraussetzung und unter der Annahme eines funktionierenden

Wettbewerbs in den Märkten für Metroaggregations-, Backbone- und Serverhostingdienste, können Co-Investitionen zu Einsparungen von bis zu 13% führen. Durch eine Analyse von Content Delivery Netzwerken wird gezeigt, dass eine potentielle Koalition von Telekommunikationsunternehmen markterfolgsbezogene Infrastruktureigenschaften replizieren kann. Darüber hinaus deutet die identifizierte Ressourcenkomplementarität der Partner auf eine langfristige Stabilität der Kooperation.

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Index of Abbreviations

ACE	Agent based Computational Economics
ADSL	Asymmetric Digital Subscriber Lines
API	Application Programming Interfaces
ARPU	Average Revenue per User
ATM	Asynchronous Transfer Mode
AS	Autonomous Systems
BEREC	Body of European Regulators for Electronic Communications
BRAS	Broadband Remote Access Server
BSA	Bitstream Access
B2B	Business to Business
B2C	Business to Customer
BGP	Border Gateway Protocol
CAIDA	Center for Applied Internet Data Analysis
CAPEX	Capital Expenditure
CDN	Content Delivery Network
CO	Central Office
CPE	Customer Premises Equipment
DSL	Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Multiplexer
DTAG	Deutsche Telekom AG
EC	European Commission
EU	European Union
FCC	Federal Communications Commission
FTTC	Fiber-to-the-Curb
FTTB	Fiber-to-the-Building
FTTdp	Fiber-to-the-distribution-points
FTTH	Fiber-to-the-Home
FTTN	Fiber-to-the-Node

FUT	Fixed Up To
GCO	German Cartel Office
GIS	Geographical Information System
GP	Geodata Points
HFC	Hybrid Fiber Coax
ICT	Information and Communication Technology
IKM	Informations- und Kommunikationsmanagement
IP	Internet Protocol
IPTV	Internet Protocol Television
IS	Information Systems
ISP	Internet Service Provider
LoI	Ladder of Investment
M2M	Machine to Machine
MDF	Main Distribution Frame
NGA	Next-Generation Access
NGN	Next-Generation Networks
OPEX	Operational Expenditure
OSM	OpenStreetMap
OTT	Over-The-Top
P2P	Peer-to-Peer
PoP	Point of Presence
PPP	Public Private Partnership
PSTN	Public Switched Telephone Network
QoS	Quality of Service
VDSL	High Speed Digital Subscriber Lines
VoD	Video-on-Demand
VHB	Verband der Hochschullehrer für Betriebswirtschaft e.V.
VKU	Verband Kommunaler Unternehmen

1. Introduction

1.1. Initial situation

Telecommunication networks are widely recognized as a basis for economic growth and as an indicator of a country's social prosperity [European Commission 2012b; FCC 2010; Ruhle et al. 2011; BMVI 2014]. These networks facilitate the development of the Information and Communication Technology (ICT) industry and enable companies to create new business models or modify existing ones [Fink/Wilfert 1999, 8]. Consequently, developments in the telecommunications industry have drawn much attention from economic and political decision makers. Moreover, scientists have documented industry challenges that require telecommunication operators to reorganize traditional value chains and explore new value creation and cost reduction strategies.

One body of literature has described the convergence between different ICT industries as a major driver of change [Zerdick et al. 2000, 132f; Fransman 2002; Li/Whalley 2002; Wulf/Zarnekow 2011]. Convergence refers to the tendency wherein the formerly distinct media, information technology and telecommunications industries start to offer similar services and products [Zerdick et al. 2000, 132ff]. This trend is facilitated by the internet protocol (IP) technology. It enables content providers to offer services to internet users without direct control of telecommunication companies. Consequently, this form of content distribution is also referred to as over-the-top (OTT) content delivery [Aidi et al. 2012]. Examples of the OTT content delivery of traditional telecommunication services include Voice-over-IP (VoIP) telephony or text messaging apps. These services have increased inter-industry competition and contributed to falling telecommunication revenues in fixed-line telephony and the short messaging market [Bundesnetzagentur 2013a]. However, IP-based content delivery has also enabled telecommunication companies to diversify their business activities into related industries [Wulf/Zarnekow 2011]. As an example, telecommunication companies have started to distribute textural content, music and television via IP networks. To date, however, they have been struggling to provide services and content that can compete with market offers by leading OTT service providers [Grove/Baumann 2012]. Thus, attempts by operators at industry-wide diversification into content provisioning have in many cases been followed by a disinvestment phase [Ulset 2007]. Consequently, cooperative IP-based service provisioning with OTT service providers and other telecommunication companies is considered a means to participate in the growing OTT market and increase stagnating telecommunication revenues [Aidi et al. 2012; iDate 2014].

A second body of literature indicates that in a deregulated telecommunications industry, the need for major broadband infrastructure investments is another driver of change [Cave et al. 2006; Gerpott 1998, 17ff; Picot/Wernick 2007; Mellewigt 2003, 151].

The increasing popularity of OTT services has contributed to a growing demand for higher download speeds. Major drivers of this development can be observed in the broad adoption of online services such as Video-on-Demand (VoD), catch-up TV and web streaming [iDate 2012]. These services are said to require download speeds from 16 Mbit/s, for a single standard quality stream, to 50 Mbit/s for several high definition streams [Goldmedia/BMWi 2013, 19]. Furthermore, the cloud computing market is currently experiencing yearly growth rates of up to 46% [BITKOM 2014]. Its popularity fosters the demand for high symmetrical upload and download speeds that are capable of handling even large data files. In the coming years, cloud computing, novel e-health and entertainment applications will require download speeds of 100 Mbit/s and above [Goldmedia/BMWi 2013, 19]. On the supply side, fast broadband access is primarily provided in urban areas [cf. Table 1-1].

	≥ 1 Mbit/s	≥ 16 Mbit/s	≥ 30 Mbit/s	≥ 50 Mbit/s
Urban	100.0	90.0	87.0	82.3
Semi-urban	99.6	70.1	58.4	58.4
Rural	97.3	50.7	32.9	20.5

Table 1-1: Fixed and mobile broadband availability in Germany [TÜV Rheinland/BMVI 2014, 8]

This is due to the fact that the semi-urban and rural upgrade of broadband access networks requires higher investments per customer than in urban areas [Grubesic 2008; Schneir/Xiong 2013].

In a deregulated telecommunication market, the required infrastructure investments are provided by multiple telecommunication operators in a competitive environment. This brings about several challenges. On a company level, investment uncertainty increases with decreasing market shares [Jay et al. 2014; Schneir/Xiong 2013]. Moreover, investments become more difficult if revenues are falling. In this sense, Figure 1-1 indicates several challenges for market-driven telecommunication infrastructure provisioning in Germany.

Figure 1-1 shows that the overall telecommunication market is confronted with falling revenues. This trend is largely facilitated by decreasing revenues in the wire-line market. In this segment, the German market leader Deutsche Telekom AG (DTAG) is confronted with falling overall revenues.

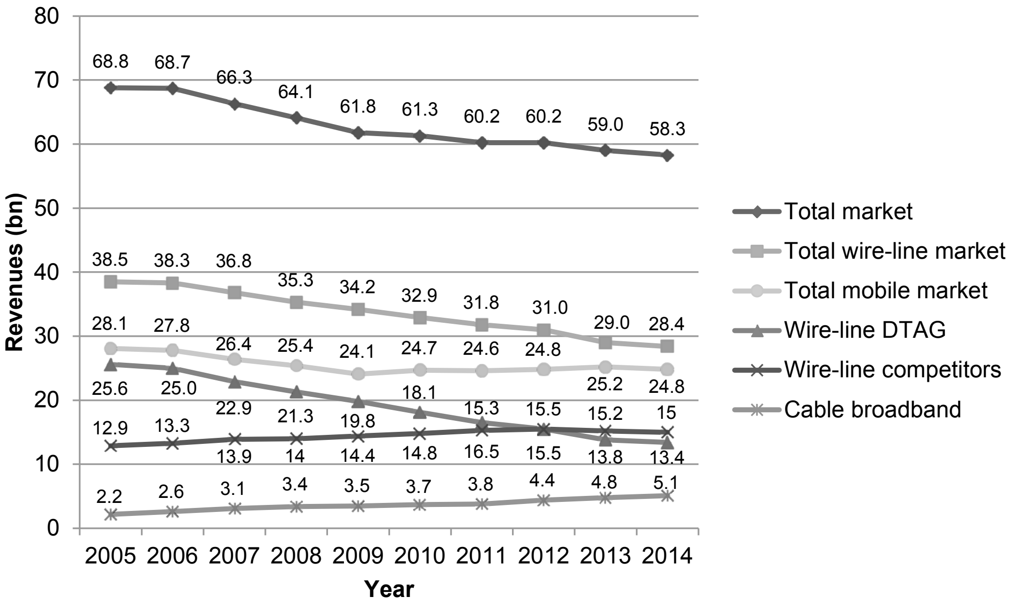


Figure 1-1: Development of revenues in the German telecommunication market [Dialog Consult/VATM 2014]

Cable operators and a large number of wire-line DTAG competitors have increased their revenues but have not been able to compensate for the DTAG revenue losses. Similarly, the revenue development in the mobile market has not been able to for compensate losses in the wire-line segment.

Acknowledging these developments, politicians have recognized that the political goal of providing download speeds of 50 Mbit/s for every German household by 2018 will require cooperative efforts from all market participants [BMWi 2009; BMVI 2014]. Consequently, politicians have mandated the German Federal Network Agency (German: Bundesnetzagentur) to improve preconditions for co-investments and the development of new wholesale products [NGA-Forum 2011]. While these measures enable additional cooperation options, it is largely unknown how various telecommunication companies with a unique set of resources will reorganize vertically integrated telecommunication value chains to cooperatively improve broadband availability [Gerpott 2010].

1.2. Dissertation objectives

The previous section indicated that increasing intra- and inter-industry competition as well as market-driven broadband deployment contributes to a growing importance of cooperation in the telecommunications industry. Consequently, telecommunication companies reorganize traditional value chains and explore cooperation as a strategic means for value creation and cost reduction [cf. Mellewigt 2003, 151ff; Gerpott 2010].

This dissertation assesses cooperative value creation and cost reduction strategies in the telecommunications industry. In a first step, cooperative value creation strategies are explored in Sections 3.1 to 3.3. Thereafter, cooperative cost reduction strategies are explored in Sections 4.1 to 4.3. Subsequently, the corresponding research questions will be introduced in detail.

Field of research	Research question	Sec-tion	Associated publication
Cooperative value creation strategies	How does cooperative value creation with Over-the-Top service providers affect the business model of telecommunication companies?	3.1	[Limbach 2014]
	How do environmental and organizational properties of telecommunication companies affect sustainable cooperative value creation in broadband provisioning?	3.2	[Limbach et al. 2013a]
	How do distinctive cooperation interfaces of a disintegrated telecommunications value chain foster value creation in broadband provisioning?	3.3	[Limbach/Zarnekow 2014]
Cooperative cost reduction strategies	Which municipal broadband adoption strategies can be distinguished and how can telecommunication companies reduce cooperation initiation costs?	4.1	[Limbach et al. 2014a]
	How can multiple fixed infrastructure owners cooperatively reduce the costs of rural broadband deployment?	4.2	[Limbach et al. 2014b]
	Which Content Delivery Network business models can be distinguished and how can a potential carrier coalition reduce the costs of market entry?	4.3	[Limbach et al. 2012b]

Table 1-2: Overview of research questions

1.2.1. Cooperative value creation strategies

As a reaction to stagnating revenues in the core business and increased intra-industry competition, many telecommunication companies have diversified their business activities into related industries such as software, hardware and media provisioning. However, the last decade showed that operators have, in most cases, been rather unsuccessful in producing offers that can compete with leading OTT service providers such as Google, Facebook and Amazon [Ulset 2007; Grove/Baumann 2012]. From an economic perspective, this development is forcing telecommunication operators into the exploration of cooperation with OTT service providers. From a technical perspective, this trend is further facilitated as telecommunication companies drastically decrease coordination costs with OTT service providers by moving their legacy infrastructure to multi-layered all-IP platforms. Recent research on the relationship between telecommunication companies and OTT service providers has predominantly assessed the question of whether companies from both industries should compete or align [Aidi et al. 2012; Bertin et al. 2011]. References to cooperation strategies are anecdotal and limited to the video delivery market [Aidi et al. 2012]. This research advances the understanding of cooperation between telecommunication operators and OTT service providers by providing a holistic cooperation typology. Thereafter, the impact of cooperation on the business model of telecommunication companies is explored. For this purpose, the following research question is proposed:

> How does cooperative value creation with Over-the-Top service providers affect the business model of telecommunication companies?

International liberalization of telecommunication markets has given rise to the emergence of new telecommunication companies. Coming from a variety of industries, market entrants differ with respect to their competencies, resources profiles and strategies. Some carriers enter the market as a subsidiary of a metropolitan or rural utility company. They address the same customers as the incumbent and engage in infrastructure competition by deploying proprietary broadband infrastructures. Other carriers focus their activities on particular target groups, such as business customers, or on selected value-added steps, such as the service provisioning layer.

In Germany, the aggregated revenues of market entrants have been exceeding those of the incumbent since 2005 [Bundesnetzagentur 2013a]. Moreover, selective entrants have become local market leaders. This market development requires carrier cooperation for corporate and national considerations. On a corporate level, cooperation is becoming increasingly important to provide the full range of communication services beyond the geographic scope of the own physical infrastructure [NGA-Forum 2011]. On a national level, carrier cooperation is required to reach national and super-national broadband goals [BMWi 2009; European Commission 2011]. Current research on cooperative broadband provisioning is primarily focusing on assessing risk sharing strategies between public and private partners in the context of infrastructure investments [Bygstad 2007; Falch/Henten 2010; Fredebeul-Krein/Knoben 2010; Gómes-Barroso/Feijóo 2010]. Success factors and the sustainability of cooperation among private investors are usually out of scope. To fill in this gap, the following research question is proposed:

> How do the environmental and organizational properties of telecommunication companies affect sustainable cooperative value creation in broadband provisioning?

The increasing demand for data-intensive services requires telecommunication companies to upgrade broadband networks. In many cases, legacy copper networks that have been rolled out by public telephone companies must be replaced in part or total. Leading countries in terms of broadband speed and coverage have provided large public funds to reach this goal. In contrast, countries such as Germany, the United Kingdom and the United States of America are avoiding large direct public investments and are lagging behind [Ruhle et al. 2011]. This gap is also due to the complexity raised by broadband plans that rely on the support of market forces. Because the investment costs of fiber infrastructures are not yet sunken, regulators and politicians must provide novel investment incentives to private investors [Cave et al. 2006]. Heterogeneous markets and disintegrated value chains exhibit multiple horizontal, vertical and diagonal cooperation opportunities that can contribute to national broadband provisioning. Previous research on cooperative broadband provision has been conceptual in nature [Gerpott 2010]. In contrast, qualitative research on the contribution of cooperation interfaces for broadband provisioning is hardly available. To address this gap, expert interviews are analyzed to identify practically relevant cooperation interfaces and derive propositions for improving cooperative broadband provisioning. Thus, the following research question is posed:

> How do the distinctive cooperation interfaces of a disintegrated telecommunications value chain foster value creation in broadband provisioning?

1.2.2. Cooperative cost reduction strategies

The high investment costs related to the civil infrastructure works of broadband deployment have been identified as the main obstacle to economically viable broadband deployment [European Commission 2010a; FCC 2010]. Therefore, the exploitation of synergies with existing physical infrastructures of utility companies is seen as a major opportunity to reduce fixed broadband deployment costs [Falch/Henten 2010]. In this sense, researchers have repeatedly highlighted the important role of public utility companies and public private partnerships (PPP) in broadband deployment [Lattemann et al. 2008; Ruhle et al. 2011; Nucciarelli et al. 2010]. Current research has primarily used qualitative case study analyses and country comparisons to derive political implications for the provisioning of financial aids. Potential municipal broadband deployment strategies have been derived in an inductive manner [Nucciarelli et al. 2010]. In contrast, quantitative research on the success of cooperative broadband deployment and municipal broadband deployment is hardly available. Another current problem of high practical relevance for cooperative broadband deployment has not been assessed. To capitalize synergies, firms need to be able to identify suitable partners and provide the organizational capability to utilize synergies [Dyer/Singh 1998]. To address both gaps in the scientific knowledge base, this research characterizes distinct municipal broadband deployment strategies based on quantitative analyses. Subsequently, environmental and organizational success factors for the implementation of a particular broadband strategy are identified. Finally, it is discussed how telecommunication companies that are interested in cooperation with utility companies can quickly identify partners for successful broadband deployment. The corresponding research question is summarized as follows:

> Which municipal broadband deployment strategies depend on telecommunication company resources, and how can telecommunication companies reduce cooperation initiation costs?

The financial challenge of overcoming the divide between rural and urban broadband availability has been repeatedly highlighted by researchers and politicians [Analysys Mason 2008; Chatzi et al. 2013; EU Commission 2010; FCC 2010; Rokkas et al. 2010]. Consequently, recent proposals of the European Commission and the Federal Communications Commission (FCC) aim to maximize synergy utilization across physical networks [FCC 2010; European Commission 2013c]. The proposed measures require owners of physical infrastructures, such as electricity, pipeline, highway and railroad networks, to host broadband infrastructures and provide additional fiber backbone capacities. State of the art research approaches for the calculation of cross-industry synergy utilization focuses on cost savings, which can be achieved through the use of spare ducts in an assumed telecommunication access topology [Analysys Mason 2008; Chatzi et al. 2013; Jay et al. 2014]. In contrast, research that assesses financial, regulatory and political implications associated with use of national physical infrastructures as a fiber backbone in rural areas is hardly available. This research has the objective of filling this gap. More precisely, it will model an optimized access network topology for all rural communities in Germany to quantify synergies that can be derived from the use of multiple fiber backbones in rural areas.

Furthermore, this research will define regulatory and political preconditions for optimal synergy utilization. These research objectives are summarized in the following research question:

> How can multiple fixed infrastructure owners cooperatively reduce the costs of rural broadband deployment?

The increasing availability of high-speed broadband connections and IP-based content provisioning contributes to the continuous traffic increase on the internet [Bundesnetzagentur 2013a; Labovitz et al. 2010]. Content Delivery Networks (CDNs) have facilitated this development because they enable the correct and efficient delivery of content by replicating data to interconnected servers that are located close to the consumer [Buyya et al. 2008]. Telecommunication companies perceive the CDN business as a natural extension of their activities in the interconnection market and have announced entry into the market [Rayburn 2011a]. Current economic and business informatics research on content delivery networks has explored telecommunication carrier activities in the CDN market based on case analyses and the theory of two-sided markets [Wulf et al. 2010a; Hau/Brenner 2009]. Explorative findings suggest that telecommunication companies exhibit favorable competencies and resources for entering the CDN market. Moreover, it is has been shown that telecommunication carriers could use their value chain position to generate additional rents by pricing content providers [Hau et al. 2011]. At the same time, analyses suggest that the CDN market is dominated by large companies such as Akamai and that most telecommunication carriers have not been able to gain significant market shares [Rayburn 2011a]. Employing a quantitative approach, this research uses real-world interconnection data to explore the relationship between CDN network properties and market success. Moreover, it assesses the sustainability of a potential CDN carrier cooperation that could reduce the costs of market entry. Accordingly, the following research question is raised:

> Which Content Delivery Network business models can be distinguished, and how can a potential carrier coalition reduce the costs of market entry?

1.3. Research design

This dissertation was written during the author’s employment at the Chair of Information and Communication Management (IKM) at the Technische Universität Berlin. The IKM research strategy is characterized by a close integration of industry and research projects to ensure the practical relevance of the research results [cf. Wulf 2012, 25; Repschläger 2013, 9; Erek

2012, 7]. In this spirit, the author's work as a research assistant was accompanied by projects with industry partners of the German telecommunications industry.

Between 2010 and 2014, the author was involved in three industry projects that inspired the publications in this cumulative dissertation.

In 2010, the author joined an ongoing project that assessed the *Impact of Quality-of-Service business models on future fixed and mobile network design*. The project was conducted in cooperation with the Deutsche Telekom Laboratories (T-Labs) and DTAG Zentrum Wholesale between 07/2009 and 03/2011 [Wulf 2012]. It was subdivided into three phases. The first and the second phases involved the qualitative exploration and documentation of Quality-of-Service (QoS) business models and laid the foundation for quantitative assessments that started in 2010 and have been supported by the author of this dissertation. In this phase, an agent-based computational economics (ACE) simulation was applied to explore financial dynamics in a QoS interconnection market [Nan 2011]. The conducted analysis inspired the publication of [Limbach et al. 2011a; Limbach et al. 2012a; Limbach et al. 2012b].

The project *Revenue streams and business models of content delivery networks* was conducted in a T-Labs cooperation between 07/2011 and 09/2011. The objective of this project was the exploration and documentation of revenue streams in various types of content CDNs. It inspired publications that involved a holistic assessment of network topology resources in the CDN market and the exploration of a CDN carrier coalition [Limbach et al. 2012a; Limbach et al. 2012b].

The third project, *Partnering models for broadband access*, was conducted in cooperation with the Deutsche Telekom Laboratories (T-Labs) and DTAG Zentrum Wholebuy between 05/2011 and 09/2013. The goal of this project was to explore cooperation opportunities for broadband access provisioning in a continuously disintegrated telecommunications value chain. In a qualitative analysis phase, 33 interviews in 15 German telecommunication companies were conducted with CEOs and experts who were directly or indirectly responsible for the initiation of cooperative relationships. Identification of the most suitable interview partners was supported by an inter-branch working group initiated by the German Federal Network Agency (German: Bundesnetzagentur). The interview assessments allowed the identification of preconditions and barriers for sustainable cooperation in broadband provisioning. Furthermore, they enabled the development of a broadband cooperation framework and the identification of the most relevant future cooperation interfaces. In the second analysis phase, more comprehensive quantitative analyses were conducted for cross-industry cooperation, which the first project phase had identified as the dominant cooperation type. This phase involved a research partnership with one of the largest associations of public communal companies in Germany, representing over 1400 utilities (German: Verband der Kommunalen Unternehmen (VKU)). A survey among the CEOs of the VKU members enabled the identification of internal and environmental factors that influence the selection of a particular utility broadband deployment strategy. Finally, by means of a techno-economic analysis, an optimized broadband access network topology has been calculated to explore the financial impact of cooperative rural broadband provisioning. This project inspired the publications [Limbach et al. 2013a; Limbach et al. 2013b; Limbach et al. 2013c; Limbach/Zarnekow 2014; Limbach et al. 2014a; Limbach et al. 2014b].

The presented projects pursue multidisciplinary goals that address economic, strategic and political aspects of the ICT industry. The first and second projects explore relationships between corporate information infrastructures and ICT markets. As such, both projects and corresponding publications address a core aspect of information systems (IS) research, that is, the conceptualization and assessment of IT artifact properties, usage and impact [Benbasat/Zmud 2003; Henver et al. 2004]. In contrast, the third project addresses IS infrastructure provisioning, which has been largely ignored by the IS community but has recently evoked calls for more IS research in this field [Tilson et al. 2010].

IS research evolved from the disciplines of organizational science, information science and business information science and is characterized by methodological and theoretical diversity [Benbasat/Zmud 2003]. Its research methods can be classified into a matrix according to their research paradigms and degree of formalization [Wilde/Hess 2007]. Research paradigms exhibit either behavioral or constructivist approaches. A behavioral research approach seeks to predict or explain organizational, market or human behavior [Hevner et al. 2004]. In contrast, a constructivist approaches aim to extend the existing knowledge base through the creation of new artifacts and theories. The degree of formalization distinguishes qualitative and quantitative research methods. Findings of qualitative research methods are predominantly presented in a natural language, whereas quantitative methods use numerical means to describe results [Wilde/Hess 2007]. Table 1-3 classifies published articles according to the applied research methods. References in black letters refer to articles that are included in this dissertation. Publications in grey letters refer to preliminary studies and other publications.

		Paradigm	
		behavioral	constructivist
Degree of formalization	qualitative	• [Limbach et al. 2011b]: case studies • [Limbach et al. 2011c]: case studies • [Limbach et al. 2012c]: case studies • [Limbach et al. 2013a]: case studies[1] • [Limbach et al. 2013c]: case studies • [Kübel et al. 2014]: case studies	• [Limbach et al. 2013b]: argumentative-deductive analysis • [Löser et al. 2013]: argumentative-deductive analysis • [Pröhl et al. 2013]: argumentative-deductive analysis • [Limbach/Zarnekow 2014]: grounded theory • [Limbach 2014]: reference model
	quantitative	• [Limbach et al. 2012a]: quantitative cross-sectorial analysis • [Limbach et al. 2012b]: quantitative cross-sectorial analysis • [Limbach et al. 2014a]: quantitative cross-sectorial analysis	• [Wulf et al. 2010c]: formal-deductive analysis • [Wulf et al. 2011a]: simulation • [Limbach et al. 2011a]: simulation • [Limbach et al. 2014b] simulation

Table 1-3: Research method classification according to [Wilde/Hess 2007]

Table 1-3 indicates that this dissertation follows a methodological pluralist approach to address the introduced research questions. In line with Hevner et al. [2004], it is argued that, driven by the properties of the research object, an appropriate method must be selected to make a meaningful contribution to the existing research knowledge base.

Qualitative research methods are suitable for the exploration of complex causal relationships [Orlikowski/Baroudi 1991]. Methods such as *case study analysis*, *grounded theory* and

[1] [Limbach et al. 2013a] is classified as a case study because the grounded theory approach is used as a data collection method within the case analysis.

reference modeling can be applied for exploratory qualitative assessments [Strauss 1987; Yin 2007, 28; Vom Brocke 2003, 37]. In such cases, they are particularly suited to assess research objects that have not been intensively assessed in scientific literature. In this dissertation, explorative qualitative research methods have been applied to ensure research relevance and guide quantitative analyses.

A *Case study analysis* assesses a contemporary phenomenon within its natural context [Wilde/Hess 2007]. It is applied if the boundaries between the phenomenon and the context are not evident [Yin 2007, 13; Benbasat et al. 1987]. In this dissertation, an exploratory case study analysis is conducted to generate hypotheses on the preconditions for sustainable cooperation in broadband provisioning [cf. Limbach et al. 2013a].

Grounded theory is a research method that inductively derives theory about a phenomenon [Strauss 1987]. In contrast to case study analysis, it postulates the use of a systematic and well-defined set of coding procedures to develop concepts and categories that are grounded in the interview data. Existing theories may be used to guide the initial coding process [Corbin/Strauss 2008, 89]. In [Limbach/Zarnekow 2014], a framework for cooperative broadband provisioning is developed to guide further research and provide political implications.

The goal of *reference modeling* is to provide a simplified and optimized model of a system [Fettke/Loos 2005]. A reference model can provide a template for specific model implementations or serve as a reference for model comparisons [Vom Brocke 2003, 37]. [Limbach 2014] uses a deductive reference modeling approach to describe customer value creation in cooperative business models.

Quantitative research methods can make an important contribution to the exploration of unilateral causal relationships, which can be explained by numerical means [Orlikowski/Baroudi 1991]. In quantitative *cross-sectorial analysis* and *simulations*, novel scientific knowledge is generated based on empirical evidence or logical deduction from premises that are known in advance. In this dissertation, quantitative research methods have been applied to quantify the impact of cooperation under premises that prior qualitative research has identified as most relevant.

A *quantitative cross-sectorial analysis* assesses data that is collected at a specific point in time and represents either the basic population or a representative sample [Wilde/Hess 2007]. In [Limbach et al. 2012b], the network topology data of CDNs is assessed to infer the impact of infrastructure properties on business performance. In [Limbach et al. 2014a], a national survey is analyzed by means of factor and cluster analyses to identify latent constructs that influence strategy selection and the success of particular broadband deployment strategies.

A *simulation* maps the behavior of a system to a formal model and considers environmental influences with particular parameter settings [Wilde/Hess 2007]. Model construction and endogenous model characteristics contribute to the generation of new knowledge [Wilde/Hess

2007]. In [Limbach et al. 2014b], a formal techno-economic model is used to simulate the cooperative deployment of broadband infrastructures to all rural communities in Germany.

More detailed information about the applied research methods and related quality measures will be presented in Chapters 3 and 4.

1.4. Dissertation structure

This dissertation is composed of the publications listed in Table 1-4. Articles have been chosen from the complete set of publications, which is provided in Section 6.1.5. The selection process was guided by considerations of publication quality and coherence.

An indication of the publication quality is provided in columns four and five of Table 1-4. Column *JQ* refers to the Jourqual ranking. This quality ranking is determined based on evaluations by members of the German association of professors for business administration (German: Verband der Hochschullehrer für Betriebswirtschaft e.V. (VHB)). Column *WI* refers to a ranking of the scientific commission for business informatics within the VHB. This ranking covers a broad spectrum of journals, conferences and lecture notes that are relevant to the German business informatics community. Both rankings represent the perceived quality of the review process and the relevance of the publication outlet to the corresponding research community.

Title	Published in	Reference	Ranking	
			JQ[2]	WI[3]
Cooperative service provisioning with OTT service providers – An explorative analysis of telecommunication business models	Proceedings of the 2014 ITS European Regional Conference	[Limbach 2014]	n/a	n/a
Cooperative private Next-Generation Access deployment – A relational view	Proceedings of the 46th Hawaii International Conference on System Sciences (HICSS)	[Limbach et al. 2013a]	C	B
Cooperative next-generation access provisioning – Evidence from the German broadband market	Proceedings of the Multikonferenz Wirtschaftsinformatik, Paderborn (MKWI 2014)	[Limbach/ Zarnekow 2014]	D	C
A contingency perspective on municipal broadband adoption	Proceedings of the International Conference on Information Systems (AMCIS 2014)	[Limbach et al. 2014a]	D	B
Improving rural broadband deployment with synergistic effects between multiple fixed infrastructures	Telecommunication Policy Journal (Under review)	[Limbach et al. 2014b]	C	n/a
Business models and competition in the content delivery network market – An infrastructure analysis	Proceedings of the 20th European Conference on Information Systems (ECIS)	[Limbach et al. 2012b]	B	A

Table 1-4: Overview of research question-related publications in this dissertation

Publication coherence was ensured along two dimensions. In the first dimension, articles can be assigned to different value-added steps along the telecommunications value chain. Table 1-5 indicates that the telecommunications value chain can be subdivided into three functional

[2] Jourqual ranking [VHB 2011]
[3] WI-Orientierungslisten [WKWI 2008]

layers: *Service*, *Network* and *Asset* [Bouras et al. 2009; Frigo et al. 2004; Fransman 2002]. The service layer ensures access to end customers. In this layer, marketing and product development are the primary value-added activities. In [Limbach 2014], it is explored how OTT service providers and telecommunication companies cooperatively produce new services. In the network layer, companies operate active infrastructure and enable data transport to backbone networks. In this sense, [Limbach et al. 2012b] assesses the economic implications of cooperation in the provisioning of content delivery backbone structures. In the asset layer, companies provide and maintain the passive infrastructure required for offering services in the network and service layers. In [Limbach et al. 2014b], potential cost savings from the cooperative usage of access network assets are explored. A more detailed introduction to the telecommunications value chain and its layers is provided in Chapter 2. Table 1-5 indicates that selected publications triangulate a layer-specific assessment with a holistic perspective on cooperation in the telecommunications value chain. In the case of the publications [Limbach et al. 2013a] and [Limbach/Zarnekow 2014], holistic value chain assessments have guided layer-specific publications [Limbach 2014; Limbach et al. 2014b].

<table>
<tr><th>Generic value chain layers</th><th>Layer-specific assessment</th><th>Holistic value chain assessment</th></tr>
<tr><td>Service layer
(Access, Services Content)</td><td>Cooperative service provisioning with OTT service providers – An explorative analysis of telecommunication business models [Limbach 2014]</td><td rowspan="3">• Cooperative private Next-Generation Access deployment – A relational view [Limbach et al. 2013a]
• Cooperative next-generation access provisioning – Evidence from the German broadband market [Limbach/Zarnekow 2014]
• A contingency perspective on municipal broadband adoption [Limbach et al. 2014a]</td></tr>
<tr><td>Network layer (Active Equipment, Backbone and distribution)</td><td>Business models and competition in the content delivery network market – An infrastructure analysis [Limbach et al. 2012b]</td></tr>
<tr><td>Asset layer
(Passive Equipment)</td><td>A synergy evaluation model for rural cross-industry broad-band deployment [Limbach et al. 2014b]</td></tr>
</table>

Table 1-5: Publications related to telecommunications value chain layers

The second coherence dimension ensures that all publications exhibit superordinate motivation, theoretical foundations, and research objectives and that they can be grouped into two chapters. Based on these considerations, this dissertation is structured as depicted in Figure 1-2.

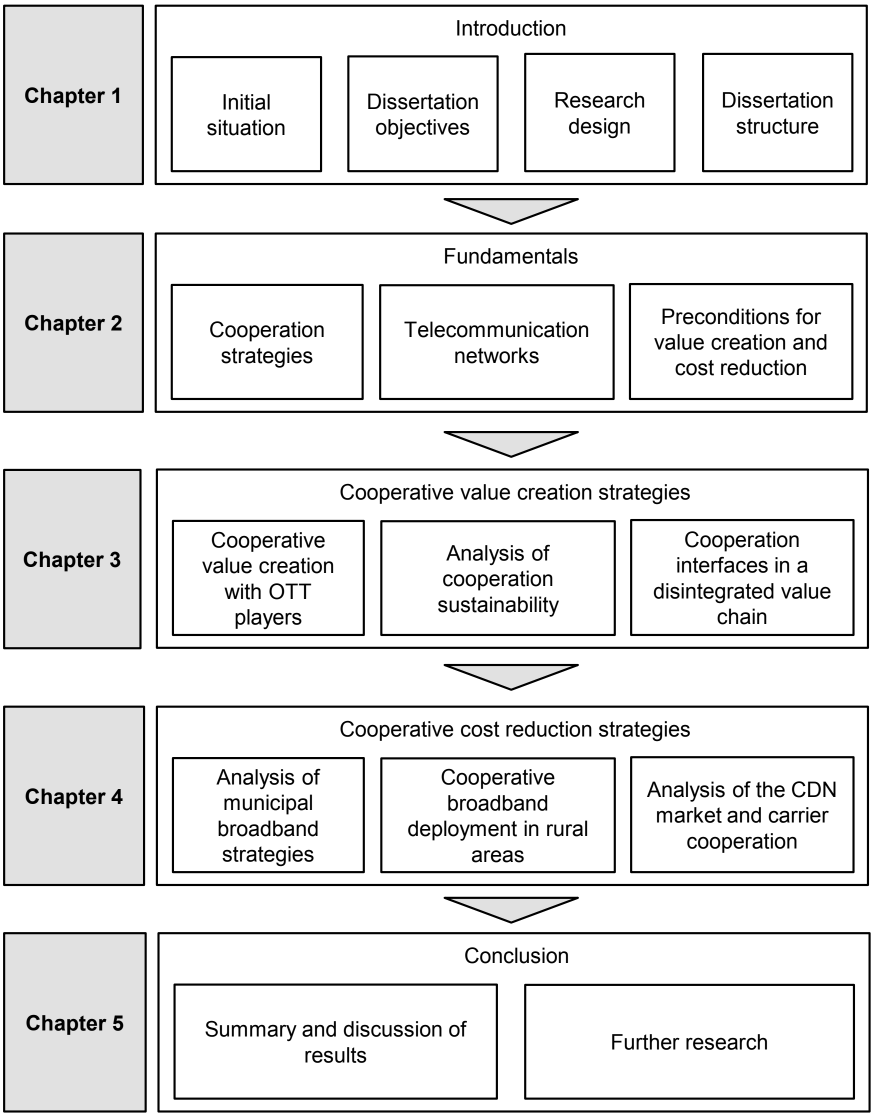


Figure 1-2: Dissertation structure

Chapter 1 presents the motivation and the objectives of this dissertation. In Section 1.1 the initial situation of the telecommunications industry is introduced in the light of increasing broadband demand and cross-sector competition. The subordinate objectives for cooperative value creation and cost reduction are introduced in Section 1.2. Thereafter, Section 1.3 is presenting the research design which motivates the use of the employed research methods. Section 1 explains how the dissertation structure is derived from considerations of publication quality and overall coherence.

Chapter 2 introduces the common scientific basis of all selected publications [cf. Table 1-4]. In this sense, Section 2.1 is defining basic concepts of *Cooperation strategies* and introducing fundamental theories that explain its emergence. Section 2.2 presents the characteristics of telecommunication access networks and content delivery networks. Strategies for value creation and cost reduction in a disintegrated telecommunications value chain are discussed in

Section 2.3. This section defines the boundaries of the assessed telecommunications value chain and introduces a fundamental regulatory framework for fostering infrastructure investments in competitive market. Selected parts of Chapter 2 have previously been published in other publications which are listed in Table 6-16.

Chapter 3 explores cooperative value creation in a disintegrated value chain based on three publications: Limbach [2014], Limbach et al. [2013a] and Limbach/Zarnekow [2014]. Section 3.1 assesses cross-industry value creation patterns and their impact on the business model of telecommunication operators. The environmental and organizational impact on the sustainability of cooperative value creation in broadband provisioning is assessed in Section 3.2. In Section 3.3, a framework for cooperative broadband provisioning is created to explore the relevance of generic cooperation interfaces at different value-added steps of a disintegrated telecommunications value chain.

Chapter 4 assesses cooperative cost reduction strategies and includes the publications Limbach et al. [2012b], Limbach et al. [2014a] and Limbach et al. [2014b]. Findings of Section 3.2 have inspired the publications in Section 4.1 and Section 4.2. In this sense, Section 4.1 presents an analysis of municipal broadband adoption strategies to reduce the costs of cooperation initiation with telecommunication companies. In Section 4.2 it is explored how multiple fixed infrastructure owners can cooperatively reduce the costs of rural broadband deployment. The subsequent Section 4.3 provides an analysis of CDN business models and assesses how a potential carrier coalition can reduce the costs of market entry.

Chapter 5 provides a superordinate conclusion for all selected publications and discusses the core results in Section 5.1. Finally, suggestions for further research are proposed in Section 5.

2. Fundamentals

This chapter introduces fundamental concepts and theories of cooperation strategies (Section 2.1), infrastructures of telecommunication networks (Section 2.2) and preconditions for value creation and cost reduction strategies (Section 2.3).

2.1. Cooperation strategies

Inter-firm cooperation has been extensively discussed in strategic literature and proposed as a key response to several challenges faced by the telecommunications industry (cf. Section 1.1). The cooperation concept represents a central foundation of this work and is introduced in more detail in the subsequent sections. First, Section 2.1.1 provides a definition for the terms *strategy* and *cooperation*. Second, the explanatory contribution of fundamental theories in strategic literature is presented in Section 2.1.2. Third, in Section 2.1.3, *cooperation* is discussed as a strategic course of action in response to environmental and internal company influences.

2.1.1. Definition and systematization

The economic literature uses the term *strategy* in a wide variety of contexts, and a universal understanding does not exist [Grant 1991, 18f; Mintzberg 1994, 23]. An early economic definition of the term *strategy* was proposed by Chandler [1962, 13] as *the determination of the basic long-term goals and objectives of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals*.

Later, Quinn [1980, 7] proposed the following extended definition:

A strategy is the pattern or plan that integrates an organization's major goals, policies and action sequences into a cohesive whole. A well-formulated strategy helps marshal and allocate an organization's resources into a unique and viable posture based upon its relative internal competencies and shortcomings, anticipated changes in the environment, and contingent moves by intelligent opponents.

Quinn's [1980, 7] definition highlights that strategy formulation requires an assessment of internal competencies and external company forces. In this sense, it aligns with the idea of Porter [1980, 35], who argues that a company should select generic strategies such as cost leadership, differentiation or niche strategies based on an analysis of the companies' competitive environment. Moreover, it aligns with Grant's [1991, 245] and Andrew's [1997, 54] finding that sustainable competitive advantage regularly stems from a company's internal resources and competencies.

The emergence of the internet has not only rapidly lowered communication costs but has also resulted in a new strategy perspective on network industries [Grant 1991, 18]. In this sense, Shapiro and Varian [1999, 227] have noted that network effects can rapidly change a firm's market position and that cooperation may be essential to achieve a competitive advantage. Similarly, Nalebuff and Brandenburger [1996, 11ff] have introduced the concept of co-opetition, emphasizing that cooperation strategies are equally important as competition strategies. Thus, the term *cooperation* shall be defined and systemized in the subsequent part of this section.

Cooperation can be defined as a *medium or long-term collaboration of economically independent organizations* [Picot et al. 2003, 305f]. Moreover, *cooperation* is *voluntary and can generally be canceled by both companies at any time* [Gerpott 2005]. *Cooperation* between two or more organizations can be systemized in several ways. In this sense, a variety of common classification dimensions exist and are summarized in Table 2-1 [cf. Gerpott 2010; Rautenstrauch et al. 2003, 13ff; Morschett 2003].

Dimension	Exemplary characteristics			
Degree of mutual binding	Contract based	Informal		
Geographic scope	Local	Regional	National	International
Number of partners	Bilateral	Trilateral	Network	
Scope	F&E	Procurement	Production	Marketing
Transaction form	Supplier contract	Firm consortium	License contract	Management contract
Direction	Horizontal	Vertical	Diagonal	

Table 2-1: Dimensions for cooperation systematization [adapted from Rautenstrauch et al. 2003, 13; Morschett 2003]

Table 2-1 shows that *cooperation* can be either informal or formal in nature. A formal cooperation is usually documented with contracts. Consequently, a basis for legal claims does exist. In contrast, informal *cooperation* does not provide a basis for legal claims and can be used for the pure exchange of knowledge and information [Rautenstrauch et al. 2003, 15]. Furthermore, *cooperation* can be systemized according to the geographical scope. In this context, it is important to distinguish between the company's home market and the location of cooperation [Rautenstrauch et al. 2003, 16]. Two international companies may, for example, decide to cooperate in a particular local market where both partners have a rather weak market position [Holtbrügge 2005]. The number of participating partners or the *cooperation* scope with respect to the value-added step within a company can be further approaches to the systemization of *cooperation* [Morschett 2003]. Many authors have also systemized *cooperation* according to the degree of internalization in a continuum between a market and a company hierarchy [Rautenstrauch et al. 2003, 9; Morschett 2003; Mellewigt 2003, 14; Picot et al. 2003, 53]. In this sense, a supplier contract denotes a type of cooperation that requires a relatively low degree of vertical integration and exhibits similarities to the arm's length exchange of products at a market [Mellewigt 2003, 14]. In contrast, a management contract is associated with a higher degree of vertical integration [Morschett 2003]. In such a cooperative agreement, managers act under preconditions similar to those that can be found in a company hierarchy [Combs/Ketchen 1999].

Of all available systemization options for *cooperation*, Gerpott [2005] has identified the *direction* as the most appropriate dimension for assessing the peculiarities of the telecommunications industry. He argues that the division of labor in the telecommunications value chain and corresponding business relations are best assessed and distinguished in *horizontal*, *vertical* and *diagonal cooperation* [Gerpott 2005]. Thus, this dimension and its characteristics are subsequently introduced in more detail.

Horizontal cooperation refers to the coordination of activities at the same value-added step of the supply chain [Gerpott 2005]. *Horizontal cooperation* activities result in similar market goals, products, and services. Moreover, economies of scale and scope can result in cost reduction effects and increase market power [Rautenstrauch et al. 2003, 14]. Therefore, from a regulatory perspective, *horizontal cooperation* is potentially harmful for competition because partners are likely to cut competitive activities in the field of their cooperation to compete in other value-added steps [Mölleryd 2011; Gerpott 2005; BEREC 2012b].

Vertical cooperation refers to the coordination of activities at upstream or downstream value-added steps of the supply chain [BEREC 2012b]. Thus, cooperating companies are either in a supplier or buyer relationship. In this context, *vertical cooperation* has to be distinguished from arm's length market relationships and the regulatory-induced exchange of wholesale products: Arm's length market relationships are characterized by the exchange of standardized products that can be produced and bought from a variety of different companies. In contrast, most telecommunication networks are complex systems that can be built from standardized equipment but require specialized integration solutions that are often provided by selected suppliers in the course of strategic *vertical cooperation* [Gerpott 2005]. In deregulated telecommunication markets, the national incumbent is required to provide various wholesale products to competing telecommunication companies [BEREC 2010]. Thus, not every observable supplier relationship for complex products is voluntary and can be considered a *vertical cooperation* [Gerpott 2005]. However, if complex wholesale products are provided to selected partners on a voluntary basis and if they cannot be bought from a variety of suppliers, this relationship will subsequently be referred to as *vertical cooperation*. In general, *vertical cooperation* secures supply or demand and improves economic efficiency within the value chain [Rautenstrauch et al. 2003, 14; Mölleryd 2011]. From a regulatory perspective, it is said to be less harmful to competition than *horizontal cooperation* [BEREC 2012b].

Diagonal cooperation refers to the coordination of activities between companies of the telecommunications industry and companies of other industries [Gerpott 2005]. Diagonal cooperation can be subdivided into input-oriented and output-oriented cooperation. Whereas input-oriented cooperation focuses on the joined utilization of complementary resources, output-oriented cooperation aims at the creation of novel services or products [Gerpott 2005; Rautenstrauch et al. 2003, 15].

2.1.2. Explanatory contribution of fundamental theories

During the last century, the strategic literature has developed several theories that provide explanations for the emergence of inter-firm cooperation. Frequently cited theories include *transaction cost theory*, *resource dependency theory* and the *resource-based view* [Mellewigt 2003, 35; Child/Faulkner 1998, 20ff; Dengler 2000, 11ff; Rautenstrauch et al. 2003, 31ff].

In the following bullet points, these theories will be introduced in more detail, as their central concepts guided the design of the semi-structured expert interviews [cf. Appendix 6.1.1]:

- *Transaction cost theory* focuses on the analysis of transactions, which can be defined as the transfer of property rights [Williamson 1991]. The organizational failure framework proposed by Williamson [1975, 40] is based on the assumption that transactions differ with respect to frequency, uncertainty and ease of measurement and the risk for opportunism. In his later work, Williamson extended the *opportunism framework* item with the *asset specificity* concept. *Asset specificity* refers to the ease of redeploying an asset for an alternative use, and it represents a central transaction property for the employment of make-or-buy decisions [Williamson 1991].
  In general, transaction costs occur during different phases of a transaction. Before a transaction is carried out, it includes costs for purchase initiation (search, consulting, travel) and purchase (negotiation, legal settlement) [Picot et al. 2003, 49]. Moreover, transaction costs involve deployment (process steering) and post-purchase (monitoring of quality and deadlines, adjustments) [Li/Whalley 2002]. Furthermore, transactions can be subject to *hold-up opportunism* and *bound rationality* [Knyphausen-Aufseß 1994, 79]. *Hold-up* referrers to a situation where two or more partners engage in a contractual relationship based on incomplete information, and an opportunistic non-owner of assets can withhold assets ex-post from production [Williamson 1975, 26f]. Based on the assessment of transaction costs, a company must decide whether to produce products and services within the company by means of cooperation or by procuring them from a market. In general, market procurement is advised when asset specificity is low, as specialized suppliers may be able to realize economies of scale [Li/Whalley 2002]. A market is characterized by autonomous adaption and few obligations between the parties of a nonspecific transaction [Williamson 1991]. In contrast, a company hierarchy is advised if the asset specificity of a transaction is high [Child/Faulkner 1998, 21]. That is, steps of the value chain should be vertically

integrated if the organizational instruments of an organization offer multiple instruments for dealing with asymmetric information, possibly resulting in opportunism [Picot et al. 2003, 55]. In transaction cost theory, cooperation can be characterized as a hybrid institutional arrangement between market and hierarchy. Thus, cooperation is advised if transactions are characterized by medium asset specificity. Although a transaction's asset specificity is an important indicator of the optimal institutional arrangement, uncertainty and complexity also need to be considered. If these transaction parameters are high, a hierarchy may be the optimal institutional arrangement. Similarly, a market is the optimal arrangement if the uncertainty and complexity are low. Consequently, medium uncertainty, complexity and asset specificity imply the establishment of cooperation. Similarly, it can be argued that cooperation develops if partners want to retain the advantage of autonomous decisions and manage to share transaction-specific investments and if the consideration of uncertainty forecloses a market arrangement [Ménard 2004].

- The *resources-dependence theory* is based on the idea that all organizations depend on resources that may be controlled or possessed by other organizations. Thus, organizations need to interact to acquire and maintain the resource mix necessary to survive [Pfeffer/Salancik 1978, 47]. Company interaction can either be competitive, symbiotic or a combination of both [Dowling et al. 1996]. Thus, companies need to become aware of these dependencies and then must decide whether it is necessary to reduce the degree of external *resource dependence*. To assess dependencies, a company must know to what percentage it depends on the resources of another organization and how critical these resources are for business success [Pfeffer/Salancik 1978, 46]. If a company identifies dependence on resources of another company, it should assess to what extend this company is free to determine rules about the resource usage and if these resources can be procured from a different supplier [Dowling et al. 1996]. Once the nature of the dependencies is known, it may be necessary to reduce the dependence on external resources. If a cooperation partner is not substitutable due to its set of resources, dependent companies will face problems similar to the hold-up situation know from transaction cost theory [Bae/Gargiulo 2004]. In general, dependencies can be reduced by selecting different market niches, by internalizing dependency effects via mergers or by establishing linkages among organizations that reduce asymmetric information and insecurities [Sheppard 1995; Pfeffer/Salancik 1978, 48]. The *resource-dependence* approach assumes that organizations are particularly willing to cooperate if resources are scarce and partners can improve their market position by bundling complementary resources. However, it can also be observed that cooperation regulates the possession of important resources [Sheppard 1995].

- The *resource-based view* of the firm represents a theoretical framework that aims to explain how firms create competitive advantage and formulate sustainable competitive strategies [Barney 1991; Wernerfelt 1984]. According to the *resource-based view*, a firm's competitive advantage stems from the resources the firm disposes of [Barney 1991; Eisenhardt 2000; Wernerfelt 1984]. Some authors, e.g., [Grant 1991, 245] or [Markides/Williamson 1996], distinguish firm resources from firm capabilities. In this sense, capabilities are regarded as the skills derived from human competencies [Markides/Williamson 1996]. However, to reduce complexity and still maintain generality of the results, the definition proposed by Barney [1991] is adapted in this work. That is, capabilities are subsumed into the concept of resources. In this sense, [Barney 1991] understands firm resources as all assets, capabilities, processes, information and knowledge controlled by a firm that facilitate the implementation of competitive strategies. Furthermore, firm resources can be classified into three categories: physical, human and organizational resources [Barney 1991]. Physical resources include a firm's physical assets, such as technology, plant and equipment, its geographical location and access to raw materials. Human resources comprise the knowledge, experience and relationships of individual employees. Finally, organizational resources comprise the management systems and informal relations within the firm and toward its environment [Barney 1991]. The *resource-based view* assumes that within an industry, different companies may control different resources, while the resources themselves may not be exchanged easily across firms in the short term [Barney 1991; Eisenhardt 2000; Wernerfelt 1984]. On the one hand, these assumptions imply that sustainable competitive advantage can be achieved if the firm's resources are valuable, rare, inimitable and non-substitutable [Barney 1991; Eisenhardt 2000; Wernerfelt 1984]. On the other hand, because long-term competitive advantage stems from the firms' resource configurations, all organizations depend on resources that may be controlled or possessed by other organizations [Pfeffer/Salancik 1978, 51]. Thus, organizations need to interact to assemble the resource bundles necessary to compete [Pfeffer/Salancik 1978, 50]. Companies may thus overcome resource-based growth constraints, as cooperation provides the opportunity to obtain and share resources [Combs/Ketchen 1999; Eisenhardt 2000]. In fact, resource sharing has frequently been used to explain inter-company cooperation [Combs/Ketchen 1999; Gulatti 1999]. The *relational view concept* can be considered an extension of the *resource-based view* of a firm [Lee/Lee 2008]. It proposes that cooperation partners need to create relational sources of supernormal profit along with mechanisms that preserve profits [Dyer/Singh 1998]. In contrast to the *resource-based view*, resources for production are not necessarily located within the firm's boundaries but are created between two or more firms. A more detailed introduction to the *relational view* in provided in Section 3.2.3.

In addition to the presented explanations for the emergence of cooperation, game theoretic approaches have been used by a community of researchers to model strategic behavior between firms. Despite recent advances, however, game theoretic approaches are limited in their ability to incorporate the complexity of firm strategies and inter-firm relationships [Sydow 1992, 171]. Moreover, the premise of fully rational decision makers neglects visionary and entrepreneurial aspects of firm strategies [Knyphausen-Aufseß 1994, 76]. Because the defined research questions [cf. Section 1.2] explore topics that often lag behind a broad body of theoretical literature that could fully guide rational decisions, it seems inappropriate to accept these limitations. Thus, game theoretic analyses have not been conducted in this work.

2.1.3. Cooperation as a strategic course of action

The previous section introduced theories that perceive processes and the structure of a firm as variables that can be freely manipulated by managers [Miles/Snow 1986, 253]. In contrast, *contingency theory* argues that managers select a particular strategy, such as cooperation, in response to existing environmental and internal conditions [Sydow 1992, 210]. Figure 2-1 depicts exemplary environmental and internal influences that can impact management decisions with respect to strategy selection and organizational design.

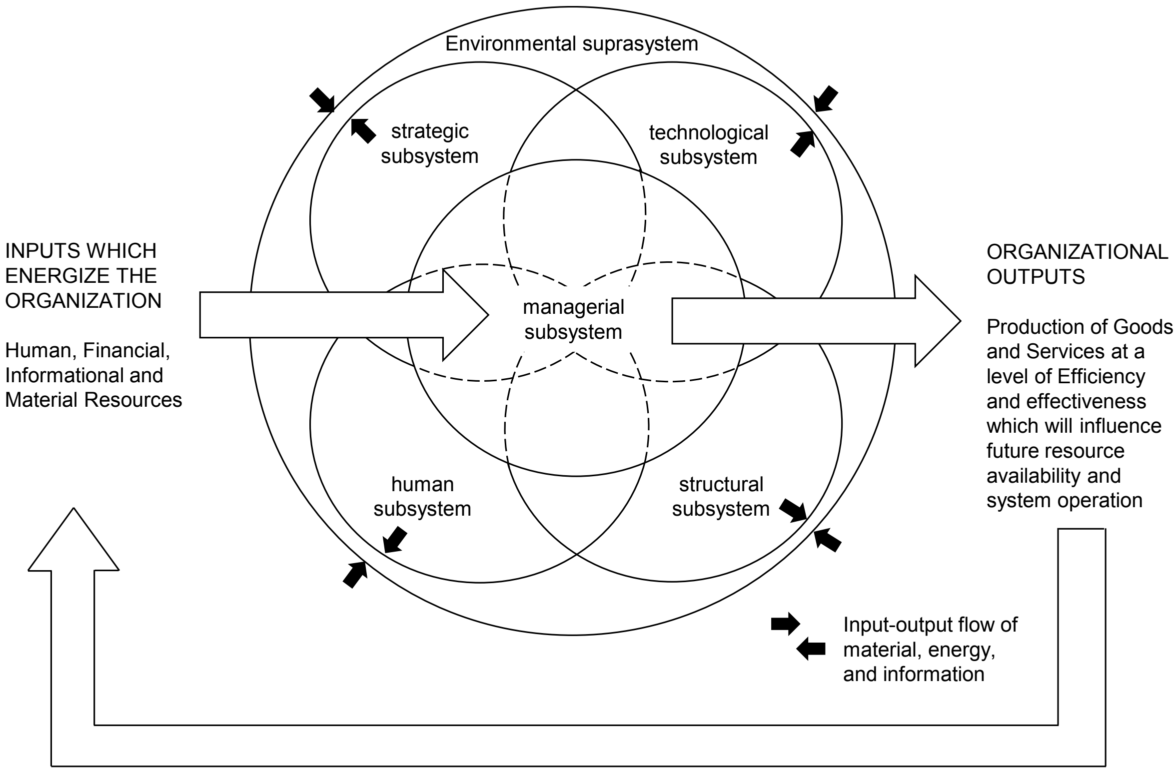


Figure 2-1: Exemplary contingency view of an organization [adapted from Morgan 1986, 49]

Over the years, a wide variety of different internal and external contingency factors that can affect organizational design have been proposed [Miles/Snow 1986, 260]. However, many authors have considered external factors such as competition and technological influences in their contingency theory assessments [Sydow 1992, 210f; Morgan 1986, 62; Miles/Snow 1986, 254ff]. Similarly, authors agree that human resources and capabilities influence management decisions [Miles/Snow 1986, 253; Sambamurthy/Zmud 1999; Morgan 1986, 63].

Dowling et al. [1996] build bridges between fundamental theories and a *contingency theory* view on cooperation by deriving external and internal drivers of cooperation based on *transaction cost* and *resource-dependency theory*. These drivers are introduced in more detail below:

External drivers of cooperation can be derived from the structural properties of an organization's environment and can influence the uncertainty of a company's decision making [Pfeffer/Salancik 1978, 146]. Dowling et al. (1996) identify the external cooperation drivers: *market concentration*, *scarce resources*, *regulation* and *global industries*. These drivers are explained in detail below:

- Cooperative relationships are more likely in *concentrated industries* because large organizations exhibit more interfaces with potential cooperation partners than smaller companies.
- An environment with *scarce resources* leads to more conflicts and dependencies between organizations than a munificence environment. In general, scarce resources can be multifold in their nature. That is, they can refer to physical or financial resources and time constrains [Wrona/Schell 2005]. Increasing dependencies between organizations increase the likelihood of cooperative relations [Dowling et al. 1996].
- *Regulation* can force organizations to cooperate. Many regulated telecommunication markets force incumbents to offer predefined products and services to competitors. Moreover, governmental intervention can prevent organizations from expanding to a different market. Thus, cooperation in network industries may be necessary to enable cross-network services for end customers [Dowling et al. 1996].
- Several authors have identified *global presence* as a driver of cooperative relations [Holtbrügge 2005; Dowling et al. 1996]. While two companies may be competitors in one country, it may to necessary to cooperate outside their home market.

Internal drivers of cooperation can be derived from company-specific properties and strategies [Pfeffer/Salancik 1978, 145]. Dowling et al. (1996) identify several internal cooperation drivers: *no intersections in their core competencies*, *combination of complementary resources*, *acquisition of knowledge* and *common goals*. These drivers are explained in detail below:

- Cooperative relations between organizations are more likely if companies do not exhibit *intersections in their core competencies* [Dowling et al. 1996]. Moreover, the bundling of competencies represents the means to avoid conflicts [Holtbrügge 2005].

- The stability of cooperation can be increased with congruent or complementary resources [Abdallah/Wadhwa 2009; Morschett 2005]. The *combination of complementary resources* enables bundling of company strengths or the compensation of weaknesses. Congruent resource profiles enable cooperation that can lead to cost degression effects, while complementary resources enable improvement of the market position [Holtbrügge 2005].
- The *acquisition of knowledge* is another driver of cooperation. Research and development cooperation is common if knowledge acquisition is desired by several companies. Moreover, organizations can turn to cooperation for the exchange of existing technology-specific knowledge, as this can improve the identification of new market opportunities [Abdallah/Wadhwa 2009].
- Another internal driver of cooperation is *common goals* of organizations. This driver requires a trustworthy relationship between the partners, and related cooperation is characterized by defined rules and processes aimed at minimizing opportunistic behavior [Abdallah/Wadhwa 2009].

Originally, *contingency theory* was proposed to advance organizational theory. However, during the last few decades, researchers have applied the theory to different fields, including IS research [Otley 1980; Sambamurthy/Zmud 1999]. In this dissertation, *contingency theory* is applied to derive a framework for cooperative broadband deployment (Section 3.3) and to assess municipal broadband adoption strategies (Section 4.1).

2.2. Telecommunication networks

Telecommunication networks enable the exchange of data between clients located at different geographical sites [Werner 2005, 4]. They are composed of routers that are connected by transmission lines that bridge physical distances [Tanenbaum 2003, 256]. Exemplary transmission mediums include copper wires, fiber optic lines and the air [Zarnekow et al. 2013].

To address the increasing data demand, operators are gradually migrating telecommunication networks and corresponding transmission protocols to IP-based *Next-Generation Networks* (NGN). In contrast to legacy infrastructures, NGNs are characterized by higher transmission capacities, more sophisticated quality insurance mechanisms and lower operational costs [Offermann/Horneffer 2009, 1]. In this sense, NGNs decrease the costs for the provisioning and operation of new network-centric services. An exemplary new telecommunication operator service is a CDN, which will be introduced in Section 2.2.2. To ensure the end-to-end quality of network-centric services, operators have to take additional measures to remove bottlenecks in their physical networks. Within this context, Section 2.2.1 discusses preconditions for the upgrade of physical infrastructures.

2.2.1. Physical network architecture

A generic telecommunication network can be subdivided into the functional sections Backbone network, Concentration network and Access network [cf. Figure 2-2].

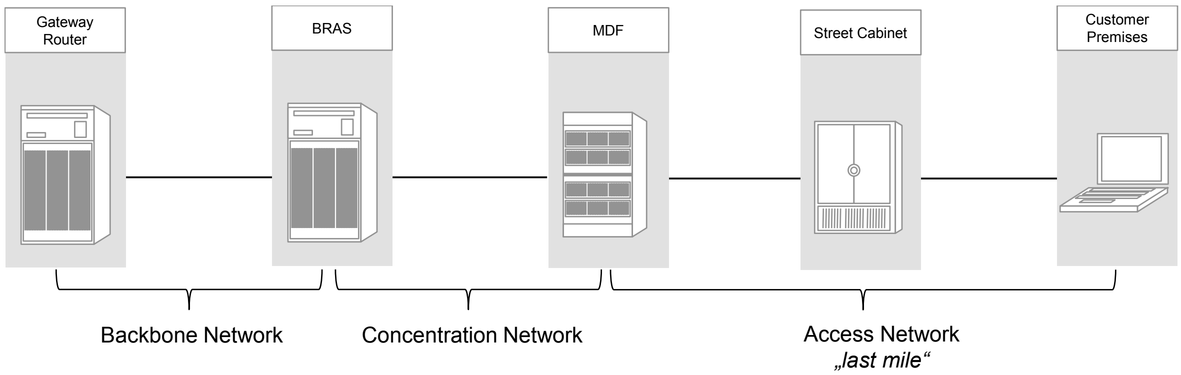


Figure 2-2: Generic telecommunication network [Offermann/Horneffer 2009, 12]

- The term *Backbone network* refers to the core section of a telecommunication network. It is composed of routers that communicate via fiber optic cables across long distances [Zarnekow et al. 2013, 10]. Backbone gateway routers are organized into more than 36,000 Autonomous Systems (AS) that pass on traffic across countries and continents [CAIDA 2011].
- A *Concentration network* consolidates the traffic of Main Distribution Frames (MDF) at a Broadband Remote Access Server (BRAS). A BRAS is responsible for customer administration and represents the first router between the customer and the core

network [Zarnekow et al. 2013, 10]. The geographic expansion of a concentration network can cover just a few kilometers or bridge physical distances of up to 100 kilometers [Offermann/Horneffer 2009, 10].

- The term *Access Network* refers to the connection between the customer premises and the MDF [Offermann/Horneffer 2009, 12]. This network section aggregates the traffic, often via intermediate consolidation points such as a street cabinet, from all connected customers. It is also referred to as a local loop or "last mile". Access networks can be made of coaxial cables, power line communications, wireless solutions, and copper or fiber cables [Amendola/Pupillo 2008]. Of all available solutions, a fully fiber-based Fiber-to-the-Home (FTTH) solution is recognized as the most future-proof and reliable solution for a broadband access network, as it directly connects the Customer Premises Equipment (CPE) to the fiber network [Breuer et al. 2011]. To date, however, the majority of households in Germany and many other countries in the world are receiving broadband services at least partially via copper access networks. In the case of Asymmetric Digital Subscriber Lines (ADSL), a twisted copper pair connects the MDF with the customer premises. In contrast, Very High Speed Digital Subscriber Lines (VDSL), also known as Fiber-to-the-Curb (FTTC) or Fiber-to-the-Node (FTTN), exhibit a fiber connection to access network consolidation points such as the street cabinet. In the case of VDSL, those fiber-connected consolidation points host active equipment, such as the outdoor Digital Subscriber Line Access Multiplexer (DSLAM). In a Fiber-to-the-Building (FTTB) deployment scenario, the fiber-connected DSLAM is located within the customer building. Finally, G.fast is an extension of the FTTC technology and requires a fiber connection to a distribution point located close to the customer [ITU 2013]. This fiber variant is also known as Fiber-to-the-distribution-points (FTTdp).

  In recent years, cable television networks have been upgraded with a return channel to provide internet access services. In these hybrid fiber coaxial (HFC) access networks, fiber-connected optical nodes consolidate customer traffic via coaxial cables [Tanenbaum 2003, 127]. In contrast to copper-pair access networks, the bandwidth in coaxial cables is shared among all connected customers. Thus, upgrading the speed of HFC networks is closely related to the introduction of additional fiber-connected nodes to reduce the number of connected customers per fiber node.

Backbone and concentration networks are constructed with fiber cables and have high transfer capacities [Breuer et al. 2011]. Capacities are widely available in this part of a telecommunication network, and capacity prices, especially in backbone networks, have been falling around the world [TeleGeography 2013]. In contrast, the upgrade of *Access Networks* forces telecommunication operators to make comparably large investments per connected customer [Kelly/Rossotto 2012, 2]. Today, ADSL and its faster variant ADSL2+ are widely available in most countries in the *Organisation for Economic Co-operation and Development*

(OECD) [OECD 2009]. This is because the majority of central offices and corresponding MDFs have a fiber connection to the internet backbone. In addition, many urban areas have been upgraded to VDSL/FTTC. However, actually achievable download speeds of copper-pair access networks largely depend on the deployed access network variant and the length of the local loop [cf. Figure 2-3].

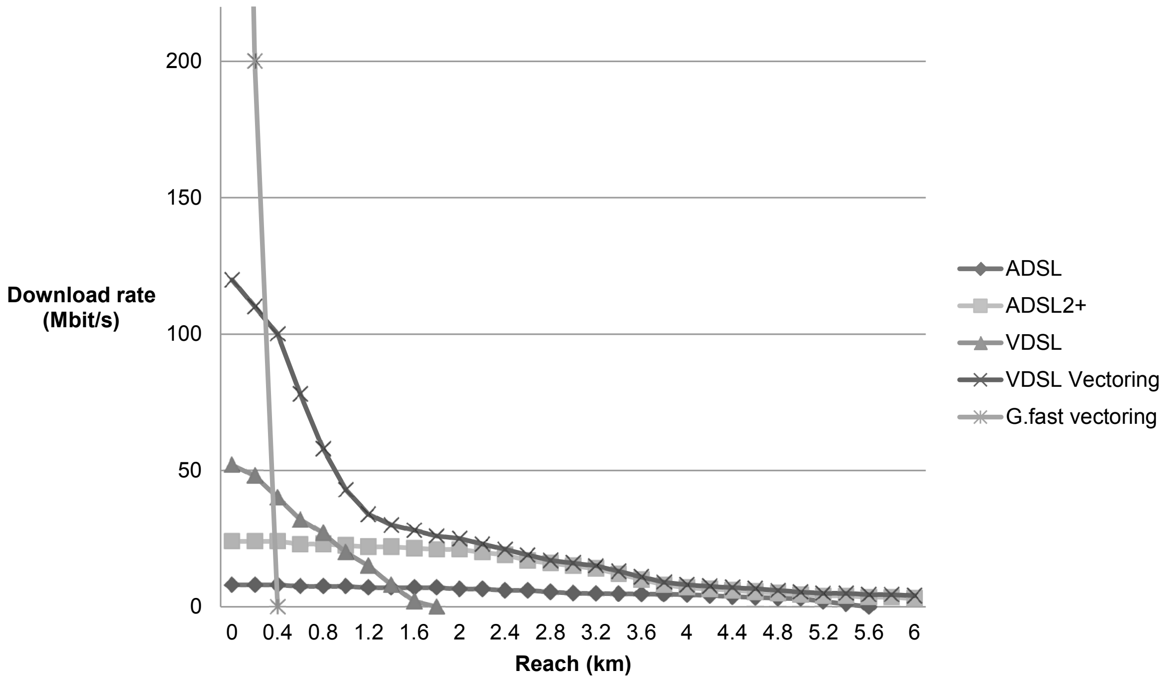


Figure 2-3: Achievable download speeds as a function of local loop length [Schnabel 2011, 211ff, Guenach et al. 2011, ITU 2013]

Figure 2-3 shows that such technologies as the widely adopted ADSL and ADSL2+ technology exhibit maximum download speeds of approximately 8 Mbit/s and 24 Mbit/s, respectively. As such, they are insufficient to meet the targeted minimum download speed of 30 Mbit/s (European Union) or 50 Mbit/s (Germany) [BMVI 2014]. In contrast, VDSL technology provides download speeds of up to 52 Mbit/s within a short distance to the street cabinet. Starting at a distance of approximately 800 meters from the street cabinet, average download speeds fall below the level of ADSL2+. These rapidly declining download speeds are caused by copper-wire cross-talk effects at the far end of the copper line and can be compensated with so-called vectoring technology [Guenach et al. 2011]. Figure 2-3 shows that VDSL with vectoring technology is capable of providing download speeds of 100 Mbit/s at a distance of approximately 400 meters from the street cabinet or 50 Mbit/s at a distance of approximately 850 meters from the cabinet. Finally, G.fast can provide download speeds of up to 1 Gbit/s within a maximum distance of 250 meters from the fiber node [ITU 2013].

Upgrading VDSL networks with vectoring technology requires a comparatively low investment for the installation of additional line cards within existing VDSL street cabinets. Consequently, VDSL vectoring has been recognized as a core technology for reaching the

German broadband goals for the year 2018 [BMVI 2014]. In this sense, the current challenge of upgrading copper-pair *Access Networks* is closely related to reaching a country-wide availability of fiber-connected street cabinets that host outdoor-DSLAMs. Figure 2-4 shows that, depending on population dispersion and network topology characteristics, countries around the world feature different preconditions for upgrading copper-pair cables in the local loop between the central office/MDF and customer premises.

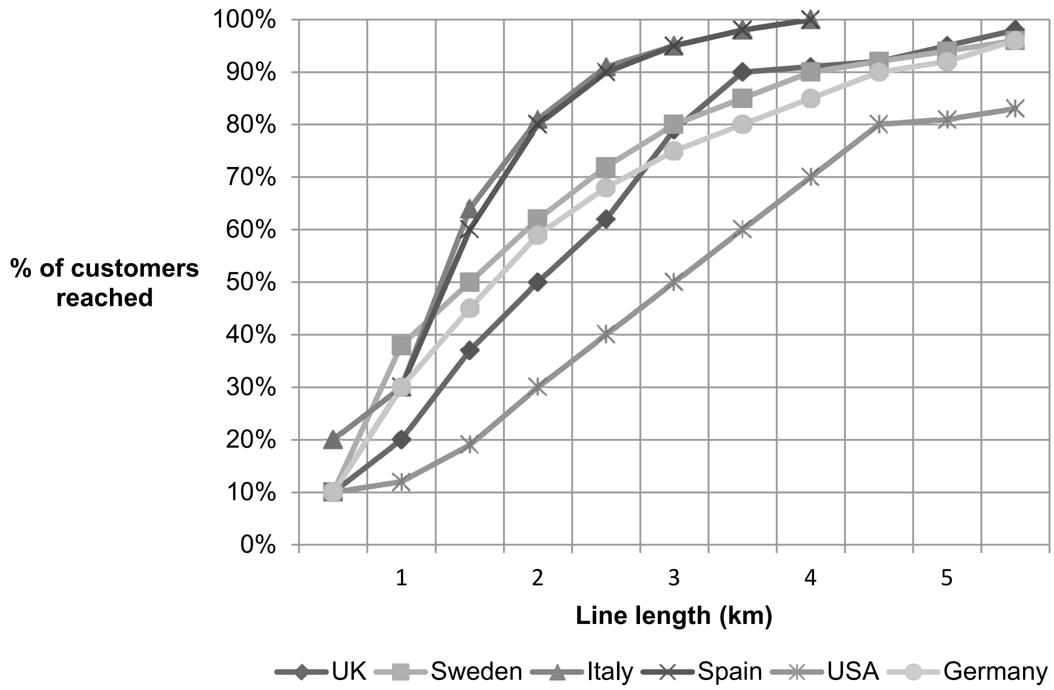


Figure 2-4: Percentage of customers reached as a function of local loop length [OECD 2009]

Countries such as Spain and Italy can reach all their customers within a distance of 4 kilometers from the central office. Thus, a total network upgrade to VDSL requires the replacement of less copper cable length per customer than in countries such as Germany or the USA. However, the curve progression of all countries indicates that rural areas exhibit longer local loop lengths than urban areas. In market-driven broadband deployment, higher network upgrade costs must be allocated to a comparably low number of customers. Consequently, rural broadband deployment is often dependent on public funding to ensure economic feasibility [Ruhle et al. 2011].

HFC networks are the second-most widespread wired broadband technology in Europe, and they show less speed loss as a function of the cable length. Consequently, HFC networks require less fiber deployment to achieve maximum download speeds, which are comparable to a DSL network. However, in most European countries, HFC networks provide little extra coverage to DSL networks because they are currently primarily deployed in densely populated areas [European Commission 2011].

2.2.2. Content delivery networks

The increasing usage of online content, such as catch-up TV, Premium VoD and streaming constitute growing market segments for content providers [iDate 2012]. Paid content in particular is often consumed in high definition and needs to be terminated at a much higher quality than free web videos. For this purpose, an increasing number of content providers commission CDN operators with content distribution and with internet access management [Zarnekow et al. 2013, 182]. Consequently, CDN traffic accounts for 36% of the total internet traffic in 2014 and is expected to rise [Cisco 2014].

CDNs maintain a geographically distributed network of server clusters or data centers that are connected to an overlay network [Ni et al. 2003]. The main purpose of a CDN is to ensure content termination quality that is measured in metrics such as jitter, packet loss or delay.

Jitter denotes the variance in the arrival of IP packages [Offermann/Horneffer 2009, 99]. High jitter can result in an uneven quality of music or movies [Tanenbaum 2003, 297]. Packet loss can occur due to disturbances in the transmission medium or if networks are congested [Kurose/Ross 2013, 613; Tanenbaum 2003, 416]. High packet loss reduces transmission speed and can even make real-time audio and video transmission impossible. Finally, delay can occur from transmission, processing or queuing in routers [Kurose/Ross 2013, 613]. High delays can result in connection time outs and disturbances in real-time time audio and video transmissions.

To address the presented quality problems, all CDNs have developed strategies for *Overlay network formation*, *Content distribution and management* and *Client request redirection* [Ni et al. 2003; Pathan/Buyya 2008]. These strategies are discussed in more detail below.

- An *Overlay network* is composed of *origin* and *surrogate servers*. *Origin servers* host the original content and are usually updated by the content provider. They communicate with the *surrogate servers*, which are placed in close proximity to the customers and host copies of the original content. CDN providers can either place their surrogate servers within the network of a single ISP or follow a multi-ISP strategy [Analysis Mason 2011]. A single-ISP approach is easier to manage, requires lower investments and is suitable for medium and low data volumes [Pathan/Buyya 2008]. To carry large traffic volumes, major CDNs such as Akamai and Limelight follow a multi-ISP strategy. In this strategy, CDN operators place *surrogate servers* at different internet backbone co-location facilities, which are denoted as Point of Presence (PoP) [Analysis Mason 2011]. Figure 2-5 shows that *surrogate servers* can connect regional customer ISPs via direct or indirect connections.

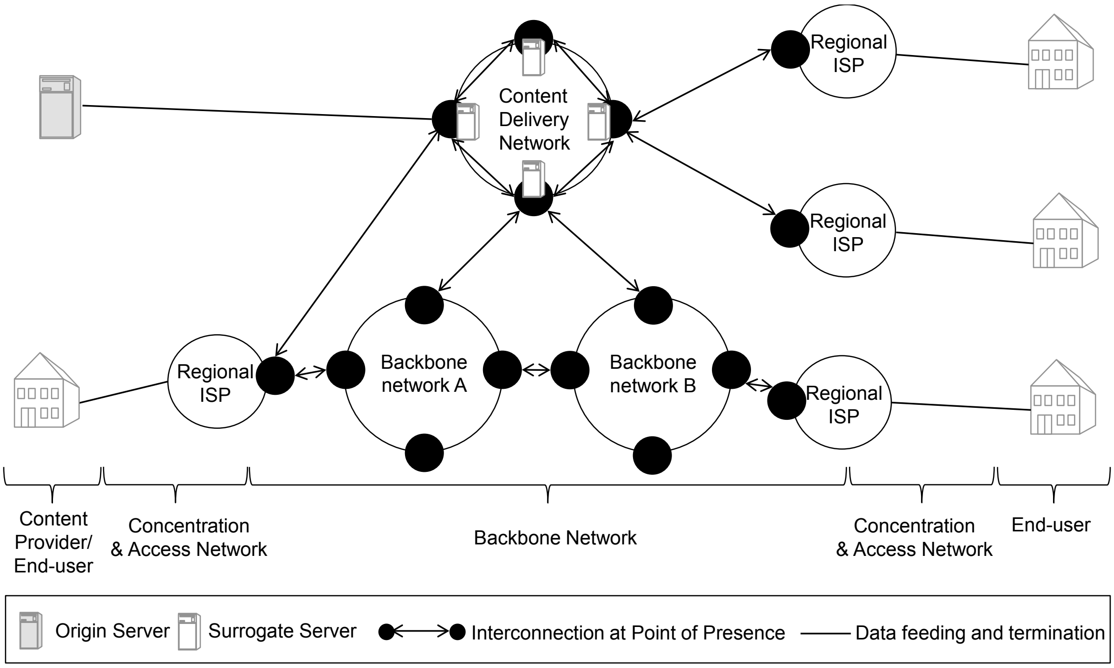


Figure 2-5: CDN server placement in a multi-ISP strategy [Analysis Mason 2011]

Generally, direct connections imply a better termination quality, as fewer potential bottlenecks such as network routers have to be traversed to terminate the CDN traffic [Krishnan et al. 2009]. However, because the internet exhibits a hierarchical topology with large networks at its core and smaller networks at the edge, indirect connections are required if world-wide coverage is aspired to [Labovitz et al. 2010]. In recent years, CDN operators have extended the multi-ISP approach by offering Software-as-a-Service CDNs and licensed CDNs that ISPs can operate inside their networks and thus closer to the End-user [Akamai 2013].

- Depending on the *Content distribution and management* strategy, different techniques for cache management and distribution technologies can be applied to increase termination quality at justifiable costs [Pathan/Buyya 2008]. For static content, termination quality can be improved if a CDN uses prefetching techniques to make content available at the *surrogate servers* [Zarnekow et al. 182]. However, due to the storage limitations of the *surrogate servers*, content can also be pulled from the origin server once it has been requested from the first local client [Pathan/Buyya 2008]. For live content, prefetching techniques cannot be applied. However, a *surrogate server* can consolidate the requests of end-users and use multicast technology to reduce costs associated with using internet backbone routes [Ni et al. 2003]. Moreover, Peer-to-Peer (P2P) technology, which uses the customer client for content distribution, can significantly reduce CDN distribution costs and improve transmission quality [Xu et al. 2006; Yin et al. 2009; Yin et al. 2009; Ha et al. 2010]. Large CDN service providers such as Akamai and Limelight have been able to reduce their costs for video-on-demand delivery by more than 66% [Hung et al. 2008]. The required P2P functionality of hybrid P2P-CDNs is provided by software such as the Adobe Flash-Player [Adobe Labs 2011].

- *Client request redirection* is executed by a request-routing system that directs client requests to an optimal surrogate server [Pathan/Buyya 2008]. The selection of an optimal server is carried out by a request routing algorithm that can take several metrics, such as geographic proximity, surrogate workload or measured latency, into account. In this context, geographic proximity is inferred based on the Border Gateway Protocol (BGP), which is stored on network routers [Poese et al. 2012]. Under a given server workload and latency, quality parameters can be improved by traffic routing algorithms if data are routed across few networks and routers [Poese et al. 2010].

Traffic among ISPs and CDNs is exchanged on the basis of so-called interconnection agreements. Figure 2-6 shows that these agreements can be distinguished according to their geographic scope and financial compensation.

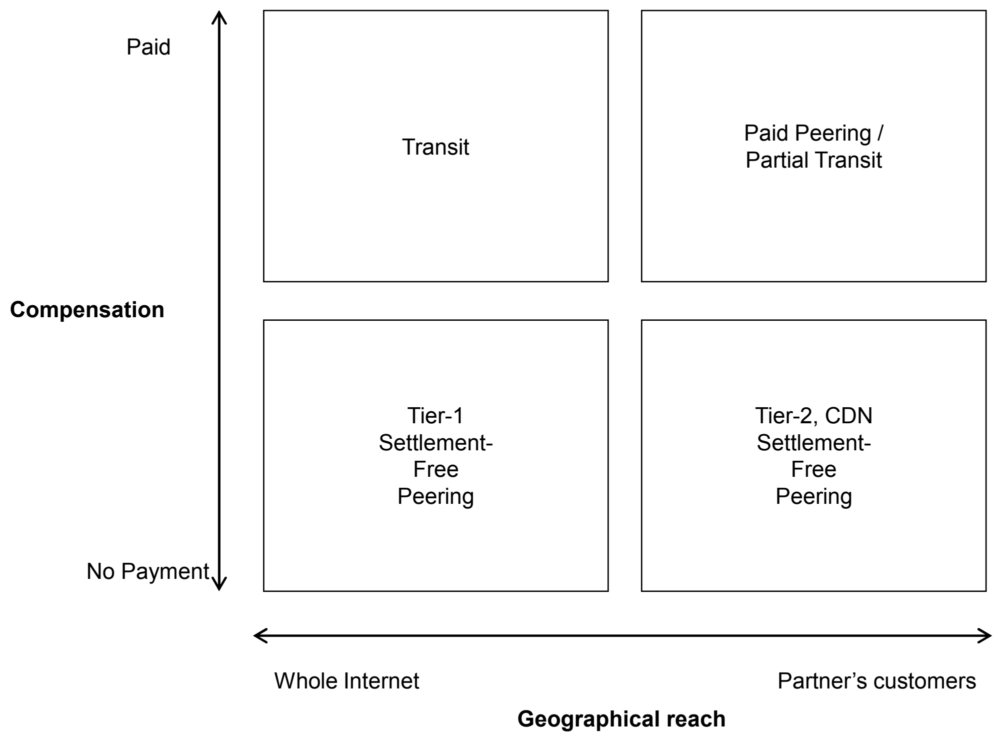


Figure 2-6: Classification of interconnection agreements [Zarnekow et al. 2013, 66; Kovacs 2012]

Subsequently, these agreements are introduced in more detail:

- A *transit* agreement provides a transit customer, such as a CDN or a smaller ISP, with access to the global internet [Norton 2011, 41]. Moreover, it announces the content of the customer to other networks on the internet [Zarnekow et al. 2013, 67]. Because the transit provider usually operates a large global network and has to distribute more traffic than the customer, this service is paid for by the transit customer [Shakkottai/Srikant 2006]. Common financial settlement agreements are either directly or indirectly based on the transferred amount of data [Zarnekow et al. 2013, 67f]. The setup of transit agreements is a fast way to extend the reach of a network, and providers usually offer volume discounts to large customers [Norton 2011, 46]. Transit agreements are usually associated with better service and maintenance conditions as opposed to interconnection agreements without financial compensation.
- *Partial transit* agreements have evolved as a response to intense competition and corresponding price declines in the international interconnection market [Norton 2011, 48]. Prices for regular transit services are determined based on a combined costing approach that includes costly transit routes in selected parts of the world [Zarnekow et al. 2013, 74; TeleGeography 2013]. In contrast, in a partial transit interconnection agreement, a transit provider restricts the customer's connection to some parts of the internet to reduce the potential costs that can be caused by the customer. Resulting cost savings can be passed on to the transit customer.
- *Peering agreements* refer to direct interconnections between networks for the purpose of transferring the traffic of their customers [Giovannetti et al. 2005]. If two networks establish a peering agreement, they no longer need to exchange traffic via paid transit connections [Zarnekow et al. 2013, 74]. However, the establishment of peerings can be more time consuming than the setup of transit connections because peerings are the result of bilateral negotiations between network owners. They often require both partners to procure and configure hardware according to agreed-upon quality standards. Consequently, peering agreements are especially suited for the bidirectional exchange of large data volumes [Norton 2011, 82]. Due to the missing financial compensation, peering can be canceled faster and more easily than transit agreements [Zarnekow et al. 2013, 81]. CDNs exhibit a heavily outbound traffic ratio. Thus, large ISPs that provide access to the whole internet and are also denoted as Tier-1 ISPs will usually not agree on settlement-free peerings with CDNs. In contrast, ISPs with a smaller network, which are also denoted as 2-Tier or 3-Tier ISPs, are often interested in settlement-free peering agreements with CDNs, as this reduces their transit costs by bypassing transit providers.
- *Paid peering agreements* exhibit the same traffic routing settings as a peering agreement. However, one peering partner pays the other a financial compensation and

can request compliance with agreed-upon quality standards [Shrimali/Kumar 2006]. In contrast to a partial transit agreement, customers cannot reach other peering partners of the paid peering provider [Zarnekow et al. 2013, 82].

2.3. Preconditions for value creation and cost reduction

This section introduces economic and regulatory preconditions for value creation and cost reductions strategies in the telecommunications industry. In a first step, actors and the value creation activities of a continuously disintegrated telecommunications value chain are introduced in Section 2.3.1. Moreover, the scope of the value chain assessments in this work is defined. In a second step, the ladder of investment concept is introduced in Section 2.3.2. It serves as a regulatory basis for stimulating private investments and competition in the deployment of telecommunication networks.

2.3.1. Disintegration of the telecommunications value chain

Academic literature has proposed various approaches to the systemization of value-added activities in the telecommunications value chain [Dengler 2000; Gerpott 2003; Fransman 2002; Bouras et al. 2009; Frigo et al. 2004; Weiber 1995, 47]. In general, two bodies of literature can be distinguished in this context. The first draws on the value chain concept as it has been proposed by Porter [1985, 37]. In this sense, the telecommunications value chain is modeled as an ordered sequence of value-added steps that consume resources, create value and are interconnected by processes [Porter 1985, 59ff]. Value-added steps are not necessarily executed by a single company. Instead, authors distinguish between four to seven actors that execute up to nine value-added activities [cf. Dengler 2000; Gerpott 2003]. The second body of literature has started to question the linearity and the ordered sequence of value-added steps in the telecommunications value chain [Weiber 1995, 46f; Li/Whalley 2002; Krafft 2003; Fransman 2002; Budde 2012, 44; Gerpott 1998, 4]. Facilitated by regulatory unbundling obligations and technological developments, many specialized companies have started to compete and cooperate across traditional industry borders [cf. Krafft 2003; Krishna/Ghatak 2008]. Moreover, traditional value chain actors have interconnected their value creation activities in both an indirect and a direct manner [Budde 2012, 44]. These trends have largely increased the complexity of value creation activities and contribute to what has been referred to as the deconstruction or *disintegration of the telecommunications value chain* [Li/Whalley 2002; Krafft 2003]. Consequently, it has become difficult to assess the increasing dynamics of change, modes of co-ordination and intra-layer diversity with the traditional linear value chain model of the telecommunications industry [Fransman 2002]. To address this shortcoming, it has been proposed that value creation in the telecommunications industry be perceived and assessed as a network of interconnected value chains with multiple entry and exit points [Li/Whalley 2002]. An exemplary layered value chain network is adapted from Weiber [1995, 47] and Budde [2012, 45] and depicted in Figure 2-7.

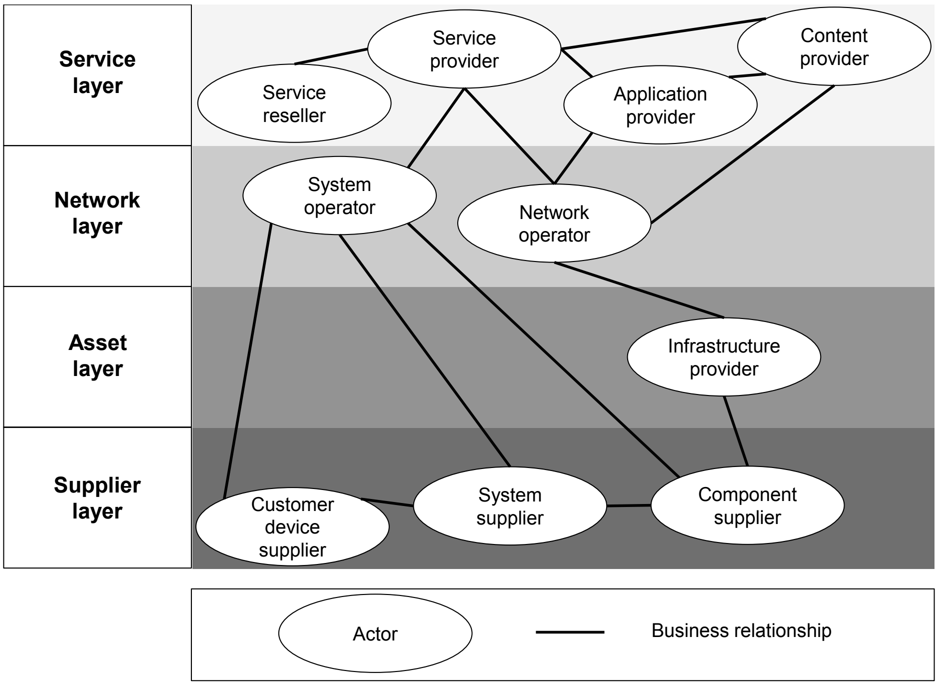


Figure 2-7: Exemplary value chain network [Weiber 1995, 47; Budde 2012, 45]

Subsequently, the distinct layers and the corresponding actors are introduced:

- At the *supplier layer*, suppliers of components, customer devices and systems can be distinguished. System suppliers provide products for the setup and maintenance of networks [Budde 2012, 45]. Exemplary activities include the provisioning of network management systems, billing systems and switches [Gerpot 2003]. Component suppliers produce hardware elements for complex systems. Exemplary products include semiconductors, fiber optic cables, copper cables and batteries [Dengler 2000, 92; Gerpot 2003]. Suppliers of customer devices produce and provide network elements such as mobile phones, notebooks, PCs and DSL splitters. Key activities of suppliers involve research and development and the setup of new customer relationships [Fransman 2007].
- At the *asset layer*, infrastructure providers conduct activities related to the maintenance and provisioning of passive infrastructure and that aim to bridge physical distances between customers [cf. Section 2.2]. Exemplary assets include fiber optic cables, copper cables and wholesale products such as dark fiber, spare ducts, server co-location space and rights of way. In a vertically integrated telecommunications value chain, related activities are conducted by a telecommunication company. Opportunities for the creation of new value chains evolve as assets are provided by companies of different industries, such as local utility companies and operators of national infrastructures such as railroads, electricity networks and the highway network.
- At the *network layer*, network operators and system operators can be distinguished [Weiber 1995, 47]. Network operators create value through activities related to

network planning and the operation of various physical networks. Exemplary networks include the Public Switched Telephone Network (PSTN) and backbone and television networks. In general, the operation and maintenance of equipment in a particular subnetwork, such as the mobile network, can also be outsourced to a distinct system operator managed by a network operator. A central goal of all activities at this layer is to reduce costs by acquiring knowledge about network management and by optimizing processes.

- At the *service layer*, the roles service provider, service reseller, application provider and content provider can be distinguished [Weiber 1995, 47; Budde 2012, 45]. A service provider and a service reseller create value through activities such as the marketing of new products, billing and brand management. Marketed products include at least network access, which is provided by the network operator in the *network layer* [Budde 2012, 46]. Application providers create value by offering software solutions that are closely related to network services. Examples include mailbox solutions, caller forwarding and VoD distribution software [Gerpott 2003]. Content providers can be considered as actors of the media industry that exhibit diagonal cross-industry business relationships with telecommunication companies [Gerpott 2005]. The main value creation activities of the content provider involve the creation and publishing of content such as music, videos and text that can be distributed via telecommunication networks [Budde 2012, 47].

The complex competitive and cooperative dynamics in an increasingly cross-linked telecommunications value chain have evoked calls for further research that maps the field [Li/Whalley 2002]. To take on this task and assess the specifics of horizontal, vertical and diagonal cooperation in the telecommunications industry in a profound way, it is necessary to narrow the scope of the value chain assessment. In this sense, business relationships with equipment or system suppliers will not be explicitly explored in this work. Instead, technological developments are considered part of a company's technological environment [cf. Section 2.1.3]. The remaining three layers will subsequently be referred to as a generic three-layer telecommunications value chain.

2.3.2. Ladder of investment

To stimulate private investments and competition in fiber broadband networks, the Body of European Regulators for Electronic Communications (BEREC) and national European regulators are following the Ladder of Investment (LoI). This concept aims to decrease entry barriers for new market entrants to eventually foster competition between fully integrated telecommunication companies [Cave 2006]. As such, the framework primarily focuses on the service provider/reseller, and the network operators and infrastructure play the role of the disintegrated telecommunications value chain [cf. Section 2.3.1]. The concept sets a frame of reference for access network investments and broadband deployment cooperation strategies in the European telecommunications industry. Figure 2-8 depicts the ladder rungs a market entrant has to climb to eventually compete as a fully integrated telecommunication company. The LoI is based on the underlying notion that lower ladder rungs exhibit a higher economic replicability than higher rungs and that economies of scale will eventually enable operators to increase the proportion of their own infrastructure by moving up the ladder [Cave 2006].

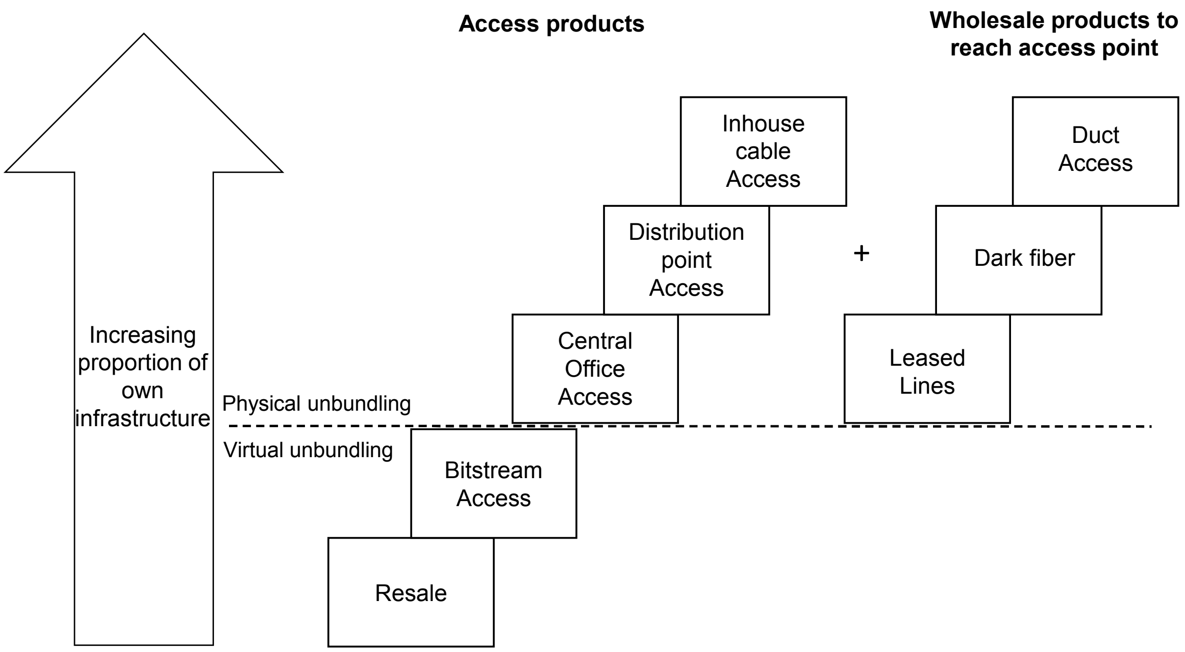


Figure 2-8: Ladder of investment [BEREC 2010]

The subsequent section will introduce the ladder rungs in more detail according the definitions provided in [BEREC 2010]:

- The *Resale* access product corresponds to the service layer of the generic three-layer telecommunications value chain [cf. Section 2.3.1]. A reseller markets products that are technically identical with the products of the infrastructure provider. A resale access product exhibits a comparatively high economic replicability, as the market entrant's primary business activities involve brand management, billing and service plan management. For this reason, resale access products are usually not the focus of regulatory measures [BEREC 2010].
- The ladder rung *Bitstream Access* (BSA) provides an access product at the network layer of the generic three-layer telecommunications value chain [cf. Section 2.3.1]. It enables operators to provide services without the requirement to make significant organizational changes to a resale business model. In general, two relevant specifications of BSA can be distinguished. A layer 2 Bitstream is accessed via Asynchronous Transfer Mode (ATM) or Ethernet protocols and implies a pure transport link between the customer data and the network access point. It enables the

modification of technical parameters in the access product provider's network and is said to provide more options for product differentiation [BEREC 2010]. A layer 3 BSA exhibits more functionalities the than a layer 2 BSA, as it provides an IP access to customers and supports application-centric control and steering functions [Obermann/Horneffer 2009, 123]. Naturally, more refined products such as BSA layer 3 restrict the number of technical modification options. In this sense, a BSA layer 3 exhibits limited options to modify transmission quality parameters that some companies consider a requirement for IPTV offers [BEREC 2010].

- A *Central Office* (CO) *Access* product provides alternative carriers with a co-location space in the provider's CO. Thus, it enables an alternative operator to deploy active infrastructure components and connect it to the provider's passive copper or fiber lines, which terminate at the CPE. In this sense, an alternative operator enters the network layer of the generic three-layer telecommunications value chain [cf. Section 2.3.1]. The freedom of choice in selecting active components results in technological modification options that exceed those of the BSA products [Cave 2006].
- A *Distribution point Access* can be provided at street cabinets, manholes or poles located along the streets between the CO and the customer. Similar to the *Central Office Access*, the provider makes a co-location space for technical equipment available to the alternative operator. *Distribution point Access* is required if an alternative operator is deploying its own fiber to a distribution point. Accordingly, this access product is required if alternative operators have entered the asset layer of the generic three-layer telecommunications value chain [cf. Section 2.3.1].
- By purchasing *Inhouse cable Access*, an alternative operator is using the fiber or copper cables of the infrastructure provider within the customer building. In the case of an FTTB deployment scenario, technical equipment is located in the building basement [BEREC 2010]. In an FTTH scenario, the CPE is directly connected to the fiber network, and active equipment of the alternative operator can be deployed at remote concentration points outside the customer building. Because purchasing this product requires connecting a building with proprietary fiber, alternative operators have entered the asset layer of the generic three-layer telecommunications value chain [cf. Section 2.3.1].

The subsequent section will introduce the additional wholesale products *Leased lines, Dark fiber and Duct Access*, which can be used to reach an access product.

Duct Access is a wholesale product that can be provided by various industries. Public and private companies that own physical networks such as utility companies, fully integrated telecommunication companies, and national rail, electricity and gas network operators are in possession of spare ducts that are generally suited to host fiber broadband infrastructures. Some ducts have been deployed during construction works for later deployment of telecommunication lines. Other duct capacities become available as redundant infrastructures are put out of service or new laying techniques become available. In this sense, sewer pipes, cable troughs, occupied ducts with a sufficiently large caliber or poles can be used to deploy fiber infrastructures. Subsequently, all those capacities will be denoted as spare ducts. By using spare duct capacities, alternative operators can significantly reduce their costs for fiber deployment in the access or concentration network.

Dark fiber refers to the provisioning of unlit fiber capacities. An alternative operator can use those fiber capacities to connect its technical equipment to access products such as the CO, distribution points or the customer premises [BEREC 2010].

Similarly, *Leased lines* refer to a wholesale product where the active equipment is operated by the leased line provider [NGA-Forum 2011].

To make the LoI operational, regulators are required to increase access prices once new market entrants start to generate enough revenues to enter the next rung. This step is intended to foster investments at downstream value-added steps of the telecommunications value chain so that the new market entrants can eventually offer more differentiated products [Cave et al. 2006]. However, most European regulators have not increased access product prices [EU-Commission 2006]. Instead, market entrants have enjoyed a high degree of flexibility in selecting, combining and avoiding various access products. Thus, critics have questioned the regulatory commitment to the LoI and have called for more research on the LoI's ability to support broadband goals outside urban areas [Bourreau et al. 2010].

3. Cooperative value creation strategies in telecommunication companies

A major part of the research in this dissertation explores cooperative value creation strategies in a disintegrated telecommunications value chain. Analyses focus on the systemization of intra- and inter-industry cooperation and identify contingency factors that influence cooperation profitability and sustainability in the telecommunication industry. Respective publications are summarized in Table 3-1.

Title	Published in	Reference	Section
Cooperative service provisioning with OTT service providers – An explorative analysis of telecommunication business models	Proceedings of the 2014 ITS European Regional Conference	[Limbach 2014]	3.1
Cooperative private Next-Generation Access deployment – A relational view	Proceedings of the 46th Hawaii International Conference on System Sciences (HICSS)	[Limbach et al. 2013a]	3.2
Cooperative next-generation access provisioning – Evidence from the German broadband market	Proceedings of the Multikonferenz Wirtschaftsinformatik, Paderborn (MKWI 2014)	[Limbach/ Zarnekow 2014]	3.3

Table 3-1: Publications related to cooperative value creation strategies

Section 3.1 assesses cooperative value creation patterns with OTT service providers and explores their impact on the business model of telecommunication operators. Thereafter, Section 3.2 analyzes the environmental and organizational impact on the sustainability of cooperative value creation in broadband provisioning. In Section 3.3, a framework for cooperative broadband provisioning is created to identify drivers of cooperation profitability at different value-added steps of a disintegrated telecommunications value chain.

3.1. Cooperative service provisioning with OTT service providers – An explorative analysis of telecommunication business models

Title	Cooperative service provisioning with OTT service providers – An explorative analysis of telecommunication business models
Authors	Felix Limbach (TU Berlin)
Published at	International Telecommunication Society Conference in Brussels 2014
Research objectives	- Development of a taxonomy of cooperation for partnerships between telecommunication operators and Over-the-Top service providers - Identification of cooperative customer value creation strategies - Classification of revenue streams that stem from cooperative service provisioning
Methodology	- A literature analysis identifies examples for cooperative service provisioning - In an inductive approach, the Osterwalder business model ontology is used to provide a business model typology for cooperative service provisioning
Results and Implications	- Seven types of cooperation between OTT service providers and telecommunication operators can be distinguished: *Promotion*, *Bundling*, *Special OTT tariffs*, *local service consultant*, *access to customer data*, *access to core services*, *technology integration*. - Cooperation contributes to customer value propositions such as: *Tailored customer solution, unique configuration of OTT and operator services in a local market, service innovation and extended scope of core service*. - Service cooperation contributes to additional retail revenues for operators.

Table 3-2: Summary of [Limbach 2014]

The contribution of this paper is manifold. First, it provides a taxonomy of cooperation for partnerships between telecommunication operators and Over-the-Top service providers. Second, it explores the impact of cooperative service provisioning on the telecommunication operator's business model. As a result of a literature review, seven types of service cooperation are identified. A business model ontology is used to assess value creation activities, customer relations and financial aspects for three generic value creation patterns. The results indicate that cooperation facilitates innovation, quality, service differentiation and tailored customer services.

3.1.1. Introduction

Market-driven provisioning of next-generation access infrastructures requires operators to carefully balance broadband supply and demand. Once investments in new infrastructure have been made, take-up rate and average revenue per user (ARPU) maximization are the core activities to recover investments. In competitive markets, provisioning of attractive customer services is the most important approach to achieve these goals. Thus, after telecommunication market liberalization, major operators have diversified their activities into related businesses to provide a broad variety of content to customers [Ulset 2007]. However, telecommunication operators are struggling to provide value-added services and content that can compete with market offers of leading service providers such as Google, Facebook or Amazon [Grove/Baumann 2012]. Thus, industry-wide diversification attempts on the part of operators into content provisioning have in many cases been followed by a consolidation and restructuring phase [Ulset 2007]. As an economic consequence, the collaboration of independent and highly specialized companies is becoming part of the focus of telecommunication companies.

On the technical side, inter-industry value creation is facilitated by the fact that telecommunication operators are moving legacy infrastructure to all-IP platforms. This development can foster drastically decreased coordination and transaction costs and enables new customer value propositions [Osterwalder 2004]. Moreover, it has been recognized that it results in complex competitive and cooperative dynamics [Li/Whalley 2002]. Both dynamics can be observed between operators and internet content providers that offer their services to internet users without direct control of telecommunication operators [Aidi et al. 2012]. Subsequently, those internet service providers are denoted as Over-the-Top (OTT) service providers.

Researchers have started to selectively explore the effects of cooperative service provisioning between telecommunication operators and OTT service providers [cf. Aidi et al. 2012; Bertin et al. 2011]. However, previous efforts have not evolved a systematic assessment of different types of cooperation. This paper aims to fill this gap and explores the effects of cooperative service provisioning on the business model of telecommunication operators. In this paper, the following research questions will be explored:

What are the types of cooperation that can be observed between OTT service providers and telecommunication operators?

To what extent do cooperative value creation patterns contribute to novel customer value propositions?

How does cooperative service provisioning impact the operator's contact with customers and its financial situation?

The proposed questions will be addressed as follows. The next section will introduce the theoretical background on telecommunication operator and OTT player interaction. Moreover, central concepts will be defined. Thereafter, the research methodology will be presented. The subsequent section explores different types of cooperative service provisioning and deduces the service cooperation taxonomy. Next, identified cooperation types will be related to value creation patterns. Thereafter, the article will explore the impact of cooperation on the financial and customer dimension of the operator's business model. Finally, a summary and conclusion will be provided.

3.1.2. Theoretical background

According to Murri [2013], five generic telecommunication operator strategies can be distinguished in addressing OTT service providers. They are denoted as aggressive, opportunistic, competitive, reactive and collaborative [Murri 2013]. Aggressive strategies include technological blocking of OTT communication services such as Skype or distribution of ad blockers that target the main revenue source of OTT service providers [cf. Murri 2013]. Similarly, opportunistic approaches aim to reserve the usability of particular OTT services for customers in operator premium tariffs. However, as noted in Krämer et al. [2013], these strategies are anecdotal, as they are very likely to have a negative impact on the operator's reputation.

Competition strategies aim to replicate and advance the functionalities of popular OTT services on the basis of operator assets. Examples include the cross-operator messaging platform Joyn and content that is provided by the operator [GSMA 2014]. However, many operators experience difficulties keeping up with the innovation speed and cost structures of OTT service providers [Grove/Baumann 2012]. Consequently, many efforts have been directed at reactive cost reduction strategies in operator networks. Examples include transparent caching and cooperation with content-delivery-networks (CDN) [Akamai 2013].

Collaborative approaches aim at cooperative customer value creation and mutual economic benefit for OTT service providers and telecommunication operators. Surveys and exemplary examples indicate the topicality of this strategy [Aidi et al. 2012; Hibberd 2014]. However, a holistic assessment of cooperative service provisioning and its impact on the operator business model has not been conducted. To address this research gap, it is necessary to define the concepts cooperation and business model.

Cooperation is a medium- or long-term collaboration of economically independent organizations [Picot et al. 2003]. It is voluntary and can generally be canceled by both companies at any time [Gerpott 2005]. Thus, mergers and acquisitions are outside the scope of the subsequent assessment.

Timmers [1998] describes a business model as:

"An architecture for the product, service and information flow, including a description of various business actors and their roles and a description of the potential benefits for the various business actors and a description of the sources of revenues."

With the rise of e-businesses and e-commerce, the academic research has developed a growing interest in assessing existing business model characteristics and has proposed future business models [Osterwalder 2004]. Starting in 1998, several widely recognized business model framework papers have been published [cf. Amit/Zott 2001; Timmers 1998; Venkatraman/Henderson 1998; Wirtz 2001]. Although all frameworks advanced the academic literature in the following years, Alexander Osterwalder recognized the need for a new business model ontology that extends previous frameworks and provides a more holistic view of business model components and their interrelations [Wulf et al. 2010b]. The newly developed business model ontology was soon adopted by many other researchers [cf. Bask et al. 2010; George/Bock 2011; Pousttchi et al. 2009; Rohrbeck et al. 2013; Wulf et al. 2010b]. Moreover, it has been used to assess the business models in the telecommunications industry [Camponovo/Pigneur 2003; Pousttchi et al. 2009]. Camponovo and Pigneur (2003) find that business model research in the telecommunications industry is often limited to an assessment of the operator's infrastructure. They conclude their research with the finding that the Osterwalder business model ontology is particularly suited for a holistic assessment of telecommunications business models. For this reason, the ontology will be used to guide the analysis of this paper. The subsequent section will introduce the business model ontology and the conducted research approach.

3.1.3. Research methodology

Osterwalder's business model ontology consists of four pillars: *infrastructure management*, *customer interface*, *financial aspects* and *product value proposition*. Each pillar exhibits one to three business model buildings blocks, which are defined in Table 3-3.

Pillar	Business Model Building Block	Description
Product	Value Proposition	Gives an overall view of a company's bundle of products and services.
Customer Interface	Target Customer	Describes the segments of customers a company wants to offer value to.
	Distribution Channel	Describes the various means of the company to get in touch with its customers.
	Relationship	Explains the kind of links a company establishes between itself and its different customer segments.
Infrastructure Management	Value Configuration	Describes the arrangement of activities and resources.
	Core Competency	Outlines the competencies necessary to execute the company's business model.
	Partner Network	Portrays the network of cooperative agreements with other companies necessary to efficiently offer and commercialize value.
Financial Aspects	Cost Structure	Sums up the monetary consequences of the means employed in the business model.
	Revenue Model	Describes the way a company makes money through a variety of revenue flows.

Table 3-3: Nine building blocks of the Osterwalder business model Ontology [Osterwalder et al. 2005]

The assessment of cooperative service provisioning is closely related with the Infrastructure Management pillar of the employed ontology. This pillar assesses how a company creates value for its customers based on capabilities and resources that may be in the possession of a firm or their partners [cf. Osterwalder 2004]. Based on a preceding paper version of Wallin [2005], Osterwalder defines a capability as the ability to carry out repeatable patterns of action. Involved actors such as the partner and the firm need to reach an agreement that specifies the conditions of the partnership and provides mutual benefit. These interrelationships are depicted in a schematic representation of the Infrastructure Management pillar, which is provided in Figure 3-1.

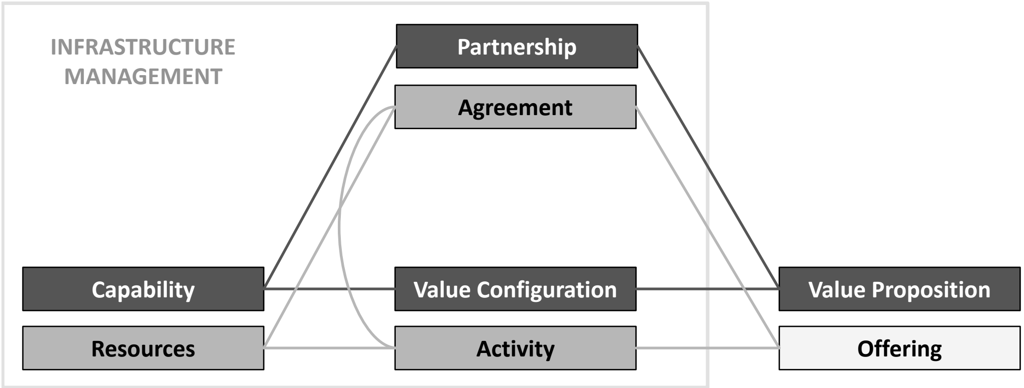


Figure 3-1: Infrastructure dimension of the Osterwalder business model Ontology [Osterwalder 2004]

The paper employs a multi-step approach to address the proposed research questions.

First, a literature and internet analysis is conducted to identify examples for cooperative service provisioning. This analysis includes detailed assessments of more than 100 expert internet blogs, operator and OTT websites. With an inductive approach, the identified examples are documented and classified to evolve a service taxonomy of cooperation.

In a second step, the impact of cooperation on the Infrastructure Management pillar of the business ontology is assessed. That is, different patterns of cooperative value creation are explored and summarized.

The third analysis step explores the impact of cooperation on the remaining ontology pillars: Customer Interface and Financial Aspects.

In the next section, the results of the literature analysis will be presented.

3.1.4. Service cooperation taxonomy

Two practitioner studies have explored strategic relationships between operators and OTT service providers [Hibberd 2014; Murri 2013]. Both provide evidence that operators exhibit increasing interest in cooperative value creation. The anecdotal evidence of these studies serves as a starting point for the subsequent holistic analysis. A summary of the cooperation taxonomy is provided in Table 3-4.

Promotion cooperation is characterized by two or more partners that create a joint value proposition for the customer. Market goals and products of the partners are complementary to each other and aim to amplify the customer's awareness for the benefits that can be derived from the complementarities [Bucklin/Sengupta 1993]. Usually, an operator is selling a certain part of its service portfolio in combination with an OTT service. One of the least complex occurrences of this cooperation type is given if an operator combines a redeemable voucher for an OTT service with its own service. An example would be an offer called "gamers choice", which combines a high-speed internet access with a voucher for a one-year Microsoft Xbox Gold membership [cf. Vodafone NZ 2014].

Bundling cooperation refers to a configuration of complementary operator and OTT services that are offered in a specially priced package [cf. Venkatesh/Mahajan 2009]. Bundling can decrease the customer's transaction costs and increase profits if customer valuations for different products are negatively correlated or a large number of customers need to be addressed with one price [Bakos/Brynjolfsson 1999]. For this type of cooperation, partners need to agree on an allocation of costs associated with the price discount. Usually, a local operator grants an OTT access to its existing and potential customer base and charges the bundled service package to the customer's bill [cf. Telefonica 2014; Yourfone 2014].

In a *Special OTT data tariff*, an operator desists from uniform pricing for data usage. Instead, several tariff models, which are common for charging short messages or telephony minutes, are applied to price the OTT service. Examples include fixed monthly fees or so-called fixed up to (FUT) plans, which include a certain contingent of data usage for a fixed price [Masuda/Whang 2006]. Simple data tariffs charge a monthly fee for free OTT service usage without further delimitations [Telekom 2014a]. In a special form of tariff, customer data usage costs may be sponsored by the content owner [AT&T 2014a]. More complex tariffs bundle OTT service usage with particular operator technologies or include free roaming options [Ovum 2012]. The most complex variant of an OTT data tariff may require special customer infrastructure such as a special sim-card to price service transactions instead of data usage [E-Plus 2014; Ovum 2012].

Leveraging the *Access to customer data* has been identified as a source of new business opportunities for the digital economy [World Economic Forum 2013]. In general, customer data can be classified into volunteered, observed and inferred data [World Economic Forum 2012]. With respect to the first data type, customers could object to the use of their data for a particular purpose but choose not to use this right. Online social networks are a major source of volunteered personal data [cf. Acquisti/Gross 2006]. Observed customers data are required for providing business functionality or service to a customer. Examples include the customer location, billing information or customer device properties. Inferred data can be derived from volunteered and observed data if the data are aggregated or joined with further data sources. Examples include credit worthiness, traffic information and detailed customer group segmentation. It has been demonstrated that video advertising revenues of OTT service providers can increase dramatically if operators provide the observed customer location [Telco 2.0 2008]. Other examples aim to decrease the customer's purchase transaction efforts by automatically providing registration and shopping form information from the operator's database [Orange 2013].

Access to core services denotes operators' endeavor to provide internal infrastructure capabilities to OTT service providers. The most common way to provide these capabilities are application programming interfaces (API). The majority of APIs offer access to charging, billing, short messaging and telephony services [cf. Kübel et al. 2014]. Depending on the operator's strategic focus, these interfaces are complemented with machine to machine (M2M), e-health or internet protocol television (IPTV) APIs [AT&T 2014b; DeveloperGarden 2014; Orange 2014]. Initiatives such as the Open Mobile Networks Alliance and the GSM Association foster the development of cross-carrier APIs to decrease the partnership initiation costs [GSMA 2014; Open Mobile Alliance 2014]. Moreover, specialized billing companies position themselves as integrators of APIs between OTTs and operators [Bango 2012]. Concerted efforts of OTT service providers and intermediaries contribute to a wide variety of billing partnerships [cf. Microsoft 2014].

As a *Local service consultant*, operators exploit their local market knowledge, brand and existing customer relations to explain and sell complex OTT services without owning the required service assets. In this type of cooperation, an OTT service usually complements a broader operator business customer service and product portfolio, which may be related to business units such as marketing or network management. Examples include operators that position themselves as consulting premium reseller for OTT advertising or consulting reseller of on-demand office environments [Google 2014b; Telekom 2014b; Vodafone 2013].

Technology integration refers to operator and OTT cooperation that aims at tighter integration of technological assets. Cooperative efforts focus on different goals such as the improvement of OTT service quality, enhanced OTT service device compatibility or distribution of basic operator services to different devices with OTT technology. Examples for cooperative quality improvement can be found in the offers of several major OTT service providers that provide special client server solutions that are deployed within the operator network [Google GGC 2014; Netflix 2014; Skype 2011]. These dedicated servers reduce the OTT dependence on intermediaries such as CDNs that have just recently begun to deploy their servers within the operator network [Akamai 2013].

Another type of technology integration allows customers to link their operator telephone number with an OTT Voice over IP account. This cooperation enables OTT caller management and forwarding capabilities that had previously required complex telephone system hardware that would have raised numerous device compatibility issues [Google 2013]. Similarly, operators use white label OTT technology to deliver existing IPTV offers to multiple screens enabling a so-called “TV-Everywhere” customer experience [Waterman 2013; Zattoo 2014]. Finally, operators offer their services via apps in OTT ecosystems such as the Google play store or on Microsoft Xbox [Swisscom 2014; Vodafone 2009].

Cooperation type	Key characteristic	Primary operator agreement benefit	Example	Source
Promotion	Amplification of the customer's awareness for the benefits that can be derived from the OTT and operator service complementarities	Address special customer groups and faster reaction to market trends	Vodafone - Microsoft Xbox live	Vodafone NZ 2014
Bundling	Specially priced package of operator and OTT services	Creation of attractive service bundles for large customer groups	Telefonica - Napster	Telefonica 2014
Special OTT data tariffs	Non-uniform pricing for OTT data usage	Offer a unique data plan in a market dominated by commodity services	Deutsche Telekom - Spotify	Telekom 2014a
Local service consultant	Operator incorporates complex OTT services in its business product portfolio	Operator is perceived as a full-range supplier that offers integrated business solutions	British Telekom - Google Adwords	Google 2014b
Access to customer data	Volunteered, observed or inferred customer data are shared	Leverage existing customer data for new business opportunities	Orange - Deezer	Orange 2013
Access to core services	Internal infrastructure capabilities are provided to partnering OTT service providers	Open internal capabilities to partners to generate additional wholesale revenues	AT&T - Google Play	Google 2014a
Technology integration	Tight integration of technological assets to improve service quality and reach	Offer innovative services to benefit from first mover advantages and extend service availability	Sprint - Google	Google 2013

Table 3-4: OTT service cooperation taxonomy for telecommunication operator business models

Though the identified cooperation types can be observed and described as discrete entities, some entity combinations can be observed on a regular basis. That is, cooperative promotion or bundling activities can be combined with special OTT data tariffs or the start of innovative services.

3.1.5. Patterns of cooperative value creation

As proposed in Osterwalder [2004], this section draws on Fjeldstad & Haanaes [2001] to assess patterns of value creation and relate them to the previously identified cooperation types. The results of this analysis will be summarized in Figure 3-2. Fjeldstad & Haanaes [2001] distinguish between three value configuration types: Value shop, Value chain and Value network.

A *value shop* sells approaches to solve unique problems for a customer and creates value by evolving a current into a more desired state [Osterwalder 2004]. The created customer value can be much higher than the costs of finding an appropriate solution [Fjeldstad/Haanaes 2001]. Operators who employ this value creation pattern need to exhibit the capability to understand specific customer needs and integrate internal and external resources [cf. Wallin 2005]. Moreover, availability and access to standardized OTT offerings constitute a prerequisite for a cooperative value creation pattern. The identified cooperation examples include operators that act as technology or advertising consultant [Google 2014b; Telekom 2014b].

In a *value chain*, companies sequentially create value by transforming inputs into more refined outputs [Porter 1985]. A customer is paying for the value of the final refined service. Consequently, a core capability of operating a value chain is the ability to produce a service at a defined quality and lower costs than the perceived customer value [cf. Wallin 2005]. Exemplary cost reduction measures in value chains involve economies of scale, efficient capacity utilization and learning effects [Fjeldstad/Haanaes 2001]. Primary value creation activities include the production of operator core services and OTT player cooperation initiation. The identified value chain related cooperation types include *promotion*, *bundling* and *special OTT data tariff*.

A *value network* is characterized by value generation through mediation of complementing partners and the generation of positive network effects [Fjeldstad/Haanaes 2001]. Service customers benefit from positive network effects through eased access to the services of participating partners. In the case of an OTT application platform such as Google Play, customers experience positive network effects from using Google devices if operators provide their services as a Google application. Similarly, customers experience positive network effects if a partnering OTT provider offers a billing option via the operator billing API [Google 2014a]. Due to compatibility requirements, value networks are subject to a tradeoff between scale and service richness [Fjeldstad/Haanaes 2001]. That is, API and application store value networks provide basic compatibility to a wide number of partners and primarily benefit from economies of scale. In contrast, technology integration value networks can create particularly innovative and integrated services if the number of members is rather small [cf. Google 2013].

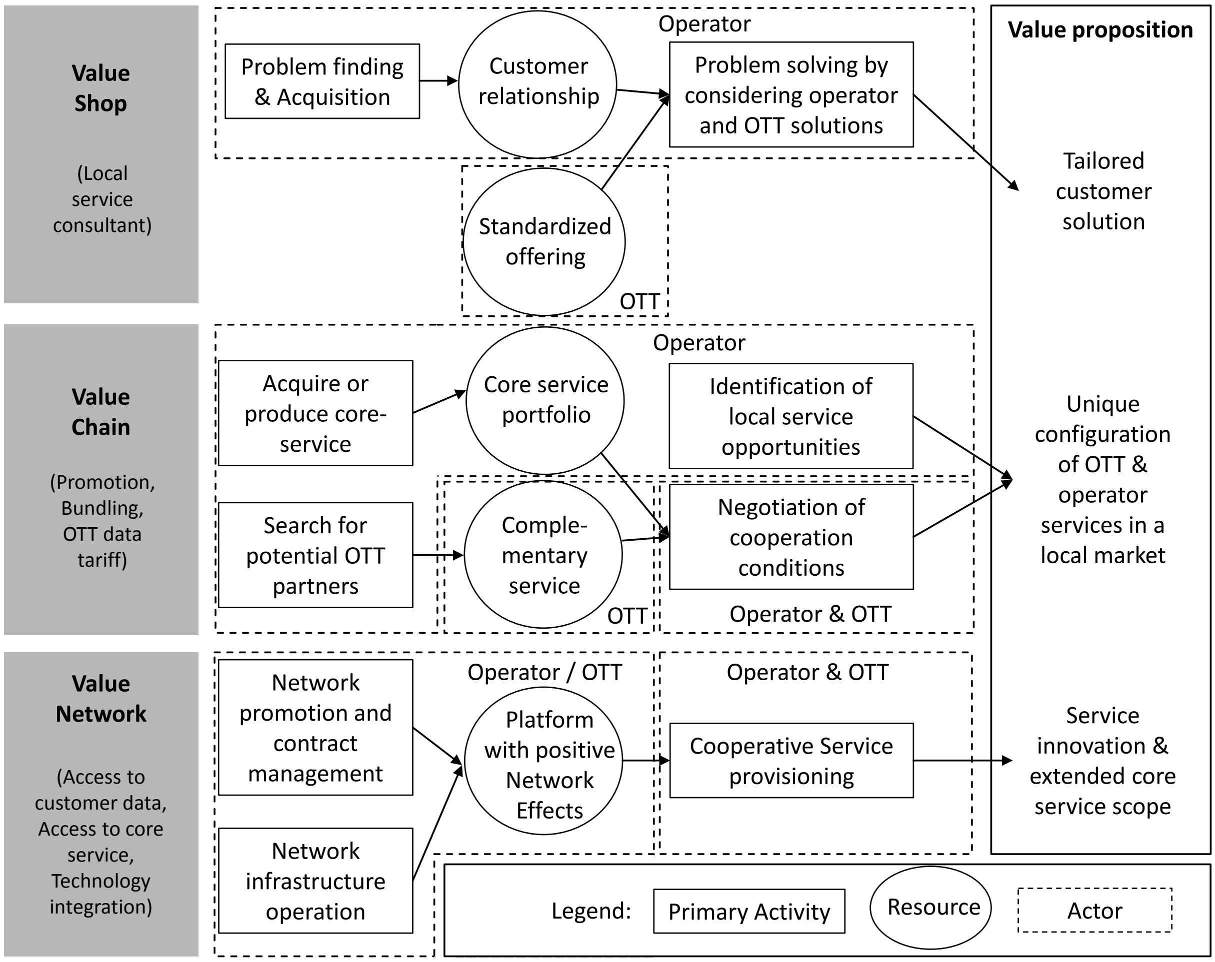


Figure 3-2: Cooperative operator and OTT value creation patterns [based on Fjeldstad/Haanaes 2001 and Osterwalder 2004]

3.1.6. Cooperation impact on the customer interface and financial aspects

This section explores and discusses the impact of cooperative operator and OTT value creation patterns on the customer interface and financial aspects of the operator business model. The results of the financial analysis will be summarized in Figure 3-3.

In a *value shop*, central value creation activities are conducted by the telecommunication operator. Value creation potential is grounded in the operator consultancy's profound knowledge about the capabilities of the operator's telecommunication infrastructure. A technology agnostic approach to solving problems and short lines of communication with internal operator departments contribute to low customer coordination requirements. Operator consultancies usually exhibit good knowledge about the local market, security requirements and local laws. Moreover, operators maintain multifaceted relationships with a large number of local business customers. This customer base constitutes the basis for economies of scope in project acquisition.

With respect to the Osterwalder business model ontology, the OTT offer can be considered a complementary resource to the consulting business model. It extends the scope of consulting projects that can be handled by the operator. The cooperation enables the operator to streamline its internal cost structure in terms of fixed consultant salaries while providing a broad scope of consulting solutions to customers. Existing consulting revenues can be retained or extended if the operators manage to attract new target customers with best-of-breed solutions. Retail revenues will increase if the proposed customer solutions are implemented by the operator's operational business unites. Existing customer relationships are likely to intensify if the operator is implementing itself as the primary point of contact for all operator and OTT services.

Value chain activities are of central importance to the core business model of most reselling and integrated telecommunication operators and subject to economies of scale. Customer value configurations are often changed on a monthly basis to attract new customers. In this dynamic market, superior performance can primarily be achieved through cost efficient processes or value chain differentiation [cf. Porter 1985]. For every step of the value chain, operators need to decide whether to produce a service internally and stay in control or whether to buy it externally and retain flexibility [Li/Whalley 2002].

In the Osterwalder business model ontology, cooperation with OTT service providers enables operators to differentiate their service portfolio without the need of new asset-specific investments. Fixed costs can be transformed into variable costs if operators decide to incorporate OTT services instead of producing a service with internal resources. Thus, cooperation is a way to partially overcome the tradeoff between cost leadership and value chain differentiation. Moreover, cooperation can facilitate the creation of new operator retail revenues if operators sell premium OTT services and agree on revenue sharing. At the customer interface, operators can attract OTT-agnostic customers with product bundles or tariffs, which can be exclusive to a specific regional market. Existing and potential customer relationships are likely to benefit from eased billing or integrated service support.

Value network activities can be observed in the business models of operators and OTT service providers. Intra- and inter-industry value networks compete to provide new services to a broad number of customers. Superior performance of value networks is heavily dependent on the mediator's ability to create positive network effects for all network members through large network scope or tight partner integration [Fjeldstad/Haanaes 2001].

In the Osterwalder business model ontology, value network cooperation implies costs on top of expenditures for core business value chain activities. Promotion costs are specific to a value network and cannot be redeployed for other purposes. Thus, value network investments are associated with higher risks than value chain activities. However, successful value networks stand to gain high additional revenues through the presence of positive network effects or through first mover advantages with innovative services. On the customer interface, value networks open up access to new distribution channels as OTT agnostic customer groups can use OTT app stores to consume operator services outside the scope of the operator's physical infrastructure. For mediators of app stores or API platforms, this can be an additional wholesale revenue source. Superior service quality or innovative services can be a source of retail revenues from new customers target groups.

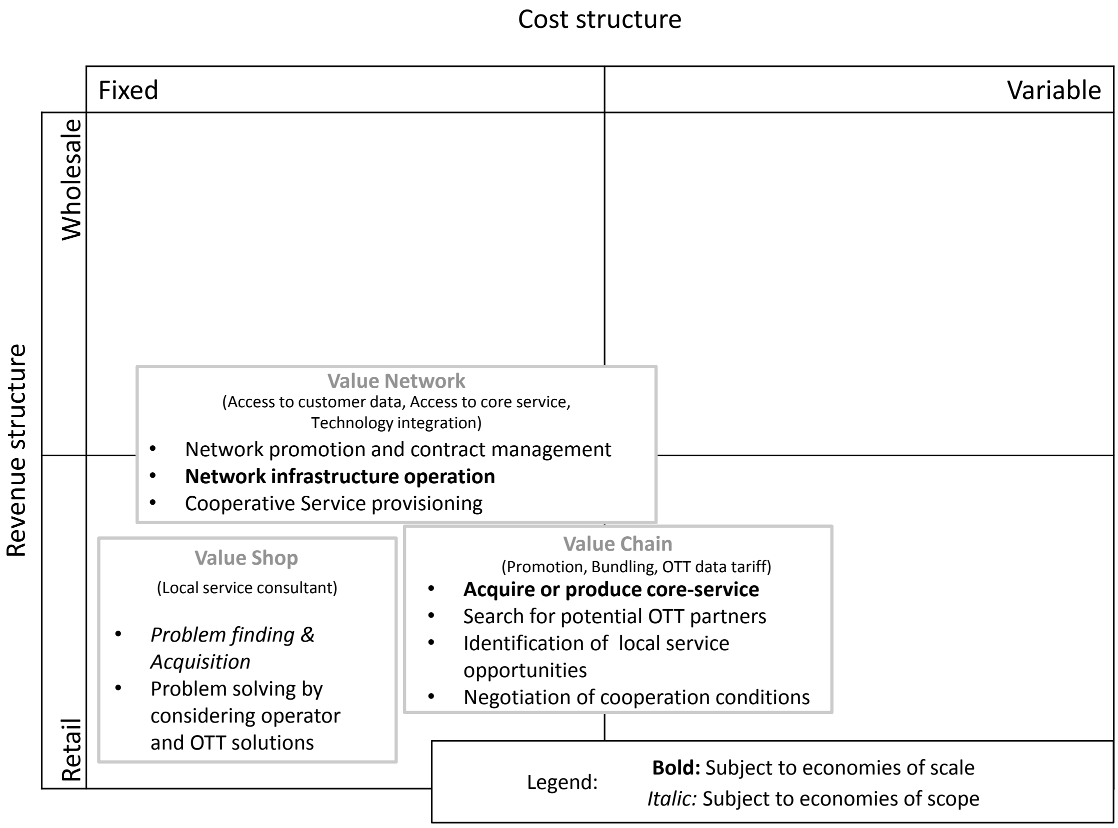


Figure 3-3: Cooperation impact on operator cost and revenue structure [adapted from Wulf et al. 2010b]

3.1.7. Summary and Conclusion

The objective of this paper is twofold. First, it provides a holistic view on service cooperation between OTT service providers and telecommunication operators. Second, it explores the cooperation type of impact on the operator business model. This second step uses the Osterwalder business model Ontology to assess the business model infrastructure with respect to patterns of cooperative value creation. Thereafter, the impact on the customer interface and financial aspects of cooperative service provisioning is explored.

The conducted analyses indicate that seven types of cooperation between OTT service providers and telecommunication operators can be distinguished: *Promotion*, *Bundling*, *Special OTT tariffs*, *local service consultant*, *access to customer data*, *access to core services*, *and technology integration*.

Every cooperation type holds different operator benefits and key characteristics. Moreover, findings suggest that cooperation types are not mutually exclusive but can be combined to aggregate cooperation benefits.
The assessment of the business model infrastructure management dimension indicates that the identified cooperation types can be related to three generic value creation patterns.

By cooperating with OTT service providers, operators can position themselves as *local service consultant* that integrates complex OTT offers with proprietary services to create value by solving specific customer problems. The success of this value creation pattern depends on trustful customer relationships and the ability to identify complex meaningful problems that customers can or will not solve themselves. By leveraging economies of scope, additional retail revenues can be generated.
Promotion, *bundling* and *special OTT tariff* cooperation create a market-specific unique customer value proposition based on an operator's portfolio of standard core services. Successful offers will include OTT services with a high perceived customer value and may be exclusive within a regional market. Revenue sharing from selling premium OTT tariffs can be a source of additional operator retail revenues.
Access to customer data, *access to core services* and *technology integration* cooperation create customer value through service innovation or new service distribution channels. Successful services should exhibit a high innovation degree or attract a large number of users for the service distribution platform to generate retail or wholesale revenues, respectively.

All three proposed value creation patterns and their corresponding business models can in general be conducted by reselling or integrated telecommunication operators. However, operators should adapt business models to their core competencies. Successful resellers are characterized by low operational costs and efficient processes. This should be reflected in cooperative service provisioning. A reselling operator may for example choose a bundling cooperation instead of a special data tariff, which is associated with higher initiation and operation costs. Moreover, a reseller's consulting scope may be limited to marketing projects. In contrast, integrated operators will leverage their technological know-how and spend additional money to create more integrated services with a higher perceived customer value.
Further research may address the question as to whether the general customer valuation of simple tariff structures and value propositions is limiting the number of cooperation agreements per operator. Moreover, the impact of the OTT player and operator size on the direction and shares of revenue streams, specifics of the partnership agreement and cooperation sustainability could be explored in future papers. Finally, this paper has outlined the diversity and innovation potential of technology integration cooperation. Thus, further research could use a case study approach to explore the success factors and barriers for this cooperation type.

3.2. Cooperative private Next-Generation Access deployment – A relational view

Title	Cooperative private Next-Generation Access deployment – A relational view
Authors	Felix Limbach (TU Berlin), Rüdiger Zarnekow (TU Berlin), Michael Düser (Deutsche Telekom Laboratories)
Published in	Proceedings of the 46th Hawaii International Conference on System Sciences (HICSS)
Research objectives	- Identification of cooperative relationship characteristics that contribute to a sustainable competitive advantage in broadband provisioning - Classification of different carrier types according to their precondition for sustainable cooperation
Methodology	- A multiple case study approach ensures external case validity - Literal and theoretical replication of results for different carrier types - Within-case analysis in combination with a grounded theory approach for data collection
Results and Implications	- National, metropolitan and municipal broadband carriers differ with respect to their preconditions for sustainable cooperation - The perceived market success of metropolitan carriers may stem from *relation-specific investments, advanced knowledge sharing routines, casual ambiguity* and *time compression diseconomies* - National carriers exhibit less advantageous preconditions for sustainable cooperation as the establishment of relationship characteristics such as *knowledge sharing routines*, *efficient governance* and *casual ambiguity* is either inhibited by organizational properties or a regulatory environment that aims to inhibit collusion

Table 3-5: Summary of [Limbach et al. 2013a]

World-wide deregulation activities on incumbent infrastructures educed competitive broadband markets in many countries around the world. However, as the customer's data

demand exceeds the technological capabilities of legacy infrastructures, large public or private investments in fiber-optic networks are required. In this paper we employ the relational view concept in order to assess how cooperation between private market service providers can contribute to reaching national broadband deployment goals. We base our findings on a combined grounded theory and case study approach with twenty-three managing experts from major telecommunication companies of the German broadband market. Our results indicate that the relational view concept can contribute to a better understanding of cooperative private Next-Generation Access deployment. Based on the result of our analysis we have been able to derive exemplary fields of action for regulators and carrier management for improving preconditions of cooperative broadband deployment.

3.2.1. Introduction

Next-Generation Access networks are widely associated with economic growth. Thus, most countries around the world have a substantial interest in improving national broadband availability. Even though measures to achieve this goal differ largely among countries, two generic mindsets can be distinguished [Ruhle et al. 2011]. Administrations with the first mindset perceive ubiquitously available telecommunication infrastructure as public good that should primarily be provided by public companies, public funds or strict regulatory measures for market participants [Picot/Wernick 2007]. Usually this kind of governmental intervention is justified with market failure with respect to private infrastructure provisioning. In the course of this mindset [Gómez-Barroso/Feijóo 2010] argued that regulation authorities and public investment are the driving force of broadband provisioning. Administrations and telecommunication operators with the second mindset argue that intensive public involvement in broadband provisioning can inhibit private investments and destroy existing market conditions [Troulos et al. 2010]. Administrations that act in the course of this mindset usually provide less funding per capita and aim to stimulate private investments [Ruhle et al. 2011]. Accordingly, the question how cooperation can foster Next-Generation Access deployment is fundamental for large super-national funding programs [European Commission 2011].

Despite its social and economic relevance IS infrastructure provisioning has been largely ignored by IS research and evoked calls for more research in this field [Tilson et al. 2010]. It is known that IS infrastructures form organizational infrastructures at a corporate level [Henver 2004]. A broader understanding of IS infrastructures extends this view to national and global infrastructures [Tilson et al. 2010]. Tilson et al. [2010] demand that the assessment of infrastructures is put at the core of future IS research.

In this paper we aim to respond to this call by assessing how cooperation between private market service providers can contribute to Next-Generation Access provisioning. This general question can be subdivided into three supporting research questions. First, we ask which characteristics can contribute to a sustainable competitive advantage. Second, we assess if carriers which are perceived to be successful in the broadband provisioning market comprise relationship characteristics that foster sustainable competitive advantages. Third, we ask if the relational view concept can contribute to a better understanding of cooperation.

In order to assess these questions we structured this article in seven sections. The next section will provide an overview on the related literature and point out our contribution to the research field. In the subsequent sections we will introduce the theoretical foundations of the relational view theory. Thereafter, we will explicitly explain our research methodology and data. In Section 3.2.5 and 3.2.6 we will present and compare our conducted case studies. Finally we will present our conclusion.

3.2.2. Related literature

Divergent views on Next-Generation Access deployment educed a wide variety of publications that are related to our research questions. Thus, in discussing the related literature we will focus on the assessment of articles that have been published in high-ranking journals or conference proceedings. A major body of the identified articles is devoted to regulation policies and its effects on market players [Bauer 2010; Bouckaert et al. 2010; Eskelinen et al. 2008; Foros 2004; Kotakorpi 2006]. This literature has gained much attention among scientists and regulation authorities and contributed to a better understanding of measures which can be implied on legacy incumbent infrastructures. However, some scientists found evidence that regulation of legacy access infrastructures has had less impact on reaching Next-Generation Access goals than market based infrastructure competition [Distaso et al. 2006]. Moreover, this body of literature does not focus on cooperative broadband provisioning of private telecommunication companies. Other scientists have assessed Public Private Partnerships [Bygstad et al. 2007; Falch/Henten 2010; Fredebaul-Krein/Knoben 2010; Gómez-Barroso/Feijóo 2010; Lattemann et al. 2008; Marscholek 2011; Nucciarelli et al. 2010]. This literature assesses the question how diverging interests of private and public stakeholders can be aligned. Moreover, articles focus on assessing risk sharing strategies between public and private partners in the context of infrastructure investments. Cooperation between private investors is usually out of scope. A third body of articles assesses the effect of broadband provisioning on economic growth [European Commission 2011; Datta/Agarwal 2004; Ford 2011; Frieden 2005; Gholami 2003; Gordon et al. 2006; Yates et al. 2011]. This research area makes an important contribution to justifying public investments into the broadband market. However, due to considerations of national budget allocation countries like Finland, Germany, United Kingdom and the United States of America have decided to focus on stimulating the private broadband market instead of providing large public funds per capita for the setup of a universal broadband infrastructure [Ruhle et al. 2011]. This strategy requires a profound understanding of market forces, private investment strategies and Next-Generation Access business models. Several researchers have contributed to improving this knowledge [Bakos/Barrie 1997; Gupta et al. 2011; Hao et al. 1997; LaRose et al. 2007; Pöllänen/Säily 2007; Pöllänen/Bhebhe 2011; Sabat 2005; Sridhar 2010; Troulos et al 2010; Whitaker et al.

2011]. The contribution closest in spirit to our work shall be discussed in a more differentiated manner.

[Pöllänen/Bhebhe 2011] use a grounded theory approach in order to assess constrains in the deployment of mobile networks in India. Their analysis focuses on the assessment of supply chain strategies and dependencies between various supply chain activities. In this paper we use a similar analysis technique but employ the relational view concept on the assessment of cooperation characteristics that can contribute to sustainable inter-firm relationships. That is, we provide a broader but less detailed view on broadband deployment. Moreover, we explicitly explore how cooperation can foster private investments in novel telecommunication infrastructures.

3.2.3. Theoretical foundations

In this section we discuss the theoretical foundation of our work in a two-step process. In the first paragraph we discuss the theoretical foundation of cooperation in the telecommunications industry. The remaining part of this section introduces the relational view concept.

According to [Gerpott 2005] cooperation between network operators are predominantly operative or strategic in nature. Operative cooperation can be observed if operators mutually grant each other access to their networks or resources at operating sites [Stacy 2011]. Usually this cooperation is characterized by little implementation and contractual complexity and has become common practice for mobile operators. Network operators establish strategic cooperation for the concerted setup of capital intensive infrastructure investments in evolving markets and international projects. This type of strategic cooperation is characterized by a high degree of interdependence between operators and is common for international sea cable projects. Strategic cooperation can also be observed between network operators at the national level. Especially broadband offers of cable operators force traditional telecommunication companies into large investments and into the exploration of strategic partnerships [Distaso 2006]. In a situation like this cooperation partners need to align competitive and cooperative strategies in order to develop a sustainable competitive advantage.

With the relational view [Dyer/Singh 1998] proposed a widely recognized concept for assessing cooperative strategy and sources of competitive advantage based on inter-firm relationships. The relational view concept addresses the limitations of the industry based view that solely explains competitive advantage based on a firm's membership in an industry [Pöllänen/Bhebhe 2011]. Moreover, it aligns with the widely recognized resource-based view of a firm that explains competitive advantage based on a firm's set of resources [Dyer/Singh 1998; Lee/Lee 2008]. At its core the relational view concept proposes that cooperation partners need to create relational sources of supernormal profit along with mechanisms that preserve profits. As depicted in Figure 3-4 both relationship characteristics need to be met in order for the cooperation to provide sustainable competitive advantages. If profit preserving mechanisms do not exist, competing firms can easily copy the sources of supernormal profit.

If the relationships do not yield sources of supernormal profit a firm will prefer Arm's length market relationships over more complex cooperative relationships.

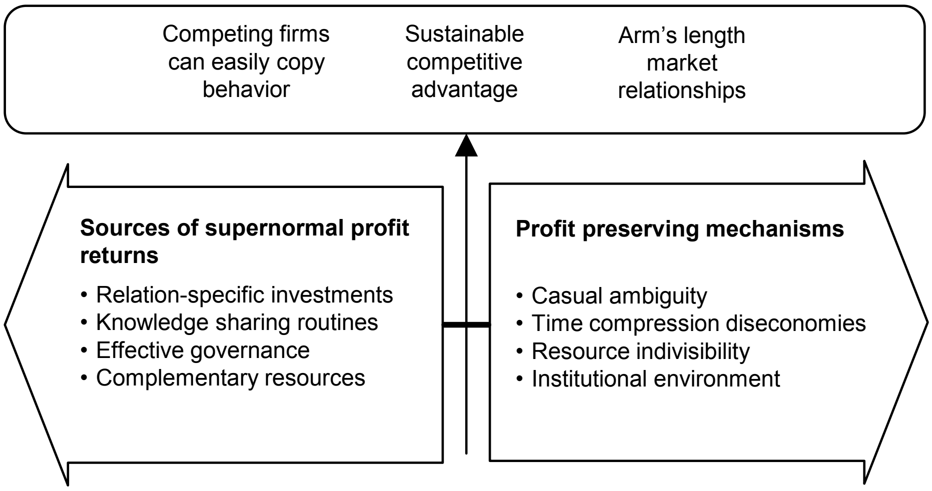


Figure 3-4: Relational view relationship characteristics [adapted from Dyer and Singh 1998]

In this paper we will assess the eight main relationship characteristics that contribute to the sustainable competitive advantage of cooperation as proposed by [Dyer/Singh 1998].

Sources of supernormal profits

Relation-specific investments can be a source of supernormal profits and usually require long contract durations and high transaction volumes in order to prevent opportunistic behavior of alliance partners [Dyer/Singh 1998; Williamson 1985]. Knowledge sharing routines can range from pure information exchange to transfer of know-how and joint utilization of innovations [Dyer/Singh 1998; Rivard et al. 2006]. In general the exchange of knowledge and innovations promises more supernormal profit returns than the exchange of information that can be reproduced easily. Trust and self-enforcement mechanisms are associated with Effective Governance as opposed to contracts and third-party-enforcement mechanisms [Zajac/Olsen 1993]. Finally, in alignment with the Resource Based View the combination of complementary resources is another source of supernormal profit. In order to capitalize these synergies the firm needs to be able to identify suitable partners and provide the organizational capability to utilize synergies [Dyer/Singh 1998].

Profit preserving mechanisms

Casual ambiguity refers to a situation where tacitness, complexity or specificity contribute to competitive advantage that is difficult to observe and thus difficult to copy by competitors [Reed/DeFillippi 1990]. Time compression diseconomies are associated with processes that cannot be speeded up at all or only at prohibitively high costs [Grant 1991; Piccoli/Ives 2005]. Thus, time compression diseconomies favor first movers within the market. Resource indivisibility contributes to the preservation of profits as specialized resources are hard to redeploy by any cooperation partner [Dyer/Singh 1998]. Finally, the institutional environment that is related to implicit rules and social controls can serve as a profit preserving mechanism as an environment of trust can lower coordination costs of alliance partners [Porter 1991].

3.2.4. Research methodology and data

In order to assess the private cooperative broadband provisioning process based on the relational view concept we need to explore inter- and intra-firm drivers and inhibitors of competition and cooperation. As stated in [Limbach et al. 2011b] this kind of assessment requires the conduction of interviews with practitioners as the nature of relationships between firms can hardly be explored based on pure literature reviews and desk research. In assessing the broadband provisioning process we advert to the Glaserian grounded theory approach [Glaser 1992]. This approach requires the researcher to be passive when conducting the interviews. That is, we refrain from mapping the relational view concept in interview questions like it would be demanded from a Straussian grounded theory approach [Halaweh et al. 2008]. Accordingly interview questions cover a broad spectrum of questions correlated with seven general categories including telecommunications value chain, cooperation initiation, cooperation design and success factors of the broadband provisioning. We choose a semi-structured interview setup for exploring the seven categories. Thus, our initial questions serve as a basis for exploring the categories but during the interview additional questions can be asked as a response to the interviewee's answers. In its most pure execution the Glaserian approach of grounded theory demands that the research does not consult any literature at all before designing interview questions. However, given the large body of literature that has been published on transaction cost theory, the resource based view, make or buy decisions and competitive advantages we designed questions in such a manner that interviewees would be able to refer to those theories if they were used for solving practical problems. At the same time questions were designed generic enough to allow the interviewees to refer to other concepts that are being used during private cooperative and competitive broadband provisioning. In this execution of the Glaserian grounded theory approach we follow common practice in IS research [Matavire/Brown 2008; Winkler et al. 2011].

Following Halaweh et al. [2008] we combine the fundamental concept of the Glaserian grounded theory approach with the concept of case study research as proposed by [Yin 1994]. Both frameworks regard an interview as primary unit of analysis and aim to identify general concepts that may be applied to a similar context [Halaweh 2008; Strauss/Corbin 1990].

Following Halaweh et al. [2008] we combine two frameworks that have been widely used and accepted in IS research. Dubé and Paré [2003] assessed more than 1500 articles in leading IS journals and found that 15 percent of them use case study research. Matavire and Brown [2008] found that 30 out of 50 leading IS journals have published articles that apply grounded theory.

In selecting the companies for our interviews we follow a multiple-case approach in order to ensure external validity [Yin 1994]. That is, we conduct interviews with several national and rural telecommunication companies in addition to the assessment of city carriers. This approach aims at the literal and the theoretical replication of results. It is based on the theoretical clusters proposed by Gerpott [2005] for systemizing broadband cooperation according to the geographic scope. We ensure the reliability of our interviews by using a case study protocol and by documenting the interviews with audio records. Moreover, we ensure construct validity by using additional sources of evidence like internal documents that have been identified as relevant to the cooperative broadband provisioning process and are provided by the interviewees. We complement this information with press releases and company specific information that is available on the internet.

We identified and selected our interview partners based on a sequential three step process. The initial starting point of our interviewee identification process was a contact to participants of the Next-Generation Access interoperability work group, which was initiated by the German regulation authority in order to foster the development of technical standards for Next-Generation Access networks. Though the work of this group focuses on operational cooperation its members have in several cases been the messengers of strategic cooperation interests between companies. Moreover, the group members represent companies that together account for more than 75 percent of the German broadband access market.

In a second step we asked the group members to establish further contacts with members of the company's cooperation department or management. Though this phase naturally had to follow opportunistic selection criteria we managed to arrange between two and five interviews per company. Following Yin [1994] we argue that it is necessary to conduct several interviews per company in order to increase result robustness by triangulating results during the interview analysis phase. In many cases interviewees were very helpful in establishing contacts with cooperation departments or top management of other telecommunication companies. Usually the contacts resulted from previous cooperation talks or existing cooperation relationships. With this incremental process we were able to conduct interviews with twenty-three experts in seven telecommunication companies. Table 3-6 provides an overview on the assessed data broken down by carrier type.

	Number of Interviewees	Number of transcribed pages	Number of Companies
National	13	235	3
Metropolitan	8	67	3
Municipal	2	23	1
Total	**23**	**325**	**7**

Table 3-6: Interview data overview

All interviewees are either a member of the company management, cooperation departments or managers with a technical background. With this interviewee constellation we managed to incorporate technical and strategic views on cooperation in our assessment.

In Figure 3-5 we summarize the previously described research model and indicate which section correlates with the three steps of our assessment process.

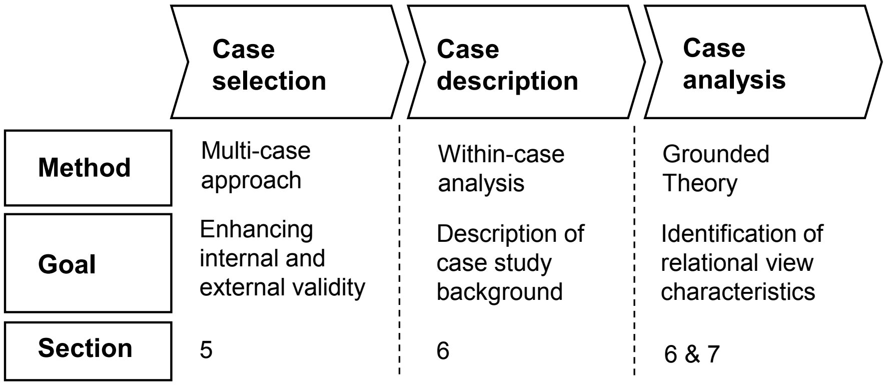


Figure 3-5: Case assessment process

3.2.5. Case study description

In this section we introduce the conducted case studies. In order to ensure the anonymity of the interviewees and their employer we will describe the case studies grouped by geographic scope as explained in the previous section. In this process we will aggregate information whenever it would be possible to relate non-aggregated information to a specific company. In each section we will first describe the carrier characteristics. Subsequently, we discuss the sources of supernormal profits and profit preserving mechanisms.

National carriers

The aggregated market shares of the assessed national telecommunication companies account for more than sixty percent of the private and cooperative broadband access market share in Germany. This set of carriers includes the national incumbent and its main national rivals in the business to customer (B2C) and the business to business (B2B) market. Some of today's non-incumbents are national subsidies of incumbent companies from other European countries. Others are national non-incumbents that have either started out as a local fully integrated provider and extended their offer nationally or entered the market as reseller of the incumbent's wholesale products. Most of the interviewed national carriers are fully integrated service providers. That is, carriers plan, build, operate and sell broadband access products. The conducted interviews show that the experts who work for national carriers are well-informed about the Next-Generation Access activities of other national carriers. Moreover, interviewees partially referred to existing cooperation with other interviewed carriers. In other cases cooperative relations were explained in general manner.

National carriers are usually large companies that exhibit many potential cooperation interfaces to other companies. Thus, national carriers need to make sure that cooperation at all company interfaces fulfills requirements with respect to technology standards and operational flexibility. Due to these requirements national carriers usually invest in standardized technology that is often provided by specialized international suppliers. Moreover, our interviews and several publications indicate that non-incumbents opt for national broadband co-investment models that result in a jointly owned infrastructure that leaves little room for infrastructure-based competitive advantages. However, regarding the necessity for the establishment of a co-investment model, interviewees from different national companies turned out to have contrary opinions. With respect to knowledge sharing routines all interviewees who participated in the Next-Generation Access Interoperability workgroup confirmed a very productive knowledge exchange regarding standardization issues and operative cooperation. At the same time all major national carriers stated that regulatory rules inhibit the free exchange of knowledge and information. Interviewees also stated that in some cases mechanisms have been established in order to make sure that no more information is been exchanged than actually required in order to accomplish a certain goal. Our interviews indicate that between national carriers cooperation governance is dominated by legal agreements whereas trust-based governance is currently an exception. Complementarity could be identified as a strong motive for cooperation. One interviewee, for example, stated that the perfect cooperation partner for private Next-Generation Access deployment would be a utility company that shares the investment risk and primarily aims at the installation of smart meters as opposed to entering the broadband access market. The importance of complementary resources was repeated similarly by other national carriers.

Based on our interviews we could not identify casual ambiguity as a profit preserving mechanism of national carriers. Desk research showed that cooperation between large carriers is not only accompanied by press releases but also often requires the approval of the regulation authority. For this reason the scope of cooperation is usually published and leaves little room for causal ambiguity. According to the interviewed experts the identification and the complexity of identifying synergies between potential cooperation partners constitutes a time compression diseconomy. Especially diagonal cooperation between utility companies and carriers can be time consuming due to different levels of knowledge on broadband provisioning. Resource indivisibility could be identified as a strong mechanism of profit preservation. That is, companies focus on long-term contracts with durations of up to 20 years. Moreover, some carriers aim to preserve profits by building networks in such a manner that latter unbundling obligations can only be enforced on a bit stream layer but not within the physical infrastructure. The institutional environment only partially fosters cooperation in broadband access. Even though politicians and the regulation authorities want to stimulate cooperative broadband provisioning traditional competitive considerations are still present in many cooperation negotiations.

Metropolitan carriers

After the German market was opened to competition more than seventy metropolitan carriers entered the market with different business models [Elixmann et al. 2010]. During the following ten years the market was experiencing a strong consolidation and carriers developed more differentiated business models. Some carriers were focusing on business costumer products and extended their activities to other cities and later to business customers all over Germany. Others were bought by larger market players or in few cases established a strong local brand. Some subsidiaries of metropolitan utility companies are among the most successful of all metropolitan carriers. We were able to conduct interviews with the three major metropolitan carriers in Germany. Today all three interviewed metropolitan carriers are fully integrated. In our findings we integrated the views of eight interviewees.

Metropolitan carriers point out that cooperation efforts between metropolitan and national carriers need to overcome the difficulty that national carriers have specific requirements with respect to the technological preconditions. These requirements force metropolitan carriers to make comparatively high investments into their own interconnection capabilities. The conducted interviews showed that metropolitan carriers have established advanced knowledge sharing routines with their partners. These carriers have started fiber roll out projects earlier than other carriers in the market and thus have been able to establish processes required to plan and roll-out new infrastructure efficiently. Interviewees made clear that potential partners and some competitors in the German market often overestimate the synergy effects that can be derived from using existing ducts. According to one interviewee the key to an efficient roll-out of a fiber infrastructure is a sound master plan but not a focus on the utilization of infrastructure synergies. With regard to the governance of projects the majority of the interviewees indicated that trust is an essential part of a partner relationship. Interviewees pointed out that a bilateral face to face communication can be very helpful in order to setup and steer cooperation. Whereas the involvement of legal departments can slow down processes dramatically and should only be applied when necessary. Similar to the national carriers metropolitan carriers agree that complementary resources are an essential part of a successful cooperation. In several cases cooperation negotiations could not be completed successfully because the potential partner could not provide the required assets necessary for a partnership at eye level. Metropolitan carriers are currently in process of opening up their fully integrated infrastructure to potential cooperation partners. That is, metropolitan carriers plan to offer wholesale products to carriers at different value-added steps of the telecommunications value chain.

Our interviews indicate that some metropolitan carriers are well aware of casual ambiguity effects which will be hard to copy by competitors that have entered the fiber market at a later point in time. While the technological know-how for the setup of Next-Generation Access networks is widely available in books, processes and planning know-how can hardly be observed by and transferred to competing companies. Thus, casual ambiguity is currently a strong profit preserving mechanism of metropolitan carriers. According to the conducted interviews time compression diseconomies are not only related to learning processes in Next-Generation Access deployment processes but are also important with respect to the accumulation of property rights agreements as the German law requires all property owner to agree to the installation of new cables on their property. Especially negotiations with private property owners can be very time consuming. The strong local brand of carriers constitutes an indivisible resource that serves as a profit preservation mechanism that leaves competitors view other options than buying wholesale products from the city carrier. Currently the national institutional environment constitutes another profit preservation mechanism for metropolitan carriers as local monopolies are currently not deregulated by the German regulator.

Municipal carriers

Just like metropolitan carriers the first municipal carriers evolved after the liberalization of the German broadband market. Usually these companies have strong local ties in rural areas. In many cases municipal carriers evolved in regions were the traditional incumbent offers did not meet the customers' demands in terms of the provided broadband speed. Even though broadband deployment strategies of municipal carriers are based on economic considerations another important driver of deployment projects is the entitlement to provide the required infrastructure for the settlement of new companies and citizens. In many cases the infrastructure of municipal carriers is only provided to a few thousand customers. In general competition dynamics are less intense than in metropolitan areas. Moreover, public funding is an essential part of most broadband deployment business cases. In the course of our analysis we conducted interviews with two experts from a municipal broadband provisioning company. We triangulated the findings with intensive desk research in order to enhance generalizability.

Interviewees of the municipal carriers point out that very close relations with suppliers result in long-term contracts with very specific technology investments. Due to small economies of scale municipal carriers invest in different technology than larger carriers. This strategy results in higher expenses for interoperability with larger carriers. In the conducted interviews with municipal carriers we identified several knowledge sharing mechanisms. While metropolitan and national carrier foster operational knowledge exchange within workgroups that have been setup by the regulation authority, municipal carrier foster knowledge exchange within the national confederation of local carriers. Moreover, municipal carriers exchange knowledge with local utility companies and authorities. According to the interviewees trust is an important governance mechanism. However, just like national and city carriers municipal carriers use contracts at every phase of the cooperative broadband provisioning process. The interviewees from municipal companies indicate that the combination of complementary resources can be multifold. That is, local carriers can jointly accomplish planning activities for new electric and fiber optic networks. Moreover, cooperation partners jointly use marketing and network operation know-how.

Due to limited financial and personal resources municipal carriers predominantly invest in broadband infrastructure that is less expensive than solutions installed by larger carriers. This precondition contributes to less complex infrastructures, processes and accordingly less casual ambiguity. Time compression diseconomies can evolve from the fact that within the broadband provisioning market prices for wholesale products are usually negotiated bilaterally. Thus, market entrants need to conduct a series of negotiation talks before they have a profound understanding of a product's or service's market value. In the case of municipal carriers potential cooperation partners often know each other from previous infrastructure projects. Due to the small company size of the potential cooperation partners a single person can subsume multiple roles within a company. Thus, cooperation initiation operation can be a lot less time consuming than in larger companies. Naturally this competitive advantage is limited to the home region of the local carrier. Just like larger carriers municipal carriers try to agree on large contract durations of up to 18 years. Due to remote competition dynamics infrastructure investments are often cooperation specific and hard to redeploy to a different utilization. Thus, these investments and contracts constitute an indivisible resource and contribute to the preservation of profits. The institutional environment of municipal carriers is characterized by trustful long-term relationships and a strong commitment to the improvement of local infrastructures. Interviewees have stated that even though it would be possible to extend activities beyond the boundaries of the municipality this possibility will not be explored before all economically feasible projects within the home municipality have been assessed.

3.2.6. Case comparison and interpretation

In this section we will summarize the case study results that were introduced in the previous section. In line with [Pöllänen/Bhebhe 2011] we used open and selective coding techniques in order to map the findings from the case study description section to the relational view concept. The relational view concepts that emerged from the grounded theory codes are presented in the subsequent table. In Table 3-7 ++ denotes a strong evidence that a factor contributes to co-opetitive performance of a carrier, whereas -- indicates strong evidence that this factor does not contribute to co-opetitive performance. The symbols +, o and – denote intermediate levels between those extremes. In the case of national and metropolitan carriers Table 3-7 comprises a checkmark if a result could be replicated literally. That is, if all assessed carriers of one carrier type appraised a co-opetitive factor the same way. Otherwise a cross will indicate that the results could not be replicated literally. In the case of municipal companies we base our findings on two expert interviews within one municipal company.

Thus, the literal replication logic cannot be applied. The last column of Table 3-7 indicates if the results could be replicated theoretically.

	National	*	Metropolitan	*	Municipal	*	**
Sources of supernormal profits							
Relation-specific investments	-	×	+	✓	-	/	(✓)
Knowledge sharing routines	-	✓	++	✓	+	/	✓
Effective governance	-	✓	+	✓	+	/	(✓)
Complementary resources	++	✓	++	✓	++	/	×
Profit preserving mechanisms							
Casual ambiguity	--	✓	++	✓	-	/	✓
Time compression diseconomies	+	✓	++	✓	o	/	✓
Resource indivisibility	-	×	+	✓	+	/	(✓)
Instituational environment	o	✓	++	✓	+	/	✓
Precondition for sustainable co-opetition	-		++		+		

* = Literal replication, ** = Theoretical replication

Table 3-7: Relational view case comparison and result replication

That is, if the findings support the assumption that carrier types differ with respect to their capability to establish sustainable co-opetitive relationships. If the preposition can neither be accepted nor rejected we will indicate this with the symbol (o). The case comparison shows that we are able to access the relational view characteristics for all carrier types. As indicated by the theoretical replication column four out of eight relationship characteristics clearly differ between carrier types. For the characteristics relation-specific investments and effective governance two out of three characteristics are not identical. The relation specific characteristic complementary resources show strong evidence that this factor contributes to supernormal profits for all carrier types. Accordingly, carriers do not differ with respect to this characteristic. Moreover, the results indicate that carriers do not differ with respect to the profit preserving mechanism resource indivisibility. However, as opposed to the previous characteristic this finding could not be replicated laterally for national carriers.

As indicated in Table 3-7 metropolitan carriers have been able to establish cooperative relationships that exhibit four sources of supernormal profits and four profit preservation properties. Thus, following the relational view concept metropolitan carriers exhibit relationship properties that foster sustainable competitive advantage. The municipal carrier shows similar relationship characteristics with respect to knowledge-sharing, effectiveness of governance and complementary resources. Resource indivisibility and the institutional environment contribute to the preservation of municipal carrier profits. In general the precondition for sustainable co-opetition of the municipal carrier is less beneficial than for metropolitan carriers. National carriers have pointed out that complementary resources are the central driver for the generation of supernormal profits, whereas other sources of supernormal profits are difficult to establish. Furthermore, Table 3-7 indicates that time compression diseconomies are the only relationship characteristic that contributes to profit preservation of all assessed national carriers. Accordingly national carriers exhibit the least advantageous preconditions for sustainable competitive advantage in cooperative relationships.

In addition to the results indicated in Table 3-7, interviews revealed that more than three fourth of the interviewees perceived the broadband provisioning activities of metropolitan carriers as successful. Our findings support the assumption that carriers which are perceived to be successful in providing Next-Generation Access networks have established relationship mechanisms that support sustainable competitive advantage. Furthermore, our results indicate that today national German carriers are inhibited from establishing sources of supernormal profits in private cooperative broadband provisioning by the same regulatory measures that aim at the prevention of collusion between market leaders in the traditional broadband market. Thus, we can draw the conclusion that the established regulatory mechanisms are currently not optimized for reaching two contradicting governmental goals of fostering private cooperative investments in Next-Generation Access networks and preventing collusion in the current broadband market. Moreover, our results point the fields of action for regulators and carrier management. That is, measures should be taken to improve sources of supernormal profits such as *relation-specific investments*, *knowledge sharing routines* and *effectiveness* of governance. Strong profit preservation mechanisms may contradict with the goal of preventing collusion. Thus, regulators and carrier management should carefully discuss the necessity of those mechanisms for receiving the required infrastructure investments. In the course of this discussion regulators will also have to address the fact that national carriers denounced the situation that metropolitan carriers are currently not subject to regulatory measures even though they are in several cases regional market leaders and have established strong profit preservation mechanisms. Our results do not allow the conclusion that the players of the German broadband market are heading for arm's length competition or that competing firms can easily copy the behavior of successful market players.

Based on the relational view concept we have been able to derive several implications for improving the preconditions for cooperative private Next-Generation Access provisioning in the German broadband market. The specific characteristics of the relational view analysis are likely to differ between countries due to different regulatory, economic and historic preconditions [Ruhle et al. 2011]. However, our results indicate that the proposed concept could be used to identify fields of action for regulators and carrier management of different countries.

3.2.7. Conclusion

In this paper we have provided an overview on the literature that has been published on Next-Generation Access provisioning. Moreover, we have pointed out that the relational view concept can contribute to a better understanding of cooperative private broadband provisioning. Our results indicate that national, metropolitan and municipal carriers can differ with respect to their cooperative relationship characteristics and that carrier types which are perceived to be successful in providing Next-Generation Access networks can be successful in establishing the preconditions required for sustainable competitive advantage. Based on the results of our analysis we have been able to derive exemplary fields of action for regulators and carrier management.

The generalization of our findings is limited by the fact that we base our findings on the assessment of the German Next-Generation Access market. Moreover, our database did not allow the literal replication of the interviews conducted in the municipal company. Thus, further research will be aimed at the triangulation of our findings with results from further interviews.

3.3. Cooperative next-generation access provisioning – Evidence from the German broadband market

Title	Cooperative next-generation access provisioning – Evidence from the German broadband market
Authors	Felix Limbach (TU Berlin), Rüdiger Zarnekow (TU Berlin)
Abstract published in	Proceedings of the Multikonferenz Wirtschaftsinformatik 2014 (A shortened version of this article has been submitted and accepted. It did not include results for business and cable operators.)
Research objectives	- Development of a contingency theory framework for cooperative broadband provisioning - Assessment of horizontal, vertical and diagonal cooperation interfaces of telecommunication companies with respect to their significance for cooperative broadband provisioning
Methodology	- Application of a Straussian Grounded Theory approach with a contingency theory coding paradigm based on 32 expert interviews in German telecommunication companies
Results and Implications	- A contingency framework for cooperative broadband provisioning is provided - At vertical cooperation interfaces standardized *Layer 2 Bitstream Access* wholesale products make the highest contribution to cooperation profitability and question the universal operation of the *Ladder of Investment* that most European regulators employ to encourage infrastructure competition - Diagonal cooperation exhibits the most favorable precondition for cooperative value creation. Reasons can be found in the utilities ability *long-term infrastructure depreciation* and in *low intersections of core competencies* with telecommunication companies - At horizontal cooperation interfaces, cooperation strategies such as *co-investments* are in many cases inhibited by high initiation costs due to *presence of competitive dynamics*, *a lack of bargaining assets* or a *complex regulatory cooperation assessment processes*

Table 3-8: Summary of [Limbach/Zarnekow 2014]

Politicians, scientists, and practitioners have been discussing whether cooperation between private broadband telecommunication carriers can contribute to a setup of next-generation access networks. To advance this discussion, we assess horizontal, vertical, and diagonal cooperation between carriers with a grounded theory approach. We base our findings on interviews with thirty-two experts in fourteen telecommunication companies in the German broadband market. Our results indicate that cooperation is primarily evolving at vertical and diagonal cooperation interfaces. Moreover, we find that the German broadband provisioning market is currently heading towards a continuously deconstructed telecommunications value chain and standardized wholesale products. However, horizontal cooperation faces numerous challenges.

3.3.1. Introduction

As governments around the world begin to place broadband provisioning higher on their agendas, investments in new infrastructures and technologies are required. In most cases, legacy copper networks rolled out by public telephone companies must be replaced in part or total. Today's leading countries in terms of broadband coverage and speed have provided large public funds to reach this goal, while countries that avoid direct public investments and support market forces are lagging behind [Ruhle et al. 2011]. This gap is also due to the complicated regulatory issues brought up by the latter approach. As the investment costs of fiber infrastructures are not yet sunken, regulators must provide novel investment incentives for private investors [Cave et al. 2006].

Next-generation access (NGA) deployment can be largely influenced by country-specific preconditions, such as broadband objectives, public funds, customer demand, and regulatory strategy elements [Ragoobar et al. 2011; Ruhle et al. 2011]. In the course of our analysis, we will therefore focus on assessing the deployment of fiber architecture variants (FTTH, FTTB, FTTC) in the German broadband market. In line with the European Commission and the NGA Forum, which was initiated by the German regulation authority, we will subsequently refer to these variants as NGA networks [European Commission 2012c; NGA-Forum 2011]. Although FTTC is partially based on incumbent copper infrastructures, we incorporate this variant in our analysis as it constitutes the next step in a gradual fiber deployment strategy. Moreover, it is an essential precondition for employing vectoring technologies, which can provide significant broadband performance gains for copper lines of up to 1000 m [Guenach et al. 2011]. As of today, FTTC has primarily been deployed in the largest 50 German cities and covers only 15 percent of all German street cabinets [VATM 2013; Carter et al. 2011].

Definitions of the term broadband differ widely. Based on the German broadband goals for the year 2014, we will subsequently denote fixed-line infrastructures that can provide at least 50 Mbps as broadband infrastructures [BMWi 2009]. Germany aims to achieve its broadband goals with less funding per capita than many other industrialized countries despite being concerned about "white spots" [Ruhle et al. 2011; Carter et al. 2011]. Calculations found that a universal FTTH and FTTB service would require investments of up to 80 € billion [Jay et al. 2011]. Current yearly private infrastructure investments account for only about five percent of this amount [Jay et al. 2011]. FTTC deployment and vectoring technology are a less expensive solution for reaching current broadband goals. However, bringing broadband infrastructures to rural areas will require joint efforts among all market participants and the provisioning of wholesale products at different value-added steps [VATM 2013].

Scientists and German broadband plans propose cooperation between private investors as a key element of a market-driven establishment of broadband networks [Ruhle et al. 2011; Carter et al. 2011; Gerpott 2010; BMWi 2009]. This proposal implies that competitors must assess the establishment of cooperative relationships. Nalebuff & Brandenburger [1996] have denoted this ambivalent relationship between companies as coopetition.

In this paper, we aim to assess how coopetition will influence NGA provisioning in Germany during the upcoming years. Moreover, we aim to understand the drivers of cooperation in the complex value network between partially disintegrated telecommunication operators. This broad research question can be subdivided into the following sub-questions. At which potential cooperation interfaces does cooperation evolve in the German broadband market? At which interfaces do companies avoid cooperation in favor of standardized wholesale products? Do carrier types differ with respect to their cooperation motivation?

We will address these questions using a bottom-up research approach based on expert interviews. In a first step, we will introduce the theoretical foundations of cooperation in the telecommunication sector. In the subsequent sections, we will elaborate our research methodology. Next, we will identify the influences that contribute to the development of cooperation strategies and how carrier types differ in their cooperation strategies perception. Finally, we will interpret our findings and derive implications in Section 3.3.5.

3.3.2. Theoretical foundations

In fostering market dynamics, many regulators are turning towards the ladder of investment. This concept aims at decreasing entry barriers for new market entrants to eventually foster competition between fully integrated telecommunication companies [Cave et al. 2006]. In its original specification, the ladder of investments requires the regulator to increase access prices once new market entrants start to generate revenues. This step is intended to foster investments at downstream value-added steps of the telecommunications value chain so that the new market entrants can eventually offer more differentiated products [Cave et al. 2006]. However, as of today, most European regulators have not increased access prices; rather, access prices have been falling [European Commission 2006]. Nevertheless, several fully integrated telecommunication carriers have evolved in European countries. Moreover, several specialized companies compete and cooperate in single value-added steps of the value chain [cf. Krishna/Ghatak 2008].

A generic telecommunications value chain can be subdivided into at least three functional layers: service, network, and asset [Limbach et al. 2011b; Mölleryd 2011]. The service layer ensures access to end customers. In this layer, marketing and product development are the primary value-added activities in the value chain. In the network layer, companies operate active infrastructure and enable data transport to backbone networks. In the asset layer, companies provide and maintain the passive infrastructure required for offering services in the network and service layers.

Cooperation interfaces between telecommunication companies can be horizontal or vertical in nature. Moreover, diagonal cooperation between telecommunication carriers and companies that initially do not provide telecommunication services can be assessed. In line with Picot & Wigand [2003] we regard cooperation as a medium- or long-term collaboration of economically and legally independent organizations. Moreover, cooperation is voluntary and can generally be ended by either company at any time [Gerpott 2005]. However, in this analysis, we do not confine cooperation to requiring joined upfront investments [cf. Carter et al. 2011]. Instead, we are also interested in products and services that at least one telecommunication company provides to other telecommunication companies on a voluntarily basis. As of today, these products and services are often technically and economically unique. Moreover, they are usually provided over a rather long period of time and can often not be bought from many alternative carriers. In line with Gerpott [2005] we will therefore refer to these vertical business relationships as vertical cooperation. With respect to the ladder of investment, the scope of this analysis includes resale, Bitstream, duct access, dark fiber, and leased lines [cf. BEREC 2010; NGA-Forum 2011]. Unbundling obligations of access products that are solely imposed on the incumbent infrastructure are out of the scope of this study [cf. BEREC 2010]. Moreover, our analysis does not focus on the analysis of access prices. Generally, we follow the access product definitions provided by BEREC [2010]. Any deviating definitions will be provided as they evolve from our analysis.

3.3.3. Research methodology and data

Research design

To explore cooperative NGA deployment, we use a bottom-up research approach based on expert interviews. In line with Myers [1997], we argue that this approach becomes increasingly useful as the focus of the research questions shifts from technical to managerial issues. We choose to enhance research rigor by applying a grounded theory approach as a data collection method. In line with Halaweh et al. [2008], we argue that this approach is particularly useful for exploring large amounts of qualitative data. Since grounded theory was first proposed, several variants have been developed. We employ one of the most widely used approaches, the Straussian grounded theory approach [Hekkala 2007; Winkler et al. 2011].

The Straussian grounded theory approach is based on a process called coding and aims to develop theory from qualitative data. Over the course of this paper, we will propose and apply a cooperation framework to assess coopetition in the German broadband market [cf. Winkler et al. 2011]. Strauss [1987] differentiates three coding types: open, axial, and selective coding. Open coding is the process of breaking down the interview data and aims to identify objects, events, and actions that are similar to or different from other concepts [Halaweh et al. 2008]. The subsequent axial coding phase aims to reassemble the data that was broken down during the open coding phase. As proposed by Strauss [1987], we use a fourfold coding paradigm that focuses on the identification of conditions, interaction among actors, strategies, and consequences to guide this phase. Moreover, our coding paradigm aligns with the structure-strategy-performance framework, which is based on the idea that companies need to use their resources and capabilities to create competitive strategies and subsequently achieve higher performance levels [Pertusa-Ortega et al. 2010]. The coding paradigm that guides our initial analysis of cooperative NGA deployment is summarized in Figure 3-6 [cf. Winkler et al. 2011].

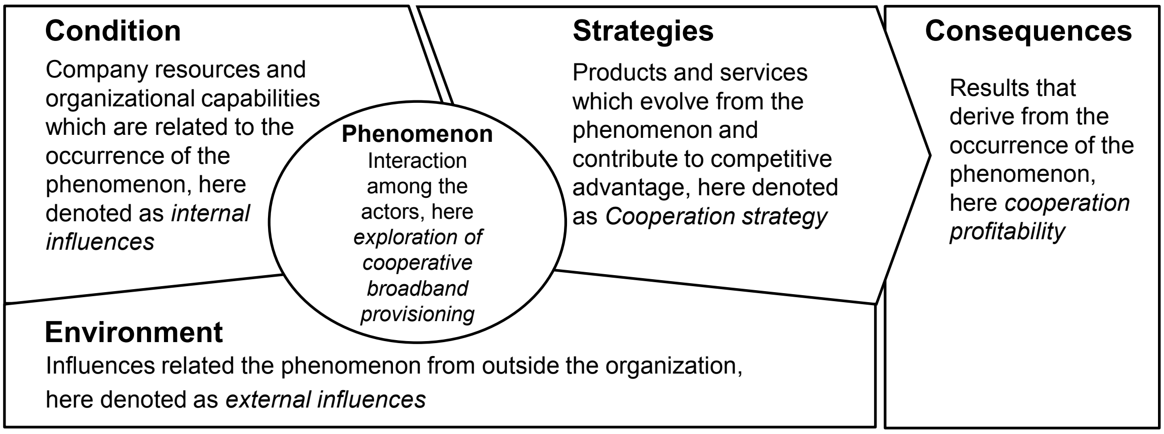


Figure 3-6: Cooperation assessment coding paradigm [adapted from Strauss 1987 and Pertusa-Ortega et al. 2010]

Our coding paradigm focuses on the assessment of endogenic company determinants that contribute to NGA deployment. As such, it is complementary to existing publications that focus on the exogenous factors that influence NGA deployment [Ragoobar et al. 2011; Ruhle et al. 2011]. Moreover, it is complementary approach to structural models of competitive dynamics [cf. Lestage et al. 2013] and to the work of Mellewigt [2003], who assessed cooperation in German telecommunication companies using a resource-based perspective and the conduction of surveys. Although the paradigm guides the initial coding process, we create additional codes and categories as they emerge from the data. With this broad coding approach, we also cover environmental influences that contribute to cooperative NGA deployment.

The subsequent selective coding phase is similar to the axial coding phase as it aims to identify a central category that emerges from the previously identified sub-categories.

However, the central concepts are more abstract and not necessarily linked to the concepts of the initial paradigm model. Two researchers separately assessed the concepts derived from the coding process. The inter-rater reliability for this assessment resulted in a Cohen's kappa of κ=0.51, which is a moderate but acceptable result [cf. Landis/Koch 1977; Winkler et al. 2011]. The process used to assess our phenomenon is adapted from Winkler et al. [2011].

Data collection and validation

The interview partners were identified in a three-step process. In a first step we contacted the participants of the work group Interoperability at the NGA Forum which was set up by the German regulation authority to foster cooperative broadband deployment projects in Germany. In a second step we asked the participants to establish further contacts to decision makers within their company. Finally, we asked the experts to establish contacts to existing cooperation partners in other telecommunication companies within Germany. Using this procedure we were able to conduct interviews with thirty-one experts in thirteen companies. Each expert interview had a length of either sixty or ninety minutes. The interviews were conducted between February and October 2012.

In conducting the interviews, we refrained from directly asking interviewees about horizontal, vertical, and diagonal cooperation. Instead, we implemented our questions about cooperation interfaces in a broad spectrum of questions correlated with seven general categories, including telecommunications value chain, cooperation initiation, cooperation design, economies of scale, scarce resources, and success factors of the broadband provisioning. These categories served as a basis for exploring the research field of cooperation in NGA provisioning. However, due to the semi-structured nature of our interview setup, we also asked additional questions based on the interviewee's responses. Within our general categories, we also asked questions related to transaction cost theory, vertical (dis)integration, and the advantages of a fully integrated broadband provider. Although these questions were related to well-known theoretical concepts, we designed the questions in such a generic manner that interviewees could refer to concepts other than those listed above.

We ensure external case validity by following a multiple-case approach. That is, we triangulate our analysis between carrier types with a heterogeneous geographic scope, customer focus, and network technology. This case sampling strategy results in the carrier categories national, metropolitan, municipal, and business. Moreover, we incorporated cable companies in our analysis. This sampling approach aims at theoretical and literal replication. That is, we expect to identify differences between and similarity within carrier categories. To ensure the assessment of industry trends, instead of pure expert opinions, we follow the procedures suggested by Yin [2003]. Accordingly, we triangulate the interview results of experts who work within the same company. Moreover, we asked the experts to provide additional documents used during the setup process of cooperation. Furthermore, we conducted interviews at several companies within one carrier category. Finally, we utilized existing literature, such as press releases, to interpret and validate our findings. Table 3-9 summarizes the interview data that serve as a basis for our further analysis. We cluster the results of the subsequent analysis by carrier category to ensure the anonymity of our interviewees and their employers.

Operator Category:		National	Metro-politan	Municipal	Business	Cable	Total
Interviewees	(#)	14	8	3	4	3	32
Transcribed pages	(#)	253	78	25	54	46	456
Companies	(#)	4	3	2	3	2	14
Qualification background of interviewees							
Academic	(%)	100	100	100	100	67	94
Technical	(%)	57	62	62	25	67	55
Economic	(%)	36	13	13	75	33	32
Legal	(%)	7	25	25	0	0	13
Personal responsibility for cooperation decisions							
Direct	(%)	36	38	38	75	67	45
Indirect	(%)	64	62	62	25	33	55
Average industry experience of interviewees	(Years)	12	13	13	17	23	15

Table 3-9: Interview data properties by operator category

3.3.4. Cooperation strategies and carrier comparison

Based on an extensive open and axial coding process, we developed more than 50 concepts from over 250 codes. For the sake of clarity, Figure 3-7 depicts only those 18 concepts that evolved from the data at least ten times and are related to our core phenomenon. We did not incorporate codes such as *open access*, which have not been clearly specified by NGA Forum documents and can be interpreted in various ways [cf. NGA-Forum 2011]. Moreover, we made sure that non-trivial concepts either align with BEREC [2010] definitions or are defined in the subsequent sections.

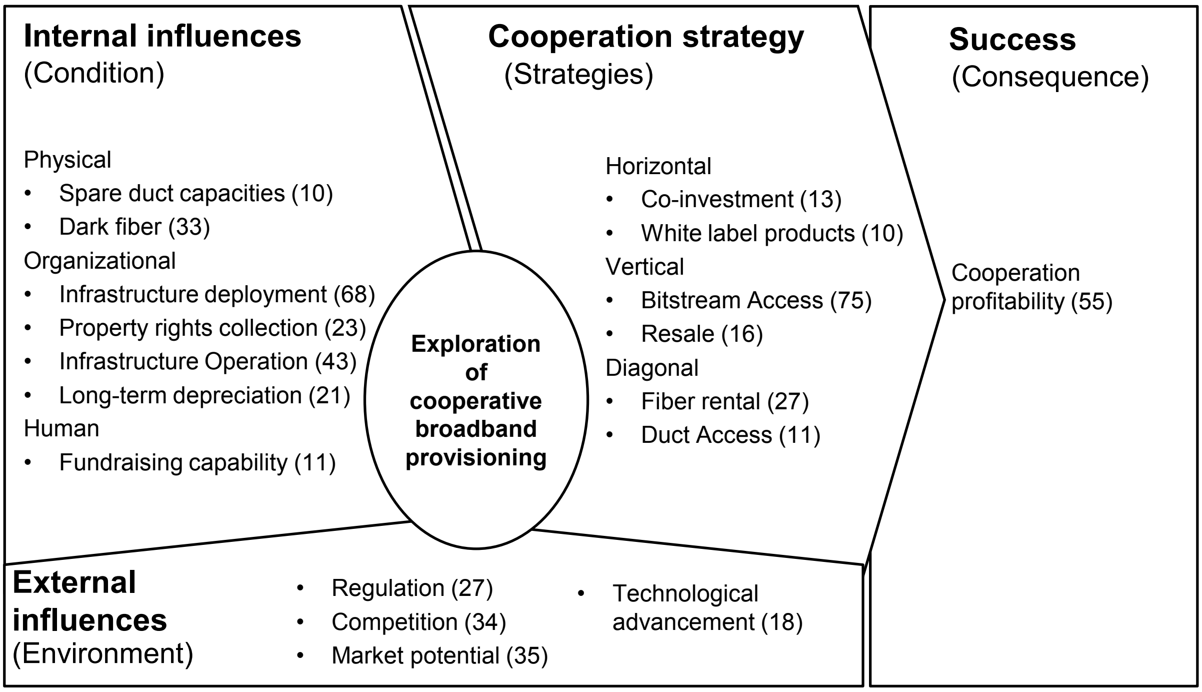


Figure 3-7: Cooperation framework, including code frequencies

In the subsequent section, we will assess the impact of external and internal influences related to the development of cooperation strategies.

Cooperation strategies

Horizontal cooperation

Horizontal cooperation is characterized by the coordination of activities that are associated with the same value-added step of the supply chain [Gerpott 2005]. Accordingly activities of horizontal cooperation result in similar market goals, products, and services. Moreover, horizontal interfaces show overlapping core competencies and common goals of cooperation partners more often than in other types of cooperation [Limbach et al. 2011].

Horizontal cooperation has been recognized as potentially more harmful for competition as vertical agreements because cooperation partners are likely to cut competitive activities in the field of their cooperation to compete in other value-added steps [Mölleryd 2011; Gerpott 2005].

Based on our coding analysis, we find that the German Cartel Office (GCO) carefully monitors horizontal cooperation efforts, which are based on upfront investments and will subsequently be denoted as co-investment [cf. Carter et al. 2011]. Accordingly, larger horizontal co-investment projects are associated with substantially higher initiation costs than all other types of cooperation. This is due to the fact the GCO requires telecommunication companies to provide and if necessary revise detailed cooperation agreements. The GCO review covers aspects such as allocation and reciprocal access agreements, and aims to ensure that infrastructure and retail competition are only reduced if cooperation parties can prove that otherwise NGA deployment would not take place [Bundeskartellamt 2010]. Interviewees indicate that this cooperation assessment process and uncertainty of future evaluations of the cooperation contribute to the negative evaluation of horizontal cooperation profitability. The GCO has indicated that complementary NGA deployment in "white spots" does not constitute hardcore competition restrains [Bundeskartellamt 2010]. For this reason, interviewees have primarily considered horizontal cooperation in rural areas, where companies can reuse less existing infrastructure and spare ductwork capacities than in urban areas [cf. Hoernig et al. 2010]. Accordingly, interviewees state that horizontal co-investments between private telecommunication companies can hardly contribute to the development of economies of scale in civil works, which contribute to approximately 80% of the total investment costs [cf. Ragoobar et al. 2011]. Moreover, co-investment models usually require cooperation governance mechanisms, which contribute to complexity [cf. NGA-Forum 2011].

The interviewees had a more positive attitude towards horizontal cooperation in the service layer, which is based on so-called white-label products. In contrast to pure resale products, which are solely marketed, distributed, and billed by resellers, white-label services, such as IP-TV, provide some customization options that enable carriers to differentiate their services to some extent [cf. BEREC 2010].

Vertical cooperation

Vertical cooperation refers to business relationships at different value-added steps of the telecommunications value chain. That is, services or products of cooperation partners are complementary to each other and are said to enhance economic efficiency [Mölleryd 2011].

Regulation requires the incumbent to provide Bitstream Access (BSA) to alternative operators, that is, a bidirectional high-speed transmission capacity link to end-users [BEREC 2010]. Although non-incumbent operators are currently not required to offer BSA, our results indicate that most metropolitan carriers are considering BSA offers to leverage additional market potential through the marketing power of national carriers. For this reason, we incorporate the assessment of BSA offers in our analysis. Generally, interviewees distinguish between Layer 2 (Ethernet) and Layer 3 (IP) BSA. Currently, the incumbent is providing a Layer 3 BSA to alternative carriers, which holds more functionality than a Layer 2 BSA but allows less freedom in customizing quality parameters [BEREC 2010]. The majority of the interviewees highlighted the importance of standardized BSA Layer 2 and 3 products for infrastructure operation.

In the service layer, we assessed interviewee statements on resale products, which constitute the first step of the ladder of investment and are usually not within the scope of regulation [BEREC 2010].

Diagonal cooperation

In addition to horizontal and vertical cooperation, we assess diagonal cooperation. Following Gerpott [2005], we refer to cooperation as being diagonal if cooperation partners belong to different industries. That is, cooperation between a telecommunication company and a utility company would be considered vertical cooperation. In general, diagonal cooperation can be subdivided into input-oriented and output-oriented cooperation. Whereas input-oriented cooperation focuses on the joined utilization of complementary resources, output-oriented cooperation aims at the creation of novel services or products [Gerpott 2005].

Our coding analysis finds that within the German market, input-oriented cooperation is currently clearly dominating over output-oriented cooperation. Moreover, interviewees indicate that fiber rental offers and duct access are the strongest drivers of cooperation with utility companies [cf. BEREC 2010]. Another strong driver of diagonal cooperation offers is the utility's ability for long-term infrastructure depreciation. The interviewees state that the competitive market environment requires companies to calculate business cases with depreciation times that are up to three times shorter than those of utility companies. We also find that public utility companies often have better access to broadband funds and can thereby foster cooperation offers [cf. Falch/Henten 2008]. Finally, we find that German and European regulatory measures and laws that increase transparency on existing duct infrastructures have a high impact on the evolution of cooperation at diagonal cooperation interfaces.

Table 3-10 summarizes the impact of internal and external influences on the development of horizontal, vertical, and diagonal cooperation offers based on a three-point scale ranging from high to low. As the coding concepts infrastructure operation and Bitstream Access co-occurred sixteen times in our transcribed interview material, we assigned the value high. Similarly, we assigned the value medium to concepts that co-occurred approximately half as often. Finally, we assigned the value low to concepts that co-occurred in only one or two cases.

Influences on strategies	Horizontal	Vertical	Diagonal	Supporting literature
Internal				
Physical				
Spare duct capacities	low	low	medium	[Carter et al. 2011]
Dark fiber	low	medium	high	[Hoernig et al. 2010]
Organizational				
Infrastructure deployment	medium	medium	medium	
Infrastructure operation	low	high	medium	[BEREC 2012a]
Property rights collection	low	low	medium	
Long-term depreciation	low	medium	high	[Falch/Henten 2010]
Human				
Fundraising capability	low	low	medium	[Falch/Henten 2010]
External				
Regulation	high	medium	high	[Cave 2010]
Competition	low	low	Medium	
Market potential	medium	medium	medium	[Carter et al. 2011]
Technological advancement	low	low	low	

Table 3-10: Extend of internal and external influences on cooperation strategies

Carrier comparison

In this section, we assess how horizontal, vertical, and diagonal cooperation contribute to the cooperation profitability of different carrier types. For this purpose, we will briefly describe the operator characteristics and explain their company's motivation for engaging in different types of cooperation. The results of our analysis are consolidated in Table 3-11.

National carrier

National carriers provide their services on a country-wide level employ several thousand employees and make several billion euros in revenues. In our analysis, we conducted interviews with a variety of national carriers including the national incumbent. The non-incumbent national carriers are a subsidiary of an incumbent from another European country, have started out as a national local carrier, or only operate in the service layer of the value chain.

Most interviewees from national carriers state that horizontal cooperation might be a feasible way to deploy broadband networks. However, large vertically integrated operators make clear that make-or-buy decisions will always be conducted before cooperation is considered because horizontal cooperation between national carriers is subject to regulatory rules and shared investments in many cases also imply shared profits. As of today, little horizontal cooperation could be observed between national carriers. This is also due the fact that horizontal cooperation brings about the need to resolve numerous technical, financial, and legal problems. Vertical collaboration is discussed by experts more often. Standardized BSA

Layer 2 products, which are provided in the service layer, are requested by most national carriers especially often. In general, the BSA product is associated with few initiation and controlling costs. Accordingly, many experts denoted it as the preferred cooperation form between telecommunication carriers. A national carrier that specializes in the provisioning of services to end-customers clearly stated that the company does not plan to follow the ladder of investment by investing in active or passive infrastructure [cf. Cave et al. 2006]. Accordingly, a standardized Layer 2 BSA is essential for providing differentiated NGA products to customers. However, experts also refer to the functional shortcomings of current BSA Layer 3 products, unresolved technological issues, and partially high Layer 3 BSA prices. All interviewed fully integrated carriers preferably engage in diagonal cooperation with utility companies if utilities invest in dark fiber and make rental offers. Duct access was denoted as the second best option as synergies between available ducts and optimal network design must be assessed in elaborate processes.

Metropolitan carrier

Metropolitan carriers offer their services in a delimited geographical region make less than one billion euro in revenue and employ up to two thousand employees. Metropolitan carriers evolved in many cities after the liberalization of the telecommunication market. Following a strong consolidation in the metropolitan carrier market, few metropolitan carriers remained. According to our interviewees these carriers are perceived to be very successful in providing broadband infrastructure to their home market. The assessed metropolitan carriers are fully integrated.

Based on our analysis, we find that metropolitan carriers are particularly interested in horizontal cooperation in the service layer. That is, metropolitan carriers would like to sell white-label broadband services to their customers, which, as of today, are proprietary products of national carriers and have been proven to foster broadband demand. Our interviewees also indicate that metropolitan carriers are willing to provide Layer 2 BSA products to other carriers in the market. Moreover, we find that metropolitan carriers are generally very open to diagonal cooperation with utility companies, especially if they have already acquired the necessary knowledge specific to broadband deployment. Finally, we find that duct access and fiber rental offers can contribute to cooperation success with metropolitan carriers.

Municipal carrier

Municipal carriers are characterized by strong local ties in rural areas. They employ less than 200 employees and generate less than fifty million euros in revenues. These carriers primarily evolved in areas where the traditional incumbent infrastructure provided lower broadband speeds than in other areas of the country. Generally, public funding is an important part of the broadband deployment business cases.

Interviewees indicate that in addition to the acquisition of public funds, municipal carriers are interested in horizontal cooperation with metropolitan and national carriers. This is particularly true for cooperation in the asset and network layers. However, such cooperation may not be successful due to a lack of municipal cooperation assets. Moreover, municipal carriers depend on the acquisition of wholesale products such as Layer 3 BSA from national or metropolitan carriers to extend broadband offerings and utilize economies of scale in marketing. Shared investments with local utility companies are usually an integral part of a broadband deployment business cases and accordingly contribute to cooperation profitability. Contracts are often characterized by contract durations of up to twenty years.

Business carrier

Business carriers are characterized by a customer base that is dominated by business customers. In contrast to the previous carrier types offers for private customers may complete the portfolio but represent a minor share of the total revenue. The assessed companies employ up to two thousand employees and generate up to 500 million euro in revenue. Business carriers specialize in providing business services as well as national and international aggregated infrastructures to their customers. Accordingly, network operation and aggregation are an important part of their business activities.

Our interviewees indicate that horizontal cooperation is generally not the preferred type of collaboration. However, in special cases, horizontal cooperation can be required by a service customer if two or more business carriers own complementary resources that are required for providing the service desired by the customer because mutual buying of these resources would increase the price of the final service provided to the customer. Some of the interviewed business carriers perceive themselves as platform operators between the asset and service layers of the telecommunications value chain. It was stated that business carriers exhibit a competitive advantage over fully integrated carriers because a specialized network operator has no incentive to discriminate services in higher value chain layers. Accordingly, those business carriers argue that duct access and fiber rental from utility companies is essential for cooperation profitability. Business carriers are particularly interested in cooperation with utility companies if future commercial areas are provided with broadband infrastructures.

Cable operator

Cable operators offer broadband services via bidirectional coaxial cables to their customers. The assessed cable operators employ up to five hundred employees and generate less than one billion in revenue. Currently, German cable operators are subject to few regulatory measures. Thus, most of the German cable operator market is subdivided among three major market participants. Moreover, cable operators barely compete or cooperate in the asset layer.

At the vertical cooperation interfaces, interviewees from one cable company state that they are generally open-minded with respect to providing fiber-optic network wholesale products to telecommunication companies. In higher value chain layers, interviewees state that technical difficulties currently prevent cable operators from providing wholesale products to telecommunication companies. However, cable operators also distribute the service offerings of competing cable operators if they are generally desired by the customer and if a proprietary cable operator infrastructure does not exist. In contrast, another interviewee stated that Layer 2 BSA offers will not be provided to telecommunication companies in the absence of regulatory obligation.

Like telecommunication companies, cable companies rent fiber-optic network capacities from local utility companies. Furthermore, cable companies partially bridge gaps within the networks of utility companies to pursue systematic roll-out plans. Accordingly, fiber rental cooperation with utility companies contributes to cooperation profitability.

Table 3-11 summarizes our findings on cooperation profitability for different carrier types and cooperation interfaces. We indicate a strong contribution to cooperation profitability with ++ and a strong negative impact with – –. Similarly, +, o and, – denote intermediate ratings. Moreover, we provide code frequencies for the co-occurrence of cooperation concepts, carrier types, and the concept of cooperation profitability.

	National	Metropolitan	Municipal	Business	Cable	Total
Horizontal						
Co-investment	– (3)		– (2)			– (5)
White label	+ (1)	+ (3)	+ (1)	+ (2)		+ (7)
Vertical						
Bitstream Access	o (16)	+ (5)	o (3)	+ (1)	– (1)	o (26)
Resale	o (5)					o (5)
Diagonal						
Fiber rental	+ (7)	+ (2)	+ (1)	++ (2)	+ (2)	+ (14)
Duct access	+ (3)	+ (2)		++ (1)		+ (6)

Table 3-11: Impact of cooperation strategies on carrier cooperation profitability

Interpretation

In Table 3-11, we summarize how different cooperation strategies contribute to cooperation profitability. The results show that interviewees associate cooperation profitability more often with vertical and diagonal cooperation than with horizontal cooperation. We find that at the asset layer horizontal co-investments are in many cases inhibited by high initiation costs due to competitive dynamics, a lack of bargaining assets and the cooperation assessment process. Horizontal cooperation is more likely to develop in the service layer, where market dynamics incentivizes owners of strongly requested services to provide white-label products to other market participants. Consequently, horizontal cooperation dynamics are rather increasing customer demand than broadband supply.

Vertical cooperation is being discussed more often than other types of cooperation, especially for Layer 2 and 3 BSA products. Due to an initiative of the German NGA Forum, the German market is headed for standardized Layer 2 BSA products, which are offered by not only the national incumbent but also several metropolitan carriers with significant regional market share. The interviewees did not provide evidence that the introduction of vectoring on FTTC infrastructure would require a modified Layer 2 BSA. This finding aligns with recent BEREC [2012] best practices, which state that a different treatment of fiber and copper infrastructure should be justified with competition problems. Our results also indicate that local carriers and operators that specialize in service provisioning at single value-added steps are the strongest advocates of Layer 2 BSA solutions. Moreover, volume discounts for wholesale purchasers contribute to the positive appraisal of Layer 2 BSA and resale products. Asset-network cooperation is rarely observed. Most interviewees indicated that such cooperation would usually result in an intersection of core competencies. Moreover, it would result in increased cooperation complexity and is said to not be required if Layer 2 BSA products are working properly.

Diagonal cooperation can be observed with all carrier types. The interviewees indicated that complementarity of resources and longer amortization times in utility company business cases contribute to the popularity of this type of cooperation. Generally, carriers prefer the rental of passive infrastructure over joint investments and long contract durations of up to twenty years over shorter contract durations. Next to fiber rental agreements, interviewees denote duct access as the second best solution to increase cooperation profitability.

In summary, cooperation between German broadband carriers can primarily be observed at vertical and diagonal cooperation interfaces. In contrast, horizontal cooperation can only be observed in a few cases. Consequently, our results do not provide evidence that the current types of broadband cooperation are reducing competitive dynamics. In fact, we find that market dynamics are forcing carriers into smaller investments. For this reason, the deployment of FTTC infrastructure and vectoring technology seem to be two important intermediate steps for a demand-driven FTTB and FTTH deployment.

3.3.5. Conclusion

In this paper, we assessed horizontal, vertical, and diagonal coopetition in the German broadband market based on a three-layer cooperation topology framework for the telecommunications value chain. We conducted interviews with four carrier types and cable operators to assess the cooperative market-driven deployment of broadband infrastructures.

Increasing demand and supply of standardized wholesale products at all value-added steps of the telecommunications value chain, volume discounts for resellers, infrastructure sharing, and aggregation strategies contribute to its deconstruction [cf. Krishna/Ghatak 2008]. This market-driven development enables coopetition at various value-added steps between fully integrated carriers and market participants that occupy market niches at single value-added steps. However, as of today, horizontal co-investments between telecommunication carriers face numerous challenges. According to our analyses, several German carriers have opted against horizontal cooperation due to uncertainty of GCO and regulatory evaluation. Although the NGA Forum is mandated to improve preconditions for co-investments it has decided to postpone the topic until the first co-investment project is evolving within the market [NGA-Forum 2011]. This deadlock situation could be addressed by putting uncertainty of co-investments higher on the agenda of the NGA Forum.

For vertical cooperation, we find that pure service providers and aggregators at the operation layer will particularly benefit from planned standardized Layer 2 BSA wholesale products and they do not plan investments in infrastructure according to the ladder of investment [Cave et al. 2006]. For this reason, the regulator should observe if the specialization and niche strategies of some carriers substantially reduce investment insecurities for other market participants and thus foster a market-driven broadband deployment.

In this paper, we assessed cooperation based on an assessment of the German fixed line broadband market. The results are likely to differ for mobile broadband infrastructure because horizontal cooperation at the asset layer is much more common. Further research will validate central findings of this paper in a survey.

4. Cooperative cost reduction strategies in telecommunication companies

A major research field of this dissertation analyzes cooperative cost reduction strategies and quantifies their effect in various cooperation scenarios. Analyses explore the preconditions for cost reductions in inter-industry cooperation initiation, synergy utilization in rural broadband deployment and cooperative diversification strategies directed at the entry in the content delivery market. The research in this chapter is, in part, a continuation of the research conducted in the previous chapter. In this sense, Section 4.1 and Section 4.2 have been inspired the results of the analysis in Section 3.2. An overview on the publications in this chapter is provided in Table 4-1.

Title	Published in	Reference	Section
A contingency perspective on municipal broadband adoption	Proceedings of the International Conference on Information Systems (AMCIS 2014)	[Limbach et al. 2014a]	4.1
Improving rural broadband deployment with synergistic effects between multiple fixed infrastructures	Telecommunication Policy Journal (Under review)	[Limbach et al. 2014b]	4.2
Business models and competition in the content delivery network market – An infrastructure analysis	Proceedings of the 20th European Conference on Information Systems (ECIS)	[Limbach et al. 2012b]	4.3

Table 4-1: Publications related to cooperative cost reduction strategies

Section 4.1 presents an analysis of municipal broadband adoption strategies to reduce the costs of cooperation initiation with telecommunication companies. Thereafter, Section 4.2 explores how multiple fixed infrastructure owners can cooperatively reduce the costs of rural broadband deployment. The subsequent Section 4.3 provides an analysis of CDN business models and assesses how a potential carrier coalition can reduce the costs of market entry.

4.1. A contingency perspective on cooperative municipal broadband adoption

Title	An Contingency Perspective on Cooperative Municipal Broadband Adoption
Authors	Felix Limbach (TU Berlin), Hannes Kübel (TU Berlin), Rüdiger Zarnekow (TU Berlin)
Published in	Proceedings of the 20th Americas Conference on Information Systems (AMCIS 2014)
Research objectives	- Identification of internal and external contingency factors that influence broadband adoption strategies of municipalities - Determination of properties that contribute to a successful implementation of a particular broadband adoption strategy - Exploration of the impact of cooperation with telecommunication companies on the success of municipal broadband adoption
Methodology	- Survey among the CEOs of 980 German utility companies based on questions that have been derived from expert interviews with telecommunication companies - Factor analyses is used to identify latent constructs that influence the strategy selection and successful broadband adoption - Discriminant analysis are used to identify internal and external factors that influence broadband adoption success with distinct adoption strategies
Results and Implications	- A major aspect of differentiation between broadband adoption strategies can be found in the municipality's attitude towards activities at the active infrastructure layer - The first group of municipalities seeks cooperation at the active infrastructure layer while the second group operates active infrastructure with internal resources - The success of particular broadband adoption strategies can primarily be explained based on the appreciation of internal organizational goals such as *access to marketing know-how, access to sales channels* or *access to network planning know-how*

Table 4-2: Summary of [Limbach et al. 2014a]

In this paper municipal broadband adoption is assessed with an empirical contingency theory research approach. Based on a survey among CEOs of municipal utility companies a multi-step analysis process is conducted to explore broadband adoption strategies. In a first part of the process 5 distinct municipal broadband adoption strategies are derived from factor and cluster analyses. Thereafter, strategy performance is assessed and related to external and internal variables. Results suggest that a municipality's attitude towards cooperation at different layers of the telecommunications value chain is essential for strategy characterization. Furthermore, the success of particular broadband adoption strategies can primarily be explained by the municipalities' appreciation for internal organizational goals such as access to marketing know-how or access to network planning know-how.

4.1.1. Introduction

The positive impact of broadband infrastructure on economic growth and social welfare is generally recognized. Several IS scholars investigate determinants and preconditions of broadband adoption from the customer perspective, e.g., [Choudrie et al. 2004; Khoumbati et al. 2007]. However, as infrastructure investment costs inhibit economically viable broadband deployment [Gillett et al. 2004], focus is put on the opportunities and challenges of the broadband technology supply side. Thus, authors have investigated municipal broadband adoption, e.g., [Shin/Tucci 2009; Ortiz 2010]. In this regard, research questions address the adoption of broadband technology by municipalities to meet national and super-national broadband goals [FCC 2014; Gillett et al. 2004; Gillett et al. 2006; Picot/Wernick 2007]. Driven by concerns about discouraged private investments and biased competition [Troulos/Maglaris 2011] some regulatory frameworks embody a tentative attitude regarding municipal broadband adoption. In the case of the US, anti-municipal broadband have been issued in a number of states [ILSR 2014] and a debate is ongoing on the question if decisions on municipal involvement should be made on a local or national level [FCC 2014]. Contrarily, leading Asian counties in terms of broadband speed have reached their broadband targets with a large degree of public involvement [Picot/Wernick 2007], while the European Union aims to unfold market forces at different layers in an unbundled telecommunications value chain. Independently of national differences in regulatory attitudes and geo-demographic preconditions, municipal broadband adoption requires collaborative service provisioning across industries.

In this light, the present work aims to provide insights on municipal adoption of broadband technology and potential for cooperation with telecommunication companies. Country comparisons are a common instrument in this field of research [Picot/Wernick 2007; Troulos/Maglaris 2011; Bouras et al. 2009], while empirical investigations are rare and usually focus on the assessment of publicly available data [Gillett et al. 2004]. Therefore, this paper investigates cooperative municipal broadband adoption on an empirical basis focusing on both external and internal factors. This allows examining the following research questions in detail:

1. What are the elements of a municipal broadband adoption strategy?
2. Which strategies do municipalities use for broadband adoption?
3. Which contingency factors determine a municipality's success with a particular strategy?
4. Can telecommunication companies, interested in cooperation, externally observe contingency factors that indicate favorable preconditions for the successful implementation of a particular strategy?

The subsequent article is structured as follows. After an introduction of the theoretical foundations of municipal broadband adoption the research methodology is presented. In the results section a four-step analysis process is described. It is followed by a discussion and the conclusion.

4.1.2. Theoretical foundation of cooperative municipal broadband adoption

In this section an overview on the theory of municipal broadband adoption is provided. In a first step, the generic value chain layers, which constitute strategic fields of involvement for municipalities, will be introduced. Secondly, an overview on existing literature that has been published on the role of municipalities in cooperative broadband adoption is presented.

A simplified telecommunications value chain can be subdivided into at least three functional levels [Bouras et al. 2009; Troulos/Maglaris 2011]. That is, the asset, network and service layer. Subsequently, these layers will be denoted as Layer 1, Layer 2 and Layer 3. In the next section the layers will be explained in detail and finally summarized in Figure 4-1.

At Layer 1 physical infrastructure such as spare ducts and dark fiber are provided and maintained. Spare ducts can refer to either dedicated spare ducts or other physical municipal infrastructures that can be rededicated to host dark fiber. Within the three-layer telecommunications value chain this layer accounts for about 70 percent of the total investment costs of broadband deployment [FCC 2010]. This layer is characterized by long product life-cycles.

At Layer 2 active equipment is operated to ensure data transport to backbone networks. In general product life-cycles at this layer are much shorter than in the first layer. In an unbundled telecommunications value chain a so-called Bitstream Access (BSA) is a wholesale product that can be offered to other companies. It is defined as a bidirectional high-speed transmission capacity link to end-users [BEREC 2010].

Layer 3 ensures access to end customers and is characterized by short product life-cycles. Common activities at this value chain layer involve service marketing and customer billing. In an unbundled telecommunications value chain alternative operators have the opportunity to resale broadband access and services.

Since the full deregulation and privatization of the telecommunication sector national and super-national governments took different measures to foster the unfolding of market forces [Picot/Wernick 2007]. Especially in areas with high population density, inter-platform competition between Digital Subscriber Line (DSL) and cable operators and intra-platform competition at different value chain layers this has led to competitive environments. In these areas all layers are predominantly operated by *Private Operators*.

Naturally similarities between the activities of a municipally owned company such as electrical utilities and activities of private broadband companies exist with respect to civil works and passive network maintenance [Troulos/Maglaris 2011]. For this reason municipalities may decide to enter the broadband market as an *Infrastructure Provider* at Layer 1 in order to reduce market entry barriers of private companies in Layer 2 and Layer 3 and create revenues from a duct and dark fiber wholesale product. As indicated by cooperation interface 1 this entry can also be done in a public-private partnership (PPP). In this municipal broadband adoption strategy private companies may generally compete at Layer 2 and Layer 3. However, it has been recognized that in the presence of competition within Layer 2, entry barriers for telecommunication companies remain sizable [Bouras et al. 2009].

In the *Carrier's Carrier* strategy municipalities operate at Layer 1 and Layer 2. This strategy eases private sectors entry to Layer 3 but impedes competition in Layer 2. Generally, it enables the development of an integrated solution for Layer 1 and 2. However, it requires municipal companies to establish network operation know-how in the telecommunication sector [Bouras et al. 2009]. Activities that involve backbone and inter-carrier connection are not related to traditional municipality activities. As indicated by cooperation interface 3 a PPP at Layer 2 may be a suitable way to address this shortcoming. This strategy aims at the setup of wholesale contracts with service providers [Nucciarelli et al. 2010].

In the *Service Operator* strategy municipalities operate all layers of the generic three layer value chain. Consequently, this strategy requires know-how in network planning, operation and end customer marketing. If utility companies engage in the municipal broadband initiative the established end customer relationship may favor this strategy [Troulos/Maglaris 2011]. As indicated by cooperation interface 5 municipalities can also acquire the necessary know-how in a PPP. If end customers do not have access to alternative broadband infrastructure this strategy does have a negative impact on competition at all value chain layers. Thus, depending on regulatory preconditions and local laws this strategy may be inhibited [Gillett et al. 2006; Picot/Wernick 2007]. However, in case of low demand for wholesale services at Layer 2 and Layer 3 municipalities may even be forced to engage in service operation at Layer 3 to address an identified public demand [Nucciarelli et al. 2010].

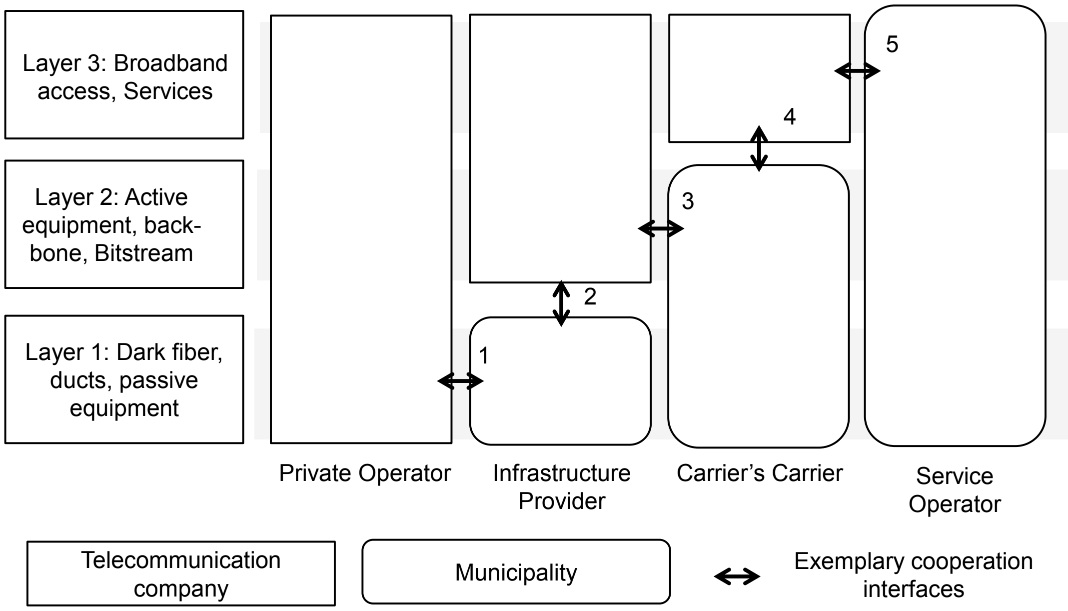


Figure 4-1: Theoretical strategies for cooperative municipal broadband adoption [adapted from Troulos/Maglaris 2011]

4.1.3. Methodology

In the subsequent section the research framework and the data that serves as bases for addressing the research questions are introduced.

Contingency theory research framework

Contingency theory is based on the idea that there is no universally best way to make strategic decisions in an organization [Otley 1980]. Instead the contingency approach assumes that managers of an organization choose an appropriate strategy in the context of internal organizational goals and environmental influences that cannot be influenced. Contingency theory was originally proposed to advance organizational theory. However, during the last decades researchers have applied the theory to different fields including IS research [Otley 1980; Sambamurthy/Zmud 1999]. Several researchers have indicated that municipal broadband adoption is depending on a variety of external factors [Gillett et al. 2006; Ragoobar et al. 2011; Troulos/Maglaris 2011; Picot/Wernick 2007]. In addition, the authors' previous research with managers in the telecommunications industry suggests that many internal factors influence municipal broadband adoption [Limbach et al. 2013b]. Thus, in this paper contingency theory is applied to get a holistic view on determinants of municipal broadband adoption. The contingency factors considered in this paper have been inferred in a two-step process and are summarized in Table 4-3.

In a first step, common *external factors* of municipal broadband have been summarized from existing literature in [Gillett et al. 2006; Ragoobar et al. 2011; Troulos/Maglaris 2011; Nucciarelli et al. 2010].

While most bullet points in the first column of Table 4-3 exhibit an intuitive relation to broadband adoption this may not be the case for the last two factors. *Distance to the backbone interconnection* relates to a municipality's distance to the next internet concentration point that is already connected to a fiber network. Usually, a longer distance is related to higher backbone interconnection costs. The literature analysis reveals that *regulatory preconditions* are very country specific. Thus, in the scope of this paper they will relate to the question if a municipality is obligated to open its infrastructure to telecommunication companies at Layer 1 or 2 in a so called open access approach [cf. Gillett et al. 2004]. Possible contingency factor dependencies will be addressed at a later point of the analyses.

Nucciarelli et al. [2010] indicate that broadband deployment is a multi-step process. First the definition of broadband targets is required. It is followed by a match of core resources and competencies. For this reason this paper covers the interrogation of the municipality's broadband adoption targets and the resources that are devoted to reaching them. The covered aspects have been derived from previous research [Limbach et al. 2013b].

External factors	Internal factors	
	Organizational broadband goals	Resources devoted to broadband projects
• Customer demand for broadband services • Competition with other infrastructure providers • Household density • Population • Broadband supply • Distance to the backbone interconnection • Regulatory preconditions	• Access to service sales channels • Area-wide coverage of households • Cost-optimized coverage of households • Access to network planning know-how • Access to investment capital • Access to marketing know-how	• Number of dedicated employees for cooperation management • Internal competition for financial resources with other utility projects • Percentage of overall investments in broadband deployment

Table 4-3: External and internal contingency factors of broadband adoption

In analogy to Otley [1980] it is assumed that contingency factors influence the broadband adoption strategy and its performance [cf. Figure 4-2]. As indicated in the theoretical foundation section, municipal broadband adoption strategies can be primarily differentiated by the degree of vertical integration and complementary cooperation requirements with telecommunication companies. Following common practice *performance* is defined as the number of households that a municipality has connected to its broadband network.

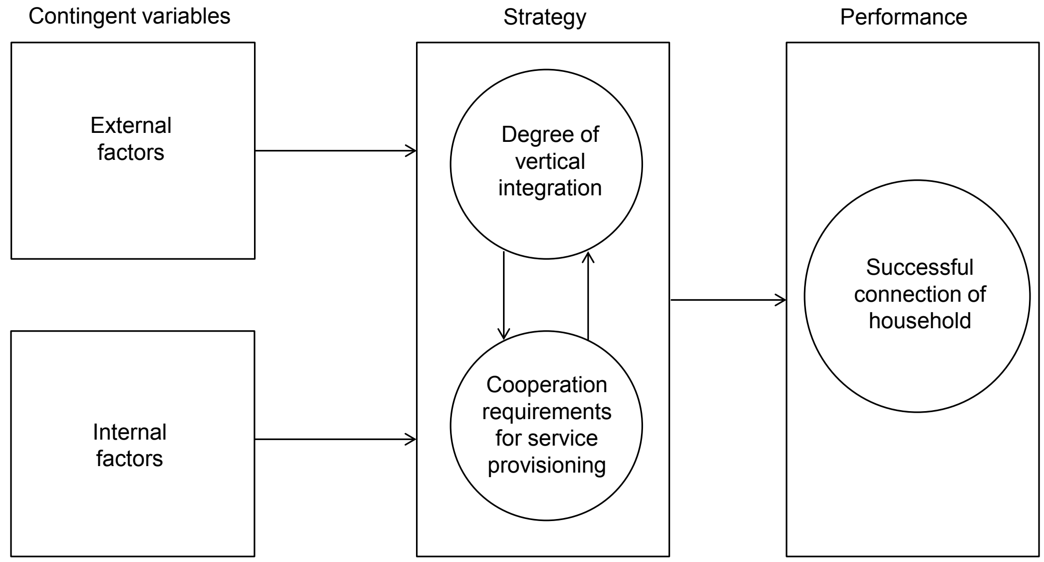


Figure 4-2: Contingency research model for municipal broadband adoption [adapted from Otley 1980]

Data

The data for the contingency research model derived above was gathered from publically available sources and a survey among utility companies in Germany.

On the one hand, information on local broadband technologies and competitive situations were extracted from the Breitbandatlas [BMWi 2014], a database on the German broadband market provided by the ministry of economics and technology. Further, a database of the federal agency of statistics on regional demographics was consulted to extract indicators for broadband demand such as the number of households, businesses and registered domains per community [Regionaldatenbank 2013]. Distances to the next internet concentration point were derived from OpenStreetMap [OpenStreetMap 2012]. Finally, information on broadband supply was drawn from contract information that internet users provide before conducting a broadband speed test at DSLWeb [2014].

On the other hand, a survey was conducted in cooperation with the Verband Kommunaler Unternehmen e.V. (VKU), one of the largest associations of public communal companies in Germany representing over 1400 utilities. The survey focused on retrieving internal information on the utilities' broadband goals and their determinants residing within and outside the companies. Therefore, an online questionnaire was developed and, after pre-testing, an invitation email was send to 980 utility companies active in the supply of gas, water, electricity and long-distance heating. Members active in sectors out of scope, like waste management or city cleaning, were excluded from the mailing list. The questionnaire was launched in the name of the industry association that allowed directly contacting knowledgeable experts, i.e., either CEOs or executive officers of broadband divisions, and stimulating their responsiveness. As well, a printable version of the questionnaire was designed to allow for responses via mail, fax or email in addition to online submissions. In total, 131 questionnaires were returned completed and, after thorough examination and discarding inconsistent answers, the sample comprises 121 responses equaling a response rate of 12.3%. In the received sample 45 municipalities had no intention of adopting broadband technology for their community. Thus, 76 municipalities were assessed with respect to their broadband adoption strategy.

The questionnaire was designed to reveal the respondents' attitudes regarding several aspects, e.g., their willingness-to-cooperate and price expectations, preferred cooperation interfaces and business models, availability of resources and funding. In order to retrieve this information the participants were asked a total of 19 questions. The majority of questions included several items that were to be evaluated on Likert-scales and, to a minor number, through multiple and single choices. As recommended by Groves et al. [2004], the Likert-scales allowed for a possible answer in the seven-point scale ranging from not relevant/very unfavorable to very highly relevant/very beneficial.

The analysis comprises the following four consecutive steps that are summarized in Table 4-4. First, an explorative factor analysis is employed to identify the latent strategy variables. Based on the resulting factor scores, a cluster analysis is applied in order to identify broadband adoption strategies, i.e., groups of similar instantiations of contingent strategy variables. Subsequently, a second cluster analysis is conducted on the performance indicators of each strategy cluster to reveal successful municipalities with a particular adoption strategy. Finally, in a discriminant analysis the contingency factors were identified that contribute to a successful implementation of a particular strategy.

Analysis step	1	2	3	4
Research method	Explorative factor analysis	Cluster analysis	Cluster analysis	Discriminant analysis
Framework item	Strategy	Strategy	Performance	Contingent variables
Objective	Identification of latent strategy factors	Empirical identification of broadband adoption strategies	Identification of most successful municipalities with a particular adoption strategy	Identification of contingency factors that contribute to a successful strategy implementation
Addressed research questions	1	2	3	3 & 4

Table 4-4: Analysis sequence for the assessment of research questions

4.1.4. Results

The subsequent sections will present the results of the 4-step analysis process. The next subsection focuses on the results of the strategy factor and cluster analyses. Thereafter, the results of strategy performance and contingency factor analyses are presented and discussed.

Strategy factor and cluster analysis

In the course of the explorative factor analysis the Kaiser-Meyer-Olkin Measure for sampling adequacy (.689) shows an acceptable intercorrelation between strategy factor items [Garcia-Santillan et al. 2012]. Using a Varimax Rotation with Kaiser Normalization 10 strategy factors can be identified that are related to 18 items in the questionnaire [cf. Table 4-5]. Following the Thurstone's Rules, items were excluded if they did not load (<0.4) [Thurstone 1967]. Moreover, validity of the main constructs was ensured by excluding strategy factors with cross-loadings (>0.4) [Saraf et al. 2007; Repschläger et al. 2013].

No.	Strategy factor label	Loading activity items	Factor Loadings	Associated Layer
1	Service provisioning	Provisioning of White label products (e.g. IP TV)	.819	3
		Provisioning of end customer services in fixed and mobile broadband	.799	
		Resale of end customer services	.704	
2	Cooperative network operation	Cooperative BSA provisioning	.792	2
		Cooperative White label provisioning	.774	
		Cooperative network operation	.609	
3	Internal use of passive infrastructure	Internal use of passive infrastructure such as dark fiber and spare ducts	.643	2
4	Network operation	BSA provisioning	.799	2
		Network operation	.572	
5	Hybrid fiber coax (HFC) utilization and Wholesale	Cable infrastructure utilization	.818	2
		Cable infrastructure wholesale	.648	
6	Rights of way collection and Service provisioning	Internal utilization of BSA	.589	1 & 3
		Rights of way collection	.585	
		Internal White label utilization	.529	
7	Cooperative deployment of passive infrastructure	Cooperative deployment of passive infrastructure	.665	1
8	Cooperative mobile network deployment	Cooperative mobile network deployment	.677	1
9	Passive infrastructure deployment	Passive infrastructure deployment	.748	1
10	Wholesale of passive infrastructure	Wholesale of passive infrastructure	.723	1

Table 4-5: Factors of cooperative municipal broadband adoption strategies

Results of the explorative factor analysis indicate that items such as *BSA*, *White label products* and *network operation* are regularly loading on similar strategy factors. Moreover, municipalities either seek cooperation for related activities or prefer to produce a set of activities with internal resources. The utilization and wholesale of cable infrastructure (HFC) evolved as a separate strategy factor besides DSL fiber broadband infrastructure indicating that utilities usually adopt one of both wire-line technologies. Based on the identified strategy factors a cluster analysis has been conducted to identify groups of municipalities that adopt a particular broadband strategy.

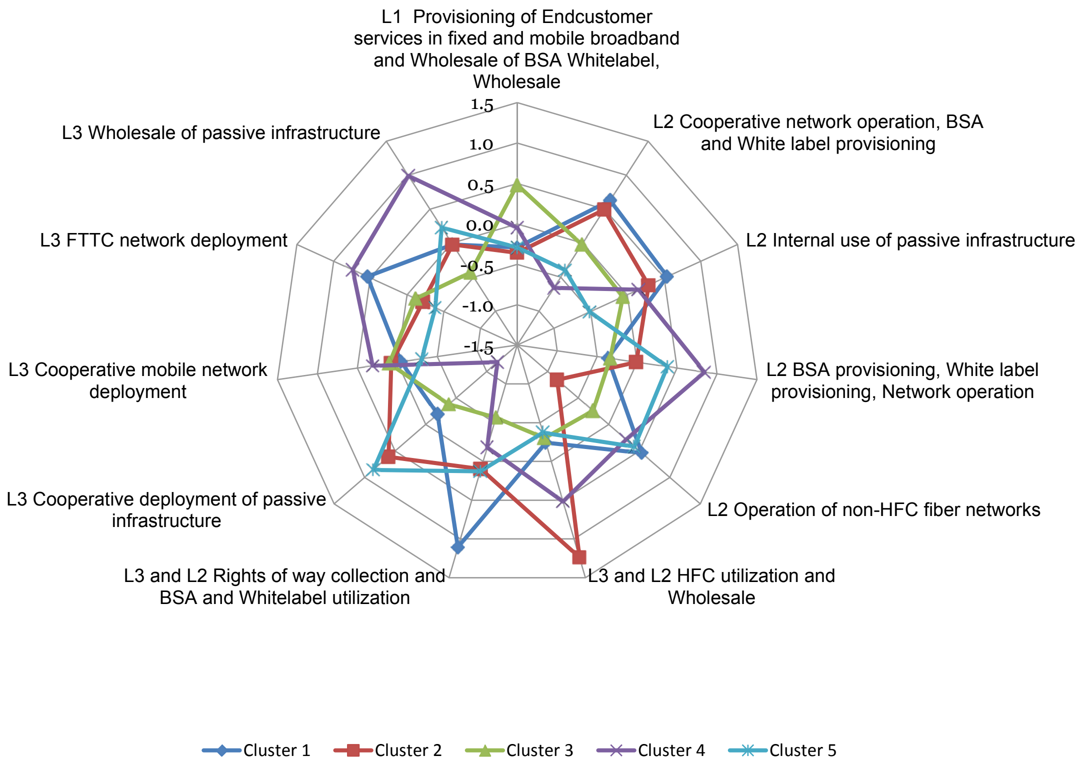


Figure 4-3: Municipal broadband strategy clusters

Figure 4-3 indicates that municipalities adopt broadband technologies with 1 out of 5 strategies that exhibit a unique combination of a particular degree of vertical integration and cooperation requirements. The majority of municipality activities are related to activities aiming at the provisioning of fixed passive infrastructure layer. At the same time, municipalities show little interest to provide mobile telecommunication networks.

Strategy clusters 1 and 2 involve cooperative network operation at Layer 2. In contrast, strategy clusters 4 and 5 involve network operation without involvement of telecommunication providers. Of those strategy clusters cluster 4 exhibits a strong focus on wholesale activities at Layer 1 and 2. Strategy cluster 3 is characterized by the fact that municipalities aim to establish a customer relation with broadband end customers.

Furthermore, cluster 3 shows few municipal activities at other layers of the telecommunications value chain.

Strategy cluster 2 exhibits a strong focus on the deployment and operation of cable infrastructures while the remaining strategies aim at the provisioning of fiber networks that use unbundled local loop DSL infrastructure or directly connect end customers to the municipal fiber network.

Strategy performance and contingency factor analyses

In the next step further cluster analyses are conducted within each strategy cluster to identify municipalities that are particular successful within their strategy cluster. The results of these analyses are summarized in Table 4-6. The table provides an overview on the number of municipalities that have adopted a particular broadband strategy. Moreover, it distinguishes the performance of average (AVG) and leading (Top) municipalities in terms of the number of connected customers. This analysis assumes that a municipality is successful in broadband provisioning if an above average number has already been connected and an above average number of customers will be connected in the next 5 years.

Strategy Cluster	Municipalities per cluster	Households connected with Spare ducts for broadband adoption				Households connected with fiber optic cables for broadband adoption			
		Experience as of today		Planned in addition		Experience as of today		Planned in addition	
	#	AVG	Top m.	AVG	Top m.	AVG	Top m.	AVG	Top m.
1	12	2,786	10,000	9,429	50,000	6,214	10,000	10,429	50,000
2	11	10,400	50,000	4,700	10,000	10,800	50,000	4,700	10,000
3	27	1,045	2,500	4,272	10,000	1,227	2,500	4,454	10,000
4	8	50,875	200,000	28,125	50,000	52,750	200,000	26,375	50,000
5	18	1,688	2,000	13,063	50,000	1,563	2,000	1,659	50,000

Table 4-6: Cluster characterization according to broadband adoption performance

Table 4-6 indicates that the majority of the assessed municipalities have connected less than 10,000 customers to their broadband network. In contrast, 19 municipalities employ a strategy described by strategy cluster 2 and 4. On average these municipalities have already connected more than 10,000 households with spare ducts and fiber cables. Except for cluster 3 and 5 leading municipalities have connected a largely above average number of households within their strategy cluster. Moreover, leading municipalities clearly plan an above average connection of further end customers.

To develop a better understanding for the external and internal contingency factors that contribute to the success of a particular broadband adoption strategy ANOVA and stepwise discriminant analyses are conducted and summarized in Table 4-7. As described in the methodology section a broad number of factors have been considered for this analysis. To improve readability Table 4-7 presents only external (E) and internal (I) contingency factors that showed significant discrimination properties in the stepwise discriminant analysis. Independence of contingency variables was ensured with further factor analyses.

The conducted discriminant analyses show that the characteristics of internal organizational objectives contribute to discriminating leading from other municipalities within all strategy clusters. Moreover, in strategy clusters 2, 3 and 4 external contingency factors contribute to the discrimination of both municipality groups.

In strategy clusters 1 and 5 less successful municipalities have indicated that cooperation with telecommunication companies could improve existing *network planning know-how*. In contrast more successful municipalities see less need to improve existing *network planning know-how* through cooperation. In cluster 3 successful municipalities also highlight the importance of network planning know-how. However, they do not seek cooperation with telecommunication companies in order to improve existing know-how.

Strategy Cluster (C)	Group discriminating parameters for top and other municipalities within strategy cluster	Univariate Analysis			Stepwise discriminant analysis[4,5]		
		Group mean 'Top municipalties'	Group mean 'Others'	F for group mean equality test	F	Wilks-Lambda	Discriminant loadings
1	I: Access to marketing know-how through cooperation	4	3.57	1.41	8.62**	.258	1.73
	I: Access to network planning know-how through cooperation	4	5.43	0.27	20.96***	.074	3.95
2	E: Customer demand (Domains in county)	148,086	53,458	218.21***	218.21***	.625	11.77
	I: Cooperative area-wide and cost-optimized coverage of households	7	6.6	.600	933.68***	.006	18.28
	I: Access to capital through cooperation	5	4.75	.055	3855,12**	.001	-7.76
3	I: Establishment of network planning know-how	4.67	3.91	.868	7.52**	.347	-.992
	E: Average download speed in community according to customer contract (Mbit/s)	9.14	14.61	6.62**	6.62**	.576	1.24
4	E: Customer demand (Companies in county)	24,581	4,319	269.4**	269.4***	.007	6.90
	I: Access to service sales channels	5	4.6	.25	3466.9**	.000	6.97
5	I: Access to network planning know-how through cooperation	2	4.5	2.35	5.55**	.684	1.41
	I: Access to service sales channels	5.3	4.6	.41	7.60**	.420	-1.17

Table 4-7: ANOVA and stepwise discriminant analysis for contingency factors of municipal broadband adoption

4 Minimal partial F-statistic for acceptance:3.84, Maximal partial F-statistic for exclusion: 2.71.

5 Wilks Lambda of discriminant function: C1: .074 ,Steps: 2; C2: .003 ,Steps: 3; C3: .347 ,Steps: 2; C4: .070 ,Steps: 2;C5: .420 ,Steps: 2

* p<0.10, ** p < 0.05,*** p<0.01

In cluster 4 and 5 successful municipalities value *access to sales channels* high within their organizational objectives. Yet, they are not to be established with cooperation but on the basis of wholesale contracts. In contrast, successful municipalities in cluster 1 seek cooperation with telecommunication companies to improve marketing know-how.

Clusters 2 and 4 indicate that customer demand in terms of registered domains per county and the number of companies in a county are positively related with the success of municipal broadband projects. Similarly, results in cluster 3 indicate that a lack of broadband speed supply within a community can facilitate success of municipal broadband adoption.

4.1.5. Discussion

The conducted analyses enable a characterization of municipal broadband adoption strategies and a discussion of the raised research questions. Based on 10 strategy factors 5 distinct strategies can be described and analyzed.

The majority of the assessed municipalities focus their broadband adoption strategies on the provisioning of wholesale services at the passive and active infrastructure layer. That is, they either employ the *Infrastructure Provider*, *Carrier's Carrier* or a combination of both theoretical business models. At vertical cooperation interfaces the success of those strategies is characterized by an above average appraisal of *marketing know-how* and *access to sales channels*. *Customer demand* constitutes an external contingency factor that contributes to success.

At horizontal cooperation interfaces a major factor of differentiation between wholesale broadband adoption strategies is the attitude towards cooperative network operation at value chain Layers 2 and 1. Generally, municipalities with more broadband adoption experience seek horizontal cooperation at Layer 1 less often for the establishment of *network planning know-how*. Strategy cluster 4 indicates that very experienced municipalities also refrain from considering cooperation at Layer 2.

Empirical findings highlight that theoretical wholesale broadband adoption strategies are not mutually exclusive but can be employed simultaneously at different layers. Moreover, some results align well with quantitative assessments of the American market. That is, findings suggest that end customer demand and demand at Layer 3 is essential for the successful implementation of wholesale strategies Layer 1 or 2 [cf. Gillett et al. 2004].

In the assessed sample the *Service Operator* strategy is employed by municipalities in strategy cluster 3. They exhibit the least experience in connecting households to broadband networks and show few broadband deployment activities at Layer 1 or 2. It is hardly surprising, that the success of this strategy is related to a lack of broadband supply within the community instead of marketing related activities. In line with Troulos and Maglaris [2011] it can be assumed that these communities are still testing strategies in pilot projects and will adopt more differentiated strategies at a later point in time.

Finally, empirical analyses show that the successful implementation of municipal broadband adoption strategies is largely affected by the municipality's appreciation of cooperation at different value-added steps within generic telecommunications value chain. As a consequence, findings complement earlier research projects on municipal broadband adoption which were based on data that is stored in national databases or is externally observable [Gillett et al. 2004; Gillett et al. 2006]. With respect to research question 4, results suggest that external factors which can serve as an indicator for successful cooperative municipal broadband adoption are rare.

For cooperation initiation, results suggest that telecommunication companies should assess a municipality's potential business customer broadband demand. Moreover, cooperation initiation talks should indicate that the municipality exhibits a high appreciation for marketing related activities.

4.1.6. Conclusion

This paper assesses cooperative municipal broadband adoption strategies with a contingency theory approach. Based on a survey among CEOs of municipalities in Germany external and internal factors of broadband adoption strategies are assessed and related to strategy performance. In a four-step analysis process 5 distinct municipal broadband adoption strategies are identified, characterized and related to contingent factors of a successful implementation.

Results indicate that theoretical broadband adoption strategies are not mutually exclusive. Instead empirical findings suggest that different theoretical wholesale strategies can be pursued at the same time. A major aspect of differentiation between broadband adoption strategies can be found in the municipality's attitude towards activities at the active infrastructure layer. The first group of municipalities seeks cooperation at the active infrastructure layer while the second group operates active infrastructure with internal resources. The success of particular broadband adoption strategies can primarily be explained based on the appreciation of internal organizational goals such as *access to marketing know-how, access to sales channels* or *access to network planning know-how*.

This paper makes a quantitative contribution to a body of existing literature on municipal broadband adoption that is predominantly qualitative in nature. As such it advances knowledge about environments in which municipalities enjoy freedom of decision at a local level. However, in the generalization of results market and regulatory preconditions can differ largely between countries and should be taken into account.

4.2. Improving rural broadband deployment with synergistic effects between multiple fixed infrastructures

Title	Improving rural broadband deployment with synergistic effects between multiple fixed infrastructures
Authors	Felix Limbach (TU Berlin), Hannes Kübel (TU Berlin), Rüdiger Zarnekow (TU Berlin)
Published in	Telecommunication Policy Journal (Under review)
Research objectives	- Quantification of cost savings that can be achieved if national infrastructures such as pipelines, highways , power lines or railroads are considered as an origin for fiber broadband deployment in rural areas - Identification of required political and regulatory measures for optimal synergy utilization
Methodology	- Street-length aware calculation of synergy optimized FTTC and FTTB networks is enabled by using the car routing capability of OpenStreetMap - Network typology optimization based on minimum spanning tree calculations with Kruskal's algorithm
Results and Implications	- For the case of Germany the proposed model indicates that cost savings can be achieved if synergetic potential that stems from synergies with the railroad network is fully used - To fully leverage synergies, local authorities should recognize the definition of broadband tender areas as a chance for the aggregation of demand - A suboptimal broadband target area size and cut will result in negative effects on competition and required state aid - To foster synergy utilization national regulators should ensure that metro-aggregation, backbone and co-location costs, that are associated with non-telecommunication infrastructures, do not exceed the costs of the incumbent (DTAG) by more than 50%

Table 4-8: Summary of [Limbach et al. 2014b]

Synergy utilization across infrastructure networks of different industries has been identified as a key to improve the broadband business case. Thus, an increasing number of broadband plans require owners of physical infrastructures such as the electricity, pipeline, highway and railroad networks to host broadband infrastructure. However, cross-industry cooperation brings about new complexity to optimal utilization of deployment synergies.

This paper explores cost savings that can be achieved if national non-telecommunication infrastructures are considered as an origin for broadband networks in rural areas. Moreover, it assesses economic, political and regulatory measures required for improving synergy utilization. The presented approach is based on a street-length aware broadband deployment model, which is applied to all rural communities in Germany. Results indicate that synergy optimized network topologies can generally decrease rural broadband deployment cost. However, it is required that local authorities recognize the definition of broadband tender areas as a chance for the aggregation of demand. Moreover, national regulators need to ensure that metro-aggregation, backbone and co-location costs, which are associated with non-telecommunication infrastructures, do not exceed the costs of the incumbent by more than 50%.

4.2.1. Introduction

Telecommunication networks are widely considered as a basis for economic growth and associated with high general economic benefits [European Commission 2012b; Ruhle et al. 2011]. Consequently, governments around the world define broadband plans to improve the availability of those infrastructures [Falch/Henten 2010]. The European Commission has initiated the Digital Agenda to foster the provisioning of download rates of up to 100 Mbps for European citizens [European Commission 2010a].

Irrespective of the employed fiber deployment variant and technology cost modelling, studies have repeatedly highlighted the economic challenges associated with rural broadband deployment [Analysys Mason 2008; Chatzi et al. 2013; Hoernig et al. 2010; Rokkas et al. 2010]. In the most sparsely populated areas, even a single infrastructure operator with a high market share may require public funding to become economically viable.

However, to limit negative market effects and reduce aid to the necessary minimum all cost reduction measures should be exhausted before public funding is granted for a project [European Commission 2013b]. Accordingly, recent proposals of the European Commission suggest a variety of measures to maximize synergy utilization across physical networks [European Commission 2013c]. In this case regulation goes beyond the telecommunication sector and requires owners of physical infrastructures such as the electricity, pipeline, highway or railroad network to host broadband infrastructures.

The majority of broadband models consider mark-downs on calculations of a given greenfield network topology to account for synergy utilization in certain segments of the telecommunication access network [Analysys Mason 2008; Chatzi et al. 2013; Jay et al. 2014]. Moreover, cross-network synergy utilization in broadband deployment has been addressed for a combined network roll out scenario of utility and telecommunication companies [Tahon et al. 2014].

However, literature that assesses economic, political and regulatory implications associated with using national physical infrastructures such as railroads, highways, pipelines, power lines or railroad as a fiber backbone in rural areas is hardly available. This contribution aims to fill this gap and will subsequently denote those infrastructures as alternative infrastructures. In the course of this paper, the following questions are explored:

What is the financial magnitude of cost savings if alternative national infrastructures are considered as an origin for broadband networks in rural areas? What political and regulatory actions are required to fully leverage the cost reduction measures?

The presented questions are addressed with a street-length aware synergy evaluation model based on OpenStreetMap (OSM), i.e., an open-source geographical information system (GIS).

This article is structured into the following sections. The next section provides details on telecommunication infrastructure topologies in rural areas and challenges of leveraging private investments, and Section 4.2.3 explains the considered deployment scenarios. Section 4.2.4 presents the synergy evaluation model. In its subsections, first, a detailed overview of the model input is provided, and second, an internet access model is presented. Subsequently, the model results are presented and discussed with respect to geographical preconditions for synergy utilization, topology characteristics and achievable cost advantages. Thereafter, political and regulatory implications are discussed in Section 4.2.6. Finally, Section 4.2.7 provides conclusions regarding the research objectives.

4.2.2. Rural broadband topologies and the role of public authorities

Characteristics of rural network topologies

Generally, telecommunication access networks can make use of coaxial cables, power line communications, wireless solutions and copper or fiber cables. Of all available options, Fiber-to-the-Home (FTTH) is recognized as the most future-proof and reliable solution for broadband access. However, due to the high deployment costs, national broadband markets currently reach FTTH saturation at a share of 20% [FTTH Council Europe 2013]. Especially for rural areas, Fiber-to-the-Cabinet (FTTC) and Fiber-to-the-Building (FTTB) have been proposed as intermediate steps in a gradual FTTH deployment process [Analysys Mason 2008]. On average, they are up to 75% less expensive than FTTH deployment [Analysys Mason 2008; FCC 2010]. Moreover, both deployment variants are suitable to meet the European Commission broadband target: 100 Mbps for 50% of the population [European Commission 2010a; Guenach et al. 2011].

Figure 4-4 depicts a typical copper telecommunication access network that is connected to an incumbent’s central office (CO) with a fiber backbone. It can be subdivided into a feeder cable and a distribution cable network. In rural areas, the feeder cable distributes the cable to different communities and the distribution points (DP) of the distribution cable network within a community. It is subdivided into joints (J) and forms a minimum spanning tree topology [Vidmar et al. 2010; Dippon/Train 2000]. That is, a connected graph of *n* verticals and *(n-1)* links, which minimizes the total cable length [Christofides 1975]. Verticals and DP constitute cable consolidation points between the CO and the customer (U). Generally, these consolidation points imply shared deployment costs in the subsequent cable segment.

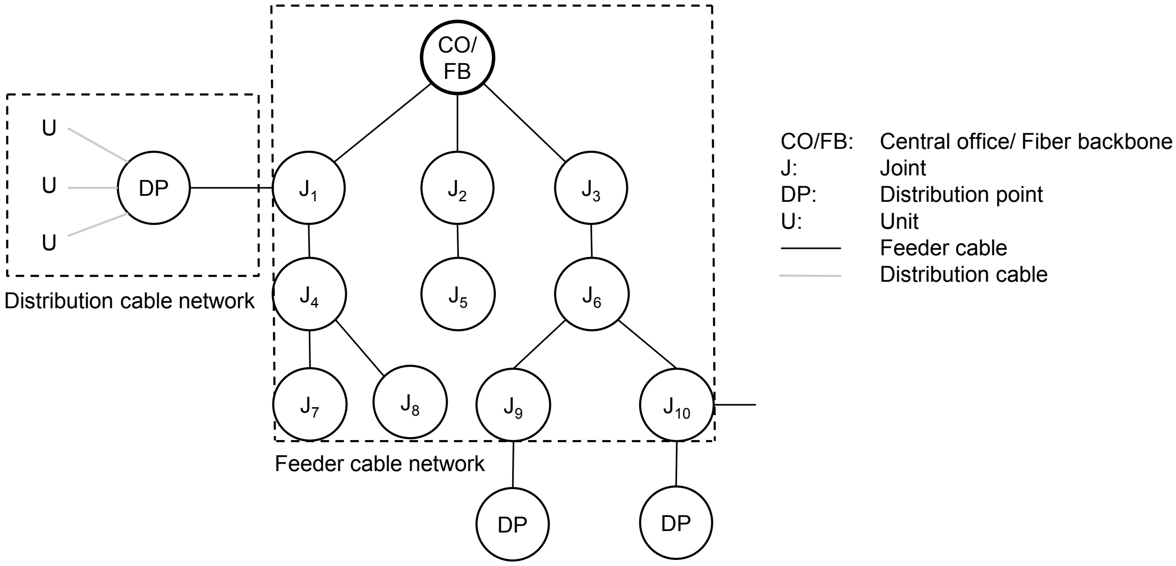


Figure 4-4: Typical access network topology in rural areas [adapted from Vidmar et al. 2010]

FTTC requires the replacement of copper cables in the feeder cable segment between the central office and a distribution point such as the street cabinet. Similarly, FTTB requires the replacement of the copper cable between the fiber backbone and the customer building. Generally, these cables are deployed along existing roads, as national laws in many cases allow the government to use these rights of way at no charge for the setup of public telecommunication networks. Moreover, this right can be transferred to private companies.

The role of public authorities in rural broadband deployment

In rural areas, average feeder cable lengths are longer and account for a higher share of total broadband deployment costs than in areas with a higher population density [Grubesic 2008; Schneir/Xiong 2013]. Moreover, these higher costs must be allocated to a smaller number of potential customers as in urban areas. Consequently, economic feasibility is particularly challenging if a rural community is located far away from the CO and encompasses few potential customers [Analysys Mason 2008]. Under these conditions, private companies may not be willing to deploy or upgrade networks within a timeframe that allows reaching national or super-national broadband goals [European Commission 2010a]. This will be referred to as market failure [European Commission 2010b].

In response to market failure, public authorities across Europe have notified the European Commission (EC) about large scale state aid measures that aim to deploy fiber networks along alternative infrastructures to foster rural broadband deployment [European Commission 2013a; European Commission 2012a; European Commission 2010b].

On a smaller community level, public authorities use EU Structural and Rural Development Funds to reduce regional disparities in broadband speeds [European Commission 2009]. These funds and national broadband deployment frameworks, which have been notified to the EU, allow a community to act as a co-investor that ensures economic feasibility of otherwise unprofitable broadband projects.

It is important to note that the requirement for public aid is determined in a bottom-up process. That is, a local public authority defines a target area for market exploration and launching a tender. According to EU state aid guidelines, the authority is free to define the size of the target area. However, it should consider that a too small target area such as a single community may provide too little incentive to bid for public aid and that a too large target area may foreclose the outcome of the selection process [European Commission 2013b]. However, current guidelines do not consider the fact that an unfavorable target area cut can result in demand fragmentation and negative effects on the usability of alternative infrastructures [Sawhney 1992]. This paper will provide the political and regulatory implications for improving synergy utilization of alternative infrastructures.

4.2.3. Deployment scenarios and cost modelling

Deployment scenarios

It has been recognized that European Member states follow either FTTC or FTTB deployment strategies to reach broadband goals [Cave 2014]. Thus the relative magnitude of cost reduction effects that can be achieved by leveraging synergies with alternative infrastructures is explored in this paper for both fiber deployment variants.

Subsequently, FTTC refers to the deployment of VDSL2 vectoring technology, which is capable of providing download speeds of up to 100 Mbps [Guenach et al. 2011]. The required street cabinets are deployed within close proximity to the customer and host active equipment. It is assumed that required power grid access is available in every community.

The FTTB deployment scenario refers to a point to multipoint 10 Gbps passive optical network (XG-PON), which is capable of providing minimum download speeds of 312 Mbps if a splitting factor of 1:32 is used [Schneir/Xiong 2013]. This scenario assumes that electrical power is provided from the customer building.

The analysis focuses on rural communities that do not host a CO because in such a case households can receive broadband services directly from the CO without additional fiber investments [Grubesic 2008]. Based on Jay et al. [2014], the term rural will be used to refer to communities with a potential customer density of 130 or less inhabitants per square kilometer. Moreover, it is assumed that one operator will upgrade a legacy copper access network in a given target area and that synergies with alternative infrastructures will be used if they are available.

In the base case, infrastructure is deployed to all customers in a target area. Moreover, the base case assumes equally distributed spare duct availabilities for a specific target area. Furthermore, backbone and co-location costs for alternative infrastructures and the CO are assumed to be at comparable costs in a competitive market [Schäfer/Schöbel 2005].

These assumptions are optimistic for several reasons. Depending on country specific preconditions, cable and wireless networks can be important alternative rural access technology [OECD 2009]. To address this aspect, optimized topologies will also be calculated for 50%, 75%, 90% and 95% deployment scenarios. Spare duct availability is likely to be higher along the pathway of the incumbent copper feeder cable topology. Thus, the effect of lower spare duct availability will be assessed for the feeder cable topology that originates at the alternative infrastructure. Finally, depending on market and regulatory preconditions, costs for backbone, co-location and metro aggregation networks could be either higher or lower than the incumbent offer. These aspects will be addressed with a sensitivity analysis.

Cost modelling

Infrastructure costs have been derived from reviews of current literature on access network cost modelling and triangulated with publicly available information. Table 4-9 summarizes the input values for FTTC and FTTB cost calculations.

Item	FTTC	FTTB
	€	€
Fiber cable/m	1	1
Street cabinet	13,000	/
Manhole	/	850
Y-Branch	/	29

Table 4-9: CAPEX for infrastructure elements

The FTTC scenario requires the deployment of new street cabinets that can host vectoring cards and other active equipment. In the FTTB scenario, manholes are deployed at every road intersection within a community, and y-branch units are used to separate the individual drop cable from the distribution cable. Both scenarios assume an average fiber cable price of 1 €/m.

Depending on the density of potential customers in rural areas, different shares and costs of installation methods will be assumed to account for the possibility of duct reuse, aerial deployment and decreasing surface restoration costs. The input parameters are provided in Table 4-10.

Installation costs						
Potential number of customers per km²	Aerial		Digging		Duct reuse	
	%	€/m	%	€/m	%	€/m
130 ≥ x > 75	0	15	80	60	20	2
75 ≥ x > 30	5	15	85	55	10	2
30 ≥ x > 15	10	15	85	50	5	2
<15	15	15	85	45	0	2

Table 4-10: Infrastructure installation methods

Following common practice, OPEX is considered as a mark-up on the modeled passive (1%) and active equipment (5%) [Jay et al. 2014; Schneir/Xiong 2013]. Moreover, metro aggregation, backbone and co-location costs are modelled as OPEX. In this sense, the monthly cost of 3.66 € per customer is derived from a market analysis that has been conducted by the German regulator [Bundesnetzagentur 2013b]. OPEX costs rise with the number of customers. Therefore, for the first three years OPEX calculations consider a take-up of 25%, 50% and 70% [Schneir/Xiong 2013]. Equal customer acquisition and customer churn rates are assumed to keep this take-up rate constant for the remaining years of the investment timeframe [Schneir/Xiong 2013]. It is assumed that networks are rolled out in equal portions over the first three years of a 10 year investment timeframe. Moreover, costs are compared on a cumulative present value basis assuming a yearly discount rate of 10%.

This model does not consider retail, service provisioning or customer equipment cost.
Moreover, it does not consider price declines of equipment.

4.2.4. Synergy evaluation model

Data and sources

The subsequent assessment is based on map data provided by OSM, which is an open-source, free-of-charge digital map of the world. OSM data are crowd-sourced from a growing community of volunteers that has contributed to a high data density and quality in terms of completeness and accuracy comparable to geodata from commercial providers [Girres/Touya 2010; Haklay 2010; Neis et al. 2010; Zielstra/Zipf 2010]. The highest levels of data density, i.e., number of nodes and ways per area, can be found in the countries of central Europe [OpenStreetMap 2012]. In the case of Germany, the total OSM street network even exceeds the information in commercial data sets by 27% [Neis et al. 2010].

The model is applied to OSM data from Germany that hold the locations of all German central offices, more than 11,000 municipalities and cities, 368,745 geodata points (GP) of the highway network, 870,831 GP of the railroad network, 184,031 GP of the power line network and 26,228 GP of the pipeline network. In addition, the complete OSM street network is incorporated in the analysis. The use of described data has been accompanied by numerous validations in satellite pictures and other public data sources. The OSM data are merged with demographic data provided by the German census to consider municipal information on the number of households and population density. Table 4-11 provides an overview of the model data and sources.

Information	Description	Derived model characteristics	Data source
Feeder cable model			
Central offices	Locations of all central offices in Germany	Distance of CO to communities in rural areas	[OpenStreetMap 2013]
Main roads	Length of main roads of a community	Required feeder cable trench length for FTTB and FTTC	[OpenStreetMap 2013]
Location centers	Center of a rural community	Approximated termination point of the feeder cable	German census bureau [Regionaldatenbank 2013]
Alternative infrastructures	Coordinates of railroads, highways, electricity networks and pipeline	Distance from next railroad, highway, major electricity network or pipeline to community center in rural community	[OpenStreetMap 2013]
Distribution cable model			
Demographic data	Households per community, population density, number of buildings per community, community center	Calculation of required deployment meters per household	German census bureau [Regionaldatenbank 2013]
Residential roads	Aggregated length of all residential roads in a rural community	Approximation of required distribution cable trench length for FTTB	[OpenStreetMap 2013]

Table 4-11: Modeling data and sources

Internet Access model

This section describes an internet access model, which assesses the required access network deployment costs per rural households, if savings through the usage of alternative backbone infrastructures are considered. The model is subdivided into a feeder cable and a distribution cable model.

Feeder cable model

The feeder cable model calculates the required trench length between a rural community center and a fiber backbone interconnection point. In contrast to related literature on broadband access models, [Analysys Mason 2008; Lannoo et al. 2008; Vidmar et al. 2010], this fiber backbone interconnection point does not necessarily have to be the incumbent's central office. Instead, the model also considers potential backbone interconnections at the next railroad, highway, major electricity network or pipeline.

In the first step, air-line distance calculations between all German community centers and the corresponding next alternative infrastructure are conducted on a national level to identify one national infrastructure that exhibits a particularly low average distance to rural communities.

In the second step, a trench-length-optimized feeder cable is calculated considering the most promising alternative infrastructure and the incumbent's central offices. This step is based on graph theory and takes advantage of the fact that telecommunication access networks are usually planned as a minimum spanning tree with the fiber backbone interconnection at its root [Vidmar et al. 2010]. A minimum spanning tree can be calculated with the well-understood Kruskal's algorithm [Kruskal 1956]. Table 4-12 indicates how this algorithm is adjusted to provide one spanning tree that originates at the CO and an additional one that originates at the alternative infrastructure.

Input: *Edges E* containing all distances between the CO, communities and alternative infrastructure interconnection points,
Set S_CO containing the CO,
Set S_Infra containing all alternative infrastructure interconnection points;
Output: Minimum Spanning Trees *T_CO* and *T_Infra*;
(1) Add temporary 0-weigth edges between *S_CO* and every element of *S_Infra* to *E;*
(2) *Edges E2* = Edges of *Kruskal_Algorithm*(*E*) with weight>0;
(3) **While**(*E2* is not empty)
    Foreach edge *(v,w)* from *E2*
        If(*v* or *w* ∈ *S_CO*)
            Add *(v,w)* to *T_CO*;
            Add *v* and *w* to *S_CO*;
            Remove *(v,w)* from *E2*;
        Else If(*v* or *w* ∈ *S_Infra*)
            Add (*v,w*) to T_*Infra*;
            Add *v* and *w* to *S_Infra*;
            Remove *(v,w)* from *E2*;

Table 4-12: Synergy evaluation algorithm

The algorithm's input requires the location of the CO, alternative infrastructure interconnection points and the distances between those locations. Alternative infrastructure interconnection points are located at an intersection between a public road and the alternative infrastructure. Distances between the two locations *v* and *w* are calculated by using the route-planning capability of OSM. They are referred to as edges and have a weight that is equivalent to the distance between *v* and *w*.

The first step of the algorithm adds 0-weight edges between all potential fiber backbone locations. This ensures that the standard Kruskal's algorithm can be used to calculate a single minimum spanning tree that minimizes the length of the total network topology, in the second step. In the third step all weighted edges of the previously calculated spanning tree are iteratively sorted to one of two spanning trees that either originates at the CO (*T_CO)* or the alternative infrastructure (*T_Infra*).

The final feeder cable topology serves all communities that have previously been served by a CO. If the total feeder cable length is smaller than the feeder cable length of the minimum spanning tree that serves all communities from the CO, this difference will be referred to as feeder cable savings potential.

Distribution cable model

The distribution cable model considers a FTTC and a FTTB fiber deployment scenario, and relates the financial savings from an optimized feeder cable topology to the total costs of broadband deployment. The FTTC distribution cable network model is based on the assumption that all housholds of a particular community are already served with a copper-wire cable for purposes of wire-line telephony and internet services, which provide less than

30 Mbps. To achieve customer download speeds close to 100 Mbps it is assumed that street cabinets with vectoring technology are deployed within a distance of 1,000 m along the residential streets of a rural community [Guenach et al. 2011]. This results in a maximum distance of 500 m to the customer premises. As indicated in Eq. (1) the number of street cabninets *c* is infered from a community's aggregated resesidential street length *r*. It is assumed that one additional cabinet is deployed if the aggregated street length is smaller than 1,000 m.

$$c(r) = \begin{cases} 1 & r < 1{,}000 \\ \left\lceil \dfrac{r}{1{,}000} \right\rceil & r \geq 1{,}000 \end{cases} \tag{1}$$

Accordingly, as described in Section 4.2.2, the additional trench length *d* between the cabinets is calculateded with the subsequent Eq. (2):

$$d = 1{,}000 * (c \quad - 1) \tag{2}$$

The FTTB deployment scenario is based on a street-length aware broadband deployment model proposed by Lannoo et al. [2008]. It is used to calculate the trench and fiber length required in addition to the FTTC deployment scenario. The intial model has been developed for the city of Ghent and assumes that trenches and fiber cables are required along both sides of a residential street. To adjust the model to rural distribution networks it is assumed that this percentage decreases with population density according to Table 4-13.

Potential number of customers per km²	Share of trenches along both sides of a residential road
$130 \geq x > 75$	90
$75 \geq x > 30$	75
$30 \geq x > 15$	50
<15	35

Table 4-13: Required trenches along roads

Following Lannoo et al. [2008], trench and fiber length are calculated seperatly. The additional fiber cable length which is required in a FTTB scenario is derived from the routing distance between the street cabinet and a customer premises of a rural community. For the defined distance between street cabinets this results in an average cable length of 250 m. Furthermore, it is assumed that buildings are located in the middle of a customer premises. The analysis of German census bureau data on average rural premises sizes and cuts results in a mark-up of 17 m for connecting the building with the distribution point at the street [Regionaldatenbank 2013].

4.2.5. Results

This section presents the results of the synergy evaluation model in two steps. First, an overview on the data of the feeder cable analysis is provided. As illustrated in Section 4.2.4, this part of the results is derived from air-line distance calculations and comparisons. The second part of the analysis builds on trench-optimized network topologies, which are based on minimum spanning tree calculations.

Geographic preconditions for synergy utilization

Table 4-14 presents the percentage of communities and associated potential customers according to the proximity to the closest potential fiber backbone.

Air-line proximity (m)	Nearest infrastructure to rural community center									
	CO		Railroads		Power lines		Highways		Pipeline	
	com. (%)	pot. cust. (%)	com. (%)	pot. cust. (%)	com. (%)	pot. cust. (%)	com. (%)	pot. cust. (%)	com. (%)	pot. cust. (%)
1,000	11.4	11.7	18.6	26.7	6.7	8.5	3.9	4.2	1.0	1.3
3,000	18.5	21.6	11.3	11.4	5.4	3.9	3.9	2.8	0.7	0.8
5,000	11.0	4.6	3.7	1.4	1.1	0.4	0.7	0.2	0.3	0.1
7,000	1.5	0.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
>7,000	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	42.4	38.3	33.9	39.5	13.2	12.8	8.4	7.3	2.1	2.2

Table 4-14: Geographic proximity of rural communities to potential fiber backbones

The table indicates that 42.4% of the rural communities (com.) in Germany are situated closer to the central office than to an alternative infrastructure. Of those communities, 11.4% are located within an air-line proximity of 1,000 m or below. Another 18.5% of the communities are located within a proximity above 1,000 and below or equal to 3,000 m. Though at least 33.9% of the rural communities are situated closer to railroads than to a central office those communities host at least 39.5% of the potential customers (pot. cust.). This value is slightly higher than the number of potential customers in close proximity to the central office. For another 23.7% of the rural communities, other alternative infrastructures are closer to the community center than to COs or railroads.

A single community within a close proximity to an alternative infrastructure will usually not justify a broadband deployment project. Consequently, it is of importance to assess the clustering degree of rural communities with a close proximity to an alternative infrastructure. Figure 4-5 addresses this aspect on a federal, state and county level. It depicts the percentage of communities with a close proximity to an alternative infrastructure within a county for three synergy density categories. Counties that exhibit less than 33% rural communities that are located closer to an alternative infrastructure than to the CO are assigned to a *low synergy density* category. Similarly, counties which exhibit more than 66% rural communities that are located closer to an alternative infrastructure than to the CO are assigned to a *high synergy density* category. The remaining counties are assigned to an intermediate category.

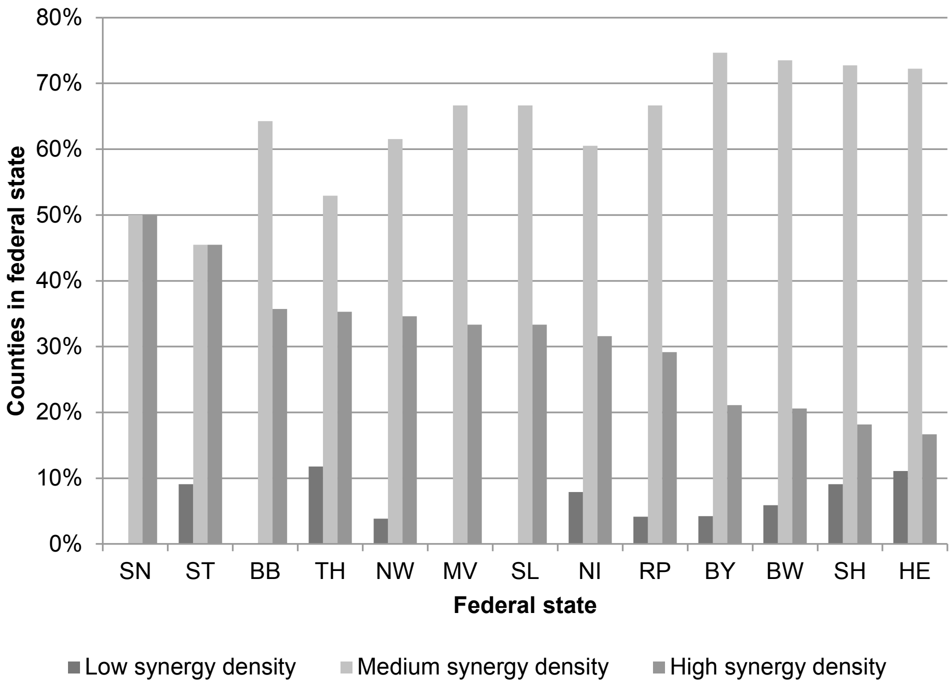


Figure 4-5: Density of rural communities with close proximity to alternative infrastructures

Figure 4-5 shows that the density of rural communities with a closer proximity to alternative infrastructures as opposed to the CO differs by county and federal state. The majority of German counties exhibit a medium synergy density. For 2 of 13 states the number of counties with a high synergy density equals the number of counties in the intermediate density category. Only a small share of the federal states exhibits a low synergy density.

Characteristics of the optimized feeder cable topology

Based on the findings of Table 4-14, the subsequent analyses focus on assessing synergies that stem from the railroad network. For this purpose every rural community of a county is allocated to a minimum spanning tree that either starts at the central office or at a railroad. Table 4-15 provides descriptive statistical figures of the resulting spanning trees.

	Railroad spanning tree	CO spanning tree
Avg # of communities	2.25	2.07
SD # of communities	1.88	1.94
Avg # of pot. Customers	1,518	1,281
SD # of customers	1,313	1,573

Table 4-15: Minimum spanning tree analysis for optimized feeder cable topology

Table 4-15 shows that an optimized feeder cable topology results in spanning trees that connect 2 communities per railroad and per CO spanning tree on average. The average number of customers reachable from a potential railroad spanning tree is slightly higher than in the CO spanning tree. The rather high standard deviation (SD) for the number of communities and customers that are served in a minimum spanning tree indicates that a variety of rural spanning tree topologies exist.

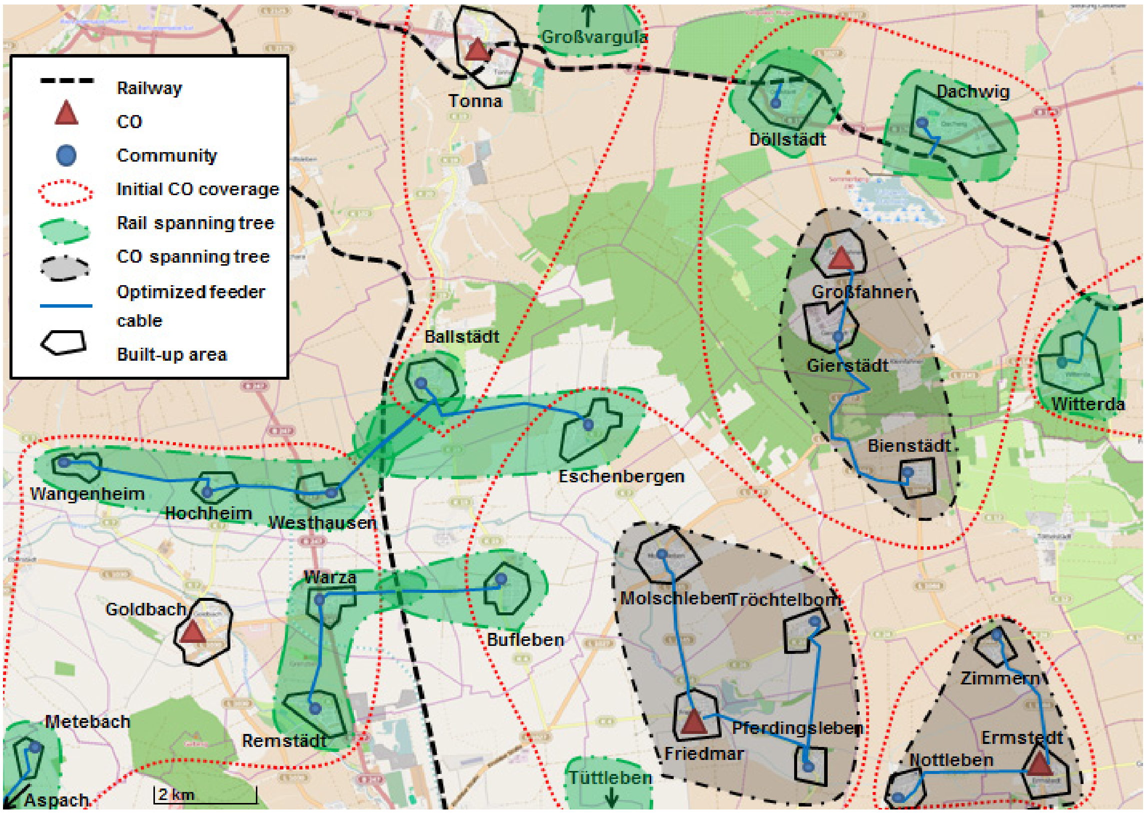


Figure 4-6: Optimized rural feeder cable topology in Thuringia (Germany)

Figure 4-6 depicts an optimized feeder cable topology in a typical rural area in the German federal state Thuringia (TH). Communities such as Ballstädt, Bufleben or Eschenbergen exhibit a street routing distance of more than 6,000 m to the next CO. In contrast, potential feeder cable lengths to the next railroad fiber connection are up to six times shorter. Thus, in an optimized topology they are associated with a railroad spanning tree. Communities such as Nottleben or Zimmern exhibit a long routing distance to railroads and are assigned to a CO spanning tree.

Using its widely available fiber capacities along railroads, the German company Arcor has deployed VDSL with download speeds of up to 50 Mbps in Ballstädt and announced a national roll-out [Briegleb 2008]. After the acquisition of Arcor by Vodafone these capacities have primarily been used for the deployment of the wireless technology LTE which requires less CAPEX per connected customer than FTTC and currently provides average rural download speeds of approximately 10 Mbps [Pages/Pe 2013].

Cost advantages of alternative infrastructures

In this section, cost advantages of alternative infrastructures are explored in two steps. First, savings of an optimized feeder cable topology are put in perspective to the total costs of FTTC and FTTB deployment. Thereafter, a sensitivity analysis explores the effects of parameter variations on possible cost reductions.

Figure 4-7 depicts the FTTC and FTTB investment per customer, which is required for connecting 50%, 75%, 90%, 95% or 100% of all households in a county with optimized feeder cable topologies. Moreover, an alternative connection via the CO is depicted for both fiber deployment variants. For determining the shares of connected households, communities have been ordered by a decreasing number of households. That is, communities with the lowest number of households within a county will only be connected in the 100% deployment scenario.

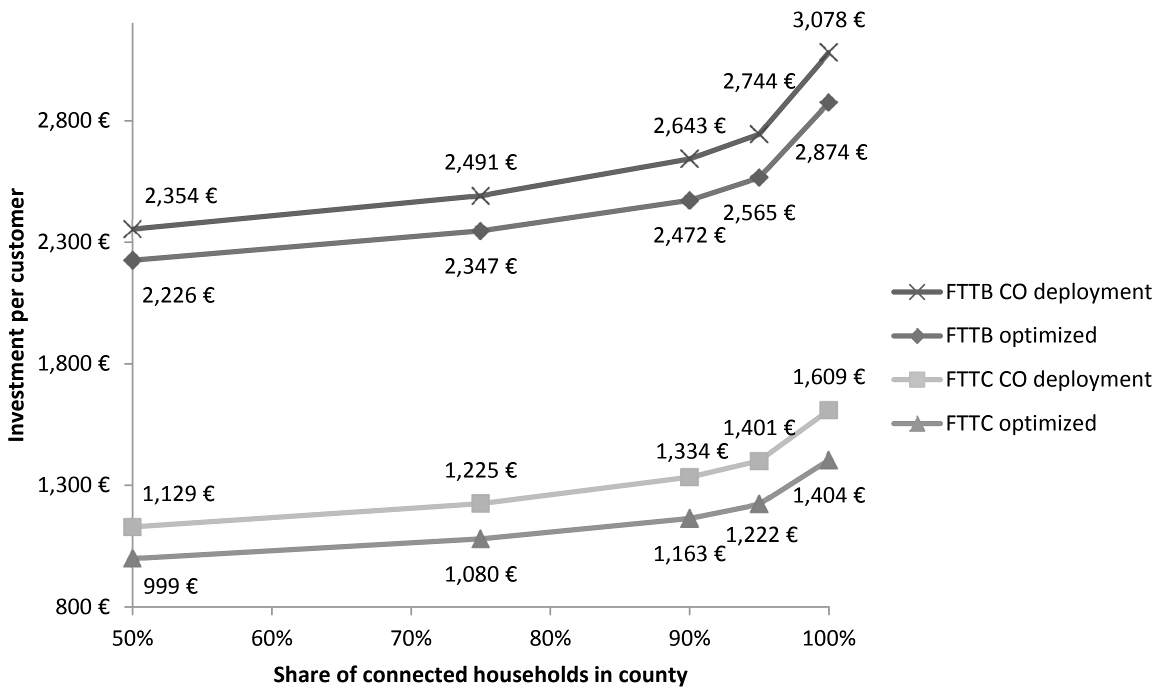


Figure 4-7: Financial impact of synergy utilization with railroads

Results indicate that in the base case absolute savings per customer vary between 205 € in the 100% deployment case and 128 € in the 50% deployment case. This results in a maximum relative savings potential of 13% for the FTTC case and 7% for the FTTB case. However, as noted in Section 4.2.3 variations in the monthly metro-aggregation, backbone, co-location costs and general spare duct availability can impact the magnitude of these savings. Thus, a sensitivity analysis is exploring these effects in Table 4-16. In this analysis, parameters for the CO deployment are kept constant while parameters of the alternative infrastructure topology are subject to parameter variations.

Parameter	Variation (%)	FTTC		FTTB	
		Optimized (€)	Difference to CO deployment (%)	Optimized (€)	Difference to CO deployment (%)
Monthly metro-aggregation, backbone and co-location costs	+ 50	1,213	- 1	2,480	- 1
	- 50	946	- 23	2,213	- 11
Spare duct availability in feeder cable topology	- 50	1,088	- 11	2,356	- 5
	- 100	1,097	- 11	2,364	- 5

Table 4-16: Sensitivity analysis for deployment to 75% of all households

Results show that a variation of the monthly metro-aggregation, backbone and co-location costs per customer has a strong impact on the relative cost advantages. If these costs are approximately 50% higher than the incumbent's offer, the savings potential of alternative infrastructure use is close to zero. In contrast, 50% lower monthly costs can increase the savings potential to 23% in the FTTC case and 11% in the FTTB case. A lower share of spare ducts in the alternative infrastructure feeder cable topology hardly reduces relative cost savings. This is due to three reasons. First, as noted in Section 4.2.2, general spare ducts availability in rural areas is usually much lower than in more densely populated areas. Second, an increase of feeder cable deployment costs is allocated to all households of a connected community. Finally, spare duct availability in the distribution cable segment is not affected by an optimized feeder cable topology.

Comparison with other studies

As of today, few national broadband deployment cost models have explored synergy optimized feeder cable topologies. Moreover, most existing cost models are not based on a street-length aware modelling approach that can account for the variety of rural cable topologies (cf. Table 4-15). Nevertheless, Figure 4-7 indicates that the investment costs per potential customer without synergy utilization align well with existing cost modelling studies. This study has identified FTTB investment costs of 3,078 € per potential customer in rural areas. Based on averaged real world cable length from several European operators, Schneir and Xiong [2013] calculate costs of 3,250 € per rural home connected for a single operator with a market share of 70%. For the FTTC deployment scenario this model indicates investment costs without synergy utilization of 1,609 € per potential customer. Analysys Mason [2008] takes into account the costs of customer premises equipment and identified costs of 1,690 € for the most remote geotype at a market share of 70%.

4.2.6. Political and regulatory implications

The presented results indicate that cost savings can be achieved if alternative national infrastructures are considered as an origin for broadband networks in rural areas. As a consequence this paper contributes to current EU efforts to maximize synergy utilization across networks and reduce the civil engineering costs of broadband deployment [European Commission 2013c]. However, the efficient use of those infrastructures depends on appropriate political and regulatory incentive structures.

The first subsection of Section 4.2.5 shows that geographic preconditions for synergy utilization can differ largely between federal states and counties. Thus, political and regulatory efforts directed at improving efficiency gains across national networks should be focused on geographic areas with favorable preconditions for synergy utilization. Under disadvantageous geographic preconditions for synergy utilization, incumbent COs are more likely to be an essential facility for co-location. If competition in the local-loop usage is desired, the regulator should ensure the availability of co-location options as the incumbent is migrating to fiber access networks and closing down facilities.

The second subsection of Section 4.2.5 shows that an optimized feeder cable topology is connecting up to five communities with every fiber backbone connection. Thus, local authority practice of starting separate tenders and market explorations for neighboring communities results in artificial demand fragmentation [Sawhney 1992; BBB 2014]. To improve the use of alternative infrastructures, tenders should be started and coordinated at a county or federal state level. At this level, companies should be allowed to bid for lots within the target area.

The presented cost analysis in the third subsection of Section 4.2.5 highlights the importance of variations in the monthly metro-aggregation, backbone and co-location costs for the efficient use of alternative infrastructures. Especially if owners of alternative infrastructures have been obligated to offer fiber or spare ducts capacities, these costs could be set prohibitively high. If necessary, national regulatory measures should ensure that the cost of using alternative infrastructure capacities does not exceed the incumbent's offer by more than 50%.

4.2.7. Conclusion

To address the economic challenges associated with rural broadband deployment, public aid and cost reduction measures will be required. This paper has used a street-aware synergy evaluation model to assess the financial magnitude of cost savings that can be achieved if national alternative infrastructures are considered as an origin for broadband networks in rural areas.

Analyses suggest that an optimized feeder cable topology can reduce the costs of rural broadband deployment if alternative infrastructure fiber backbone, metro-aggregation and co-location costs do not exceed the incumbent's offer by more than 50%. To foster the deployment of cost optimized network topologies, public authorities should aggregate customer demand in large tender areas which cover multiple rural communities. Moreover, regulators need to be aware of regional differences in the preconditions for synergy utilization and should consider them as COs are closed down in the context of the migration to fiber networks.

This paper finds that railroad networks exhibit the largest national synergy potential in the case of Germany. Because densities of railroad networks differ across European countries, synergy potentials may be alike. Thus, it would be worthwhile to apply the proposed model to other markets. Although corresponding OSM data are available for 69 countries in the world [OpenStreetMap 2012] and its quality has been certified within several case studies, triangulation with other data sources should complement data usage. Further research may build on this contribution and explore related aspects. First and foremost, research should be devoted to the amount of savings that can be achieved through the reduction of COs, as the incumbent is migrating infrastructure to fiber access networks as well as geographical aspects of regulation or co-investment strategies.

4.3. Business models and competition in the content delivery network market – An infrastructure analysis

Title	Business models and competition in the content delivery network market – An infrastructure analysis
Authors	Felix Limbach (TU Berlin), Jochen Wulf (TU Berlin), Rüdiger Zarnekow (TU Berlin), Michael Düser (Deutsche Telekom Laboratories)
Published in	Proceedings of the 20th European Conference on Information Systems (ECIS)
Research objectives	- Characterization of participants of the CDN market according to their business model and their set of resources - Identification of infrastructure properties that are associated with success in the CDN market - Sustainability evaluation of a hypothetical Inhouse CDN coalition
Methodology	- Segmentation of the CDNs market based on a literature review - Operationalization of infrastructure success factors based on discriminant and longitudinal analyses with CDN infrastructure data on 18,001 interconnections and 392 path lengths measurements - Resource complementarity analysis based on resource dependency theory
Results and Implications	- The CDN market typology exhibits three generic CDN business models with distinct resource profiles - Successful CDNs have established significantly more transit connections then other market participants - Common interconnection quality parameters such as the average number of traversed networks or routers do not generally explain the success of leading CDNs - An Inhouse CDN coalition could reproduce the infrastructure properties associated with success with market success - From a resource dependency perspective such a coalition is likely to be stable

Table 4-17: Summary of [Limbach et al. 2012b]

The contribution of this paper is threefold. First, we characterize the participants of today's commercial CDN market according to their business model and their set of resources. Second, we use real-world internet topology data in order to infer CDN infrastructure resources that are associated with market success. Third, resource-dependency theory is utilized to assess if a cooperation of market participants with different business models can change the CDN market concentration based on its resource profile. Our results indicate that the most successful CDNs use a large number of direct interconnections with networks that are situated close to the content consuming end-customer in order to improve termination quality. Moreover, we can show that White Label CDNs are successful in acquiring the resources that are associated with market success. Finally, our results point out that a large ISP coalition that includes today's Inhouse CDNs could reproduce the most important infrastructure properties of the current market leaders.

4.3.1. Introduction

The world-wide diffusion of broadband access, the development of new services and the increase of internet-based content provisioning contribute to the rapid increase of the traffic that is carried on the internet [Labovitz et al. 2010]. Content Delivery Networks (CDNs) have largely fostered this process. CDNs enable the efficient and correct delivery of content by replicating data to interconnected servers that are located close to the consumer [Buyya et al. 2008]. This service enables content providers to optimize the perceived end-customer quality by reducing effects such as latency, jitter and packet loss.

While the carried data volume continues to rise, CDNs are increasingly faced with falling revenues per data volume entity. This development is caused by investments in ever more efficient network infrastructures and new market participants [Ha et al. 2010]. These new participants such as Amazon, Telefonica and Deutsche Telekom are characterized by different resources and business models than the traditional CDNs but aspire to increase their revenues in an emerging market.

Thus, in the first part of this paper we will provide a typology for the classification of the current actors in the CDN market. This typology will consider the company's business model, resources and its conducted value-added steps in the CDN value chain. In the next step we assess which resources are associated with success in the CDN market and how these resources are distributed among the different CDN types. Based on considerations from resource-dependency theory we will assess if a coalition of current market players is capable of acquiring the resources that are necessary for gaining additional market share.

4.3.2. The Content Delivery Market

In this section we will introduce the theoretical foundations and a provider typology for the assessment of the current CDN market.

Theoretical foundations

The main task of a CDN is the provisioning of static data, web applications and services by distributing content among servers that are close to the content consumers [Buyya et al. 2008]. In order to accomplish this goal a CDN requires resources such as trained IT professionals, a sales force but also an infrastructure for the delivery of content. Experts and scientists agree that the content delivery infrastructure is the most important resource for the business success of content delivery networks [Rayburn 2011b; Hau/Brenner 2009; Wulf et al. 2010a].

Generally this content delivery infrastructure is established based on peering and transit connections with other networks of the internet. Peering connections refer to bilateral agreements between companies that use their direct interconnections with each other exclusively for the purpose of transferring the traffic of their own customers [Giovannetti et al. 2005]. Especially for the bidirectional exchange of large data volumes it can be economically efficient to agree on peerings [Norton 2011]. However, the establishment of peerings can be time-consuming as peerings are the result of bilateral negotiations between network owners. Transit connections are characterized by financial compensation for the transit provider and denote a business relationship that allows the internet-wide termination of data [Shakkottai/Srikant 2006]. The setup of transit connections is a fast way to extend the reach of a network and providers usually offer volume discounts to large customers [Norton 2011]. Moreover, transits are usually associated with better service and maintenance conditions as opposed to un-paid peering connections.

In designing the content delivery infrastructure CDNs need to consider the termination quality. In general termination quality parameters like jitter, delay or packet loss can be improved if the content can be terminated close to the content consumer. However, as the internet exhibits a hierarchical topology with large networks at its core and smaller networks at the edge, this implies the setup of many direct connections if a world-wide coverage is aspired [Labovitz et al. 2010]. Quality parameters can also be influenced by traffic routing algorithms. Following Krishnan et al. [2009] routing paths across few networks and routers are usually associated with good jitter, delay or packet loss values. Interconnections which exhibit the required quality parameters constitute a resource that is required for offering CDN services. Thus, resource-dependency theory can be applied to assess the interaction between networks [Wade/Hulland 2004].

Resource-dependency theory is based on the idea that organizations require resources that may be possessed or controlled by other organizations. Moreover, it assumes that organizations need to interact in order to receive the resource mix required for production [Pfeffer/Salancik 1978]. According to Sheppard [1995] organizations are particularly willing to cooperate if resources are scarce and partners can improve their position by bundling complementary resources. For further analysis we will characterize the CDN companies in the next step.

Provider typology for the CDN market

According to an analysis conducted in this paper we can distinguish three commercial CDN provider types. In this section we characterize these types based on their resources and business models. Subsequently we consolidate the results in Figure 4-8.

The CDN market analysis is based on a CDN directory that lists all video-delivery-service providers [Rayburn 2011a]. By conducting an additional internet research we make sure that no major CDNs are missing in the list and that a CDN product is explicitly offered on the company website. We do not include pure resellers of CDN services in our subsequent analyses. Based on this methodology we identified 26 commercial providers of CDN services for our further analyses [cf. Appendix 6.1.4].

Classic CDNs

Classic CDNs maintain a geographically distributed network of server clusters or data centers that are connected to an overlay network [Ni et al. 2003]. Moreover, Classic CDNs use their own sales offices and establish direct business relationships with large content providers. For the subsequent analyses in this paper we define that Classic CDNs do not offer White Label products on their website.

In the content delivery value chain classical CDN-providers focus on server and delivery management and the establishment of new business relations with content providers. Moreover, Classic CDNs receive a direct financial compensation from content providers for distributing the content [Wulf et al. 2010a]. Classic CDNs do not have an internet access network with direct access to the content consuming end-customers. Therefore, they need to establish interconnections with internet service providers (ISPs) for the termination of their content. The ownership of an access network constitutes an important resource for the ISP as in most cases the classical CDN will financially compensate the usage of the last-mile termination-network. The most established representatives of this CDN type are Akamai, Limelight Networks and CDNetworks. Together these three networks account for more than 75% of today’s CDN revenue [Tier1Research 2011].

Inhouse CDNs

Inhouse CDN-providers denote ISPs that operate a proprietary CDN-infrastructure within their network. The required knowledge for the provisioning of this service can either be generated incrementally within the company or is bought from specialized companies. Important characteristics of most Inhouse CDNs are access to a large customer base via a last-mile access-network and a well-developed backbone network that enables the direct interconnection with content providers [Wulf et al. 2010a].

The control over an access-network and the value-added steps network operation and server & delivery management constitutes a strategic competitive advantage for Inhouse CDNs over classical CDN-providers as data requests can be handled in such a manner that important data quality parameters can be improved significantly [Poese et al. 2010]. In a constantly changing internet-topology ISPs can utilize this advantage in order to address the danger of becoming a data pipe provider for large content-providers such as Google [Labovitz et al. 2010]. Established representatives of this CDN-type are companies like AT&T, Verizon and British Telecom.

White Label CDNs

Besides classical CDN-providers and Inhouse CDNs a third commercial CDN-provider type could be identified in our analysis. This provider type offers CDN-technology as White Label product to ISPs. In this paper we define those CDNs as White Label CDN that actively promote White Label CDN products on their website. In analogy to the classical CDN-providers a White Label CDN accounts for server & delivery management while the ISP is responsible for network management and selling of CDN-services to the content-providers. This is a cooperation in which both partners contribute complementary and limited resources to a partnership in order to improve their market position [Pfeffer/Salancik 1978; Sheppard 1995]. While the CDN-provider contributes the knowledge about efficient and high-quality distribution of content into the cooperation, the ISP contributes its business relations with content providers and consumers. While White Label CDNs can commercialize their products at low sales costs, ISPs can expand their product portfolio and gain experiences in dealing with content-providers.

Figure 4-8 summarizes the commercial business models described in this section [cf. Limbach et al. 2012a]. In order to maintain clarity we abbreviate content consuming end-customers (E) and content-provider (C).

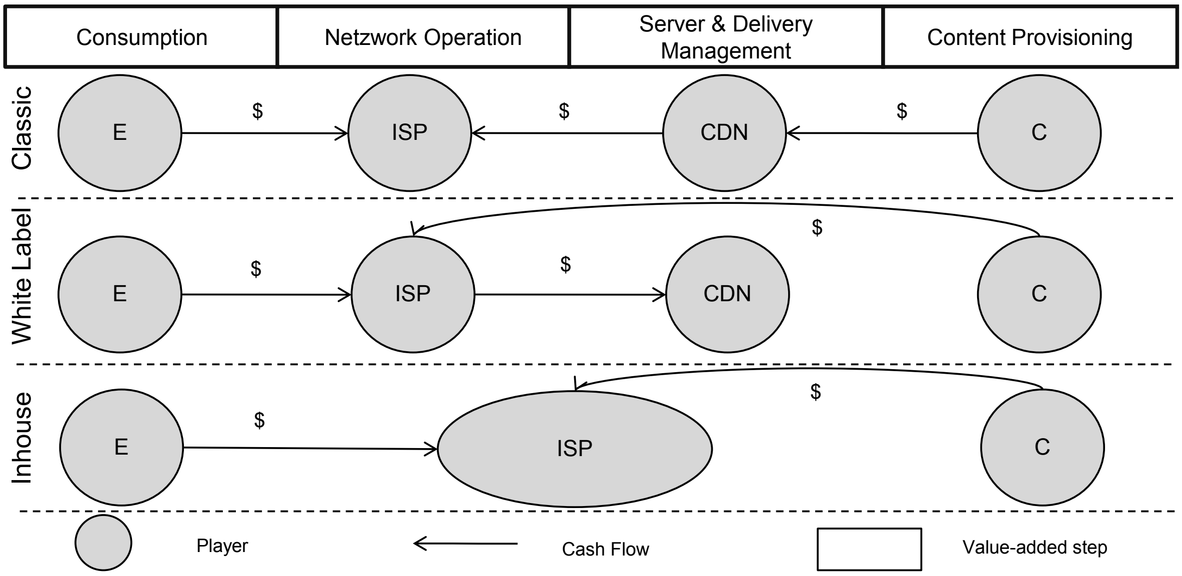


Figure 4-8: Simplified visualization of commercial CDN-Business Models

Research questions

In the current CDN market most companies do not report their CDN revenues but announce new strategies and products on a regular basis [Rayburn 2011b]. This situation leaves the current market participants but also new entrants guessing about the required steps to increase the market share. We aim to address this situation by assessing real-world infrastructure properties in order to answer the following research questions:

- Which infrastructure properties are associated with success in the CDN market?
- How do different CDN types of today's market differ with respect to those properties?
- Can a cooperation of today's Inhouse CDNs and new market entrants change the current market based on its resource profile?
- Would such a coalition be stable from a resource-dependency point of view?

The analyses in Section 4.3.4 will address research questions 1 and 2 while the analyses in Section 4.3.5 addresses research question 3 and 4.

4.3.3. Research methodology

We address our research questions in a four-step procedure. In a first step we conduct a discriminant analysis in order to identify network properties that discriminate CDN market leaders from the remaining market participants. In order to ensure the reliability and objectivity of this analysis we follow the directives for content analysis research as proposed by [Kassarijian 1977] and [Kolbe/Burnett 1991]. The analysis incorporates network properties of all commercial CDNs that could be identified with the market analysis described in the previous section.

In the second step we perform a longitudinal analysis for those network properties that were identified significant for discriminating market leading CDNs from the remaining CDNs. This analysis will reveal how different CDN business models differ with respect to those properties.

In a third step we deepen the analysis for those network properties that were identified to be most important in the first and the second analysis step. Based on additional data, which is available for the year 2011, we will conduct a second discriminant analysis. This analysis leads to a more profound understanding of the infrastructure properties that are associated with market success.

Finally, we perform an intersection analysis for the infrastructure resources of a possible ISP-CDN coalition and today's market leading CDNs. This way we infer if an ISP-CDN coalition can acquire the required tangible resources to gain a large market share. In a last step we conduct a similarity analysis for the coalition's resources in order to assess its stability according to resource-dependency theory.

Data

In order to conduct the CDN market infrastructure analyses we aggregate and consolidate data from two sources. The first data source is the AS-relationship dataset that is provided by the research institution CAIDA [2011]. This dataset distinguishes amongst others *transit* and *peering* relationships between more than 36,000 autonomous systems (AS) that make up the internet. CAIDA educes this dataset from publicly accessible Border Gateway Protocols (BGP) based on an algorithm that was first proposed by [Gao 2001]. A review based on the results determined from the Gao-algorithm shows that 96.5% of the transit- and 82.8% of the peering relationships are ascertained correctly [Dimitropoulus 2007]. In addition to the data described above CAIDA offers two figures of the year for the estimation of a network's size. The first figure is denoted as AS degree and refers to a network's number of direct connections with other networks. The second figure is a network's AS number that includes the number of networks which can be reached by recursively following all transit- and peering relations. Subsequently we will use these two figures in order to infer the size of transit provider's termination-network. By using the CAIDA-data we accept the limitation, that connections that are not announced in public BGP tables cannot be considered in our analyses. Furthermore, paid and un-paid peerings cannot be distinguished due to similar routing characteristics [Dimitropoulus 2007]. The second data source provides information about a network's applied routing algorithms by measuring the average number of traversed networks and routers of a data package with any other network on the internet [Fixedorbit 2011]. Based on this data we assess the influence of routing decisions on market success. As Fixedorbit does not provide historical data we use the Internet Archive project in order to retrieve data for the last four years [Internet Archive 2011]. Table 4-18 aligns the analysis steps of the subsequent section with the applied research method and the research question to be addressed.

Analysis step	1	2	3	4
Research method	Discriminant analysis	Longitudinal Analysis	Discriminant analysis	Similarity & intersection analysis
Data	CAIDA AS Relationship & FixedOrbit data for 2007 - 2011		CAIDA termination-network data for 2011	
Addressed research questions	1	2	1 & 2	3 & 4

Table 4-18: Analysis sequence for the assessment of our research questions

The first discriminant analysis and the longitudinal analysis are based on the assessment of 18,001 interconnections and 392 path lengths measurements for the years 2007-2011. We aggregate and join this data and receive 117 datasets *n* for further analyses.

4.3.4. Discriminant and longitudinal analyses for the current CDN market

Based on the collected data described above we assess CDN network parameters with a univariate ANOVA analysis and a stepwise discriminant analysis. For this purpose we classify the datasets into two groups. The first group contains the datasets of the top 3 CDNs in matters of market share as proposed by [Tier1Research 2011] for the years 2007 to 2011. This group generates more than three-fourths of overall revenues in the market. The second group contains the datasets of the remaining CDNs.

	Univariate Analysis			Stepwise discriminant analysis[6,7,8]		
	Group mean 'Top 3 CDNs' (n=20)	Group mean 'Others' (n=97)	F for group mean equality test	F	Wilks-Lambda	Discriminant loadings[9]
Avg. # Networks traversed	2.70	2.53	3.367*	2.288*	.972	.029
Avg. # Routers traversed	4.08	3.76	1.704	.008	.985	.233
# Transits	28.80	6.99	26.850***	26.850***	.811	1.000
# Peerings	17.60	30.44	.701	.057	.994	-.110

Table 4-19: ANOVA and stepwise discriminant analyses for the current CDN market

Univariate and stepwise discriminant analyses show that the top 3 CDNs significantly differ from other CDNs in terms of the number of transit interconnections. According to our analysis the average number of transit connections is four times higher within the group of the market leading CDNs. Moreover, market leading CDNs differ weakly significant in terms of the average number of networks traversed. However, the analysis shows that the group of the top 3 CDNs on average routes data across more networks then CDNs in the second group. The number of peerings and the number of traversed routers does not make a significant contribution to discriminating the two groups.

Subsequently we perform a longitudinal analysis for the parameters that significantly contribute to distinguishing successful networks from less successful networks. By performing this analysis we aim to assess network dynamic differences between different business models and market leading CDNs. For this purpose we assess four CDN groups. The first group comprises the top 3 CDNs. The remaining CDNs are grouped by their business model. The results depicted in Figure 4-9 indicate that all types of CDNs have increased the number of transit connections during the last four years. Moreover, the Figure 4-9 shows that the top 3 commercial CDNs are classical CDN providers. These successful CDN providers have established more transit connections than other companies. Though White Label CDNs do not belong to the top CDNs as a matter of market share they also largely increased their

[6] Minimal partial F-statistic for acceptance:3.84, Maximal partial F-statistic for exclusion: 2.71.
[7] Wilks Lambda of discriminant function: 0.811 , Number of Steps: 1.
[8] Class mean values of discriminant function: Top 3 CDNs = 1.32 , Others = -0.19.
[9] Correlation between discriminating variables and the canonical discriminant function.
* $p<0.10$, ** $p < 0.05$, *** $p < 0.01$

average number of transit connections during the last years. Other CDN providers and Inhouse CDNs have hardly increased the number of transit connections.

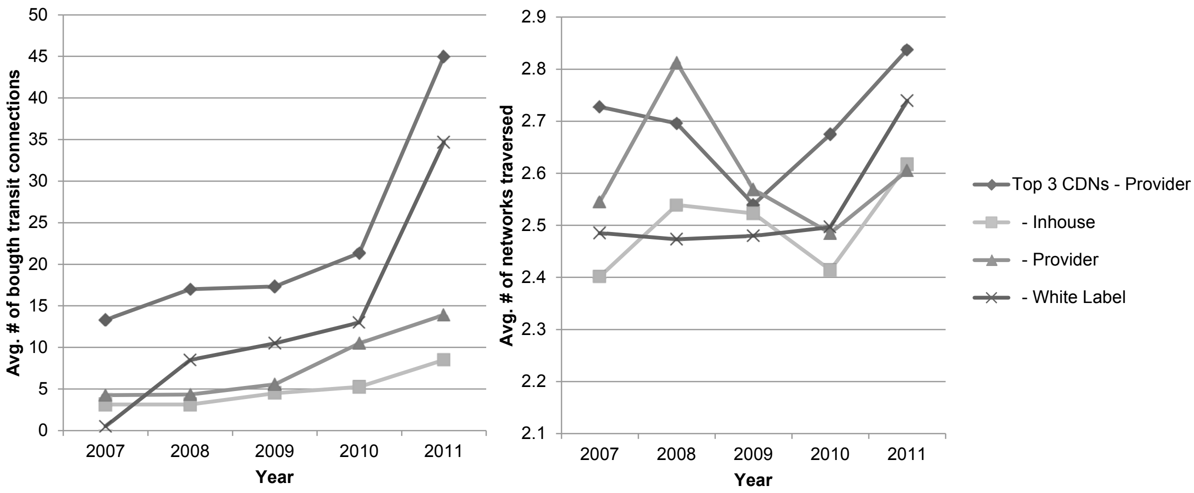


Figure 4-9: Longitudinal analysis for group discriminating network parameters

The right-hand side of Figure 2 shows that CDN networks hardly differ with respect to the routing parameter networks traversed. Moreover, our analysis indicates that the top 3 CDNs on average traverse more networks than other CDNs. Moreover, the analysis shows that classical CDN providers on average route data across more networks than Inhouse and White Label CDNs. Since a short path-length does not seem to be characteristic for successful CDNs we will exclude the parameter networks traversed from the third step of our analysis. Instead we will focus on the question how transit connections contribute to success in the CDN market.

In the last step of the current CDN market analysis we assess the characteristics of networks that connect with CDNs via transit connections. By conducting this analysis we aim to understand if the CDN transit providers differ with respect to their AS degree and the AS number. Because CDNs pass on content to their transit providers, this analysis will reveal insights into the characteristics of the termination-networks of different CDN types. For this analysis we use 278 datasets about transit providers of today’s 26 CDNs.

	Univariate Analysis					Stepwise discriminant analysis[10,11,12]		
	Group mean 'Top 3 CDNs' (n=93)	Group mean 'Other Providers' (n=82)	Group mean 'White label' (n=53)	Group mean 'In-house' (n=50)	F for group mean equality test	F	Wilks-Lamb-da	Dis-criminant loadings[13]
Ø AS Degree	834.38	1023.96	681.60	1258.62	5.47***	5.47***	.941	1
Ø AS Number	27165.20	28204.16	22758.55	30756.88	2.32*	2.32*	.974	.69

Table 4-20: Discriminant analysis for the termination-network of different CDN types

The ANOVA and the stepwise discriminant analyses show that the average number of directly connected networks to a transit provider significantly contributes to the discrimination of CDN groups. The number of indirectly connected networks is close to the overall number of networks and contributes only weakly significant to the discrimination of CDN groups. Moreover, the analysis indicates that the top 3 CDNs and White Label CDNs on average use transit providers with a smaller network. Usually smaller networks can be found at the edge of the internet, this means closer to the content consuming end-customer [Labovitz et al. 2010]. Less successful Classic providers and Inhouse CDNs preferably establish transit connections with networks that are close to the core of the internet and reach most content consuming end-customers via indirect connections.

4.3.5. CDN-market impact of a possible CDN-ISP cooperation

According to a formal model proposed by [Hau/Brenner 2010] ISPs can fundamentally change the current CDN market because Classic CDNs and White Label CDNs critically depend on the access to their termination -network. However, until 2010 no Inhouse CDN could be found among the top ten CDNs with the highest revenues [Tier1Research 2011]. Our results from Section 4.3.4 indicate that the main reason for this situation might be a termination-network that exhibits too few transit connections. Based on resource-dependency

[10] Minimal partial F-statistic for acceptance:3.84, Maximal partial F-statistic for exclusion: 2.71.
[11] Wilks Lambda of discriminant function: 0.941 , Number of Steps: 4.
[12] Class mean values of discriminant function: Top 3 CDNs = 1.32 , Others = -0.19.
[13] Correlation between discriminating variables and the canonical discriminant function.
* $p<0.10$, ** $p < 0.05$, *** $p<0.01$.

theory and our previous analyses we argue that the existing network interconnections constitute tangible resources that are required for being successful in the CDN market [Wade/Hulland 2004]. Thus, we aim to predict the market success of a cooperation based on properties that are related with the coalition's termination-network. For our cooperation analysis we will assume based on Rayburn [2011b] that all ISPs that have announced their own CDN activities and all current Inhouse CDNs will form a cooperation.

In a first analysis step we calculate the coalition's number of transit relations by identifying and eliminating redundant connections. In the course of this analysis we also assess a member's contribution to the coalition by calculating the bilateral similarly index SI:

$$SI(A, B) = \frac{2 \times |A \cap B|}{|A| + |B|}$$

In this formula A denotes the number of transit connections of ISP A and B the number of transit connections of ISP B. The similarity index is equal to 1 if two networks use exactly the same transit providers. In this case one of the networks does not make an additional contribution to the ISP-coalition in terms of extending the network with additional transit connections. Accordingly, the mutual contribution of two networks is large if the similarity index is close to 0.

In a second step we assess the termination-network property AS Degree that was identified to be highly significant for discriminating CDNs types during current CDN market analyses. Finally, we aim to understand how the cooperative infrastructure of the ISP-coalition can impact the current CDN market. For this purpose we perform an intersection analysis based on the infrastructure of the current market leader Akamai, the infrastructure of the top 3 CDNs and Telefonica, which is the ISP with the largest number of transit providers. The results of the termination-network analysis are consolidated in Table 4-21. In this table the first number of each cell refers to the number of transit connections that both networks have in common. The second number indicates the average network size of the transit providers that both networks have in common.

Intersection analysis	Akamai	Top 3 CDNs	Telefonica	ISP-cooperation
Akamai	53 | 582.31	53 | 582.31	37 | 736.68	47 | 727.15
Top 3 CDNs	-	93 | 834.38	57 | 728.72	73 | 716.63
Telefonica	-	-	63 | 634.57	63 | 634.57
ISP-cooperation	-	-	-	92 | 774.99

Table 4-21: Intersection analysis for the ISP-cooperation network

The results of the intersection analysis show that a CDN-ISP cooperation consisting of the current Inhouse CDNs and those ISPs that already have announced CDN activities could cover up to 88.7% of the termination-network of the present CDN market leader Akamai. Even Telefonica as the ISP-coalition member with the largest number of transit connections could cover only 69% of the current termination-network of Akamai. Moreover, the analysis shows that the ISP-coalition would exhibit as many transit connections as the three market leader exhibit together. The assessment of the average termination-network size per transit connections shows that ISP-coalition partners on average establish transit connections with termination-networks that are larger than those of the market leader Akamai and thus usually further away from the content consuming end-customer. However, the average network size connected to the ISP-cooperation is smaller than the average network size of the top 3 CDNs.

The similarity index analysis showed that the ISP-cooperation members on average have a similarity index of 0.22 with a standard deviation of 0.03. That is, the cooperation members have on average 22% of their transit connections in common. With as similarity index of 0.64 Telecom Italia and Bell Canada exhibit the largest similarity between two coalition members. In contrast British telecom and Deutsche Telekom have a similarity index of 0.04 as both networks have only one transit connection in common. In the subsequent section we will interpret the findings of our current CDN market analysis and the results of ISP-cooperation analysis.

4.3.6. Interpretation

The empirical assessment of the current CDN market indicates that successful CDNs use content-delivery infrastructures that differ significantly from other content-delivery infrastructures in terms of the number of transit connections and the average size of the connected termination-networks. Moreover, our results show that successful CDNs pay a large number of transit providers, which provide a rather small termination-network. Following Labovitz et al. [2010] this can be explained by the fact that smaller networks are usually located closer to the edge of the internet and accordingly the content terminating ISPs. Thus, termination quality parameters like delay, jitter and latency can be improved for the content consumer [Krishnan et al. 2009]. Furthermore, the results show that the success of a CDN does not primarily depend on a short routing path. As CDNs usually deliver large amounts of data it can be more efficient to redirect user request with an elaborated multi-step routing algorithm, which selects the best server in terms of optimized quality parameters, as opposed to serving the request via the shortest routing path [Buyya et al. 2008]. Thus, routing information about the average number of traversed networks should not be used as a measure of termination quality in the CDN market.

In addition to the identification of infrastructure properties that are related with market success we were able to show a trend towards cooperation within the CDN industry. This trend becomes manifested in the growing importance of the White Label business model that is based on close cooperation with ISPs. During the last four years White Label CDNs have established a termination-network that exhibits properties which are similar to today's top 3 CDNs. Inhouse CDNs have been less successful in setting up a termination-network that is in close proximity to a large number of content consuming consumers.

Accordingly the announcement of Inhouse CDNs and ISPs to establish a CDN-ISP cooperation is comprehensible. Based on the infrastructure assessment of a possible CDN cooperation we can derive the implication that such a cooperation would be capable of reproducing the network properties that are associated with market success. Furthermore, our network similarity analysis showed that most networks of the announced coalition would contribute complementary infrastructure resources to the cooperation. Thus, we can deduce from resource dependency theory that such a coalition is likely be stable once it is established [Pfeffer/Salancik 1978; Sheppard 1995; Wade/Hulland 2004].

4.3.7. Summary and Outlook

In this paper, we provide an assessment of all major commercial CDNs of today's market. Moreover, we present a typology for the classification of CDN networks that is based on the characteristics of their value chain activities. In a quantitative analysis we infer from real-world infrastructure data that the most successful CDNs pay a large number of small networks for the termination of their content. In the course of this analysis we argue that this strategy can improve important quality parameters for content delivery. Based on a longitudinal analysis we can point out that White Label CDNs are increasingly successful in the setup of market leading termination-networks. Finally, we show that a large ISP coalition which includes the current Inhouse CDNs could reproduce the most important infrastructure properties of the current market leaders. Based on our analyses we can conclude that the CDN market is moving towards less market concentration and manifold CDN offers.

The generalization of our results is limited do the usage of CAIDA data. Even though there is currently no more advanced research project for the assessment of the internet infrastructure it is not possible to assess private network interconnections. Moreover, it is obvious that even in a network industry an infrastructure analysis can only make a partial contribution to a holistic explanation of success factors in the CDN market. Thus, further research should focus on assessing the impact of intangible resources on success in the CDN market.

5. Conclusion

Market-driven broadband deployment and increasing inter-industry competition require telecommunication companies to reorganize value chains and explore cooperation as a means for cost reduction and value creation. This dissertation has assessed cooperative value creation and cost reduction strategies along a generic three-layer value chain to understand their contribution to the creation of sustainable competitive advantage and market-driven broadband deployment. Section 5.1 will subsequently provide a summary of the research findings. Thereafter, suggestions for further research are provided in Section 5.2.

5.1. Summary of central findings

To assess the impact of cooperation with actors of the OTT industry, cooperative value creation patterns of operator business models have been assessed. The results indicate that seven types of cooperation between telecommunication operators and OTT companies can be distinguished. Cooperation types such as *Promotion*, *Bundling*, and *Special OTT tariffs* create market specific, unique customer value propositions that extend the telecommunication operator's portfolio of standard core services. By selling premium tariffs for OTT services with a high perceived customer value and agreeing on a revenue sharing approach, operators can create sources of additional retail revenues. Moreover, telecommunication operators can position themselves as a *local service consultant* that integrates complex OTT offers with proprietary services to create value by solving specific customer problems. By leveraging economies of scope, additional retail revenues can be generated in the operator's consulting business. *Access to customer data*, *access to core services* and *technology integration* cooperation create a customer value through service innovation or new service distribution channels. Successful services exhibit a high innovation degree or attract a large number of users for the service distribution platform to generate retail or wholesale revenues, respectively.

> Cooperative value creation with Over-the-Top service providers enables telecommunication companies to differentiate existing customer solutions and extend the availability of core services beyond the scope of physical infrastructures to generate additional retail and wholesale revenues.

The increasing broadband capacity requirements of OTT services require telecommunication companies to upgrade their access networks. In a deregulated telecommunication market, required infrastructure investments are provided by multiple telecommunication operators. Thus, to extend service and product availability beyond the scope of the own physical infrastructure or deploy new infrastructure, mutual cooperation of heterogeneous carrier types may be required [NGA-Forum 2011].

For various telecommunication operator types, this research has explored the preconditions of sustainable cooperation. The results indicate that national, metropolitan and municipal broadband carriers differ with respect to their preconditions for sustainable cooperation. The perceived market success of metropolitan carriers is likely to stem from *relation-specific investments, advanced knowledge sharing routines, casual ambiguity* and *time compression diseconomies.* Various national carriers exhibit less advantageous preconditions for sustainable cooperation. For national carriers, the establishment of relationship characteristics such as *advanced knowledge sharing routines*, *efficient governance* and *casual ambiguity* is restricted by complex legal requirements, complex enterprise processes and a regulatory environment that aims to inhibit collusion.

Sustainability of cooperative value creation in broadband provisioning can be improved with advanced knowledge sharing routines, casual ambiguity, time compression diseconomies and a supportive regulatory environment.

Disintegrated telecommunication value chains exhibit multiple horizontal, vertical and diagonal cooperation interfaces, which can contribute to the market-driven setup of national broadband infrastructures in theory [cf. Section 2.3.1]. To identify practically relevant cooperation interfaces, a contingency framework for broadband provisioning has been developed. It assesses how horizontal, vertical and diagonal cooperation strategies contribute to the cooperation profitability of different carrier types.

The results indicate that horizontal cooperation strategies such as *co-investments* are in many cases inhibited by high initiation costs due to *presence of competitive dynamics*, *a lack of bargaining assets* or a *complex regulatory cooperation assessment processes*. In contrast, horizontal cooperation strategies such as the voluntarily *provisioning of white-label products* to other market participants can contribute to cooperation profitability. As a consequence, current horizontal cooperation dynamics are rather increasing customer broadband demand than broadband supply. At vertical cooperation interfaces, reciprocal offers of standardized *Layer 2 Bitstream Access* wholesale products are the strongest drivers of cooperation profitability between fully integrated telecommunication operators. Moreover, pure network and service operators indicate that a standardized *Layer 2 Bitstream Access* wholesale product makes a higher contribution to cooperation profitability than the replication of passive infrastructure assets. As a consequence, the universal operation of the *Ladder of Investment* is put to the question. At diagonal cooperation interfaces, *fiber rental* offers, *duct access*, *the* *ability for long-term infrastructure depreciation* and *low intersections of core competencies* are the strongest drivers of cooperation with utility companies. Finally, German and European *regulatory measures* and laws that *increase transparency* about the availability of existing duct infrastructures contribute to cooperation profitability at diagonal cooperation interfaces.

> Cooperative value creation in broadband provisioning can primarily be observed at diagonal cooperation interfaces. The financial option of long-term infrastructure depreciation, low intersections of core competencies and progress in the transparency of duct and fiber availability foster this cooperation type.

To reduce the initiation costs for the establishment of diagonal cooperation, telecommunication companies need to understand utility broadband deployment strategies and factors that determine cooperation success. This research employs a quantitative approach to characterize broadband strategies of utility companies and identifies external and internal contingency factors that influence their success.

Results indicate that five utility broadband strategies can be distinguished along the dimensions *valuation of cooperation at different value-added steps of the supply chain* and the *degree of vertical integration*. Many municipalities focus broadband activities on the provisioning of wholesale services at the network layer or the passive infrastructure layer. Wholesale services are either provided with internal resources or in cooperation. Results show that if wholesale services are provided in cooperation with telecommunication companies, cooperation success stems from the utility's above average appraisal of telecommunication carrier's *marketing know-how* and *access to sales channels*. *Business customer demand* constitutes an external contingency factor that contributes to the success of wholesale strategies. Utility companies with an average broadband deployment experience seek cooperation with telecommunication companies at the passive infrastructure layer less often for the establishment of *network planning know-how*. Very experienced municipalities conduct all value-added activities with internal resources. As a consequence, they refrain from considering cooperation at the passive and active infrastructure layers.

> Utility companies seek cooperation with telecommunication companies primarily for the joint provisioning of wholesale services at the active and passive infrastructure layer. A high local business customer broadband demand and an above average appreciation of the telecommunication company's marketing related activities contribute to cooperation success.

To reduce the high costs of rural broadband deployment, national broadband plans propose to use the fiber capacities of national infrastructures such as pipelines, highways, power lines or railroads as an origin for rural access networks. This research exemplarily explores the magnitude of cost savings that can be achieved if national German railroad infrastructures and the incumbent's network are jointly considered for the setup of rural broadband networks. Moreover, it explores political and regulatory measures required for improving synergy utilization.

Base case calculations for an FTTC scenario, which provides download speeds of up to 100 Mbit/s, indicate that the cooperative deployment of broadband infrastructures results in average cost savings of 13%. Similarly, base case calculations for an FTTB scenario, which provides download speeds of 312 Mbit/s, show that cost savings of 7% can be achieved. However, these savings are nullified if metro-aggregation, backbone and co-location costs associated with railroad fiber infrastructures exceed the costs of using the incumbent's infrastructure by more than 50%. Contrarily, savings increase to 23% (FTTC scenario) and 11% (FTTB scenario) if metro-aggregation, backbone and co-location costs of railroad fiber infrastructures are 50% lower than the cost of the incumbent. The results indicate that geographic preconditions for synergy utilization can differ largely on a federal state and county level. Thus, political and regulatory efforts directed at improving efficiency gains across national networks should be focused on geographic areas with favorable preconditions for synergy utilization. Moreover, results show that in using synergistic potential with alternative infrastructures, distinct tenders for selected rural communities will usually increase the total required state aid for reaching national broadband goals. Thus, to fully leverage deployment synergies, authorities should recognize the definition of broadband tender areas as a chance for the aggregation of broadband demand.

> To leverage the synergistic cost reduction potential between multiple fixed fiber infrastructures in rural broadband deployment, authorities should aggregate customer demand in larger broadband tender areas. Given a competitive market for metro-aggregation, backbone and co-location services, co-investment savings of 13% (FTTC) and 7% (FTTB) can be achieved.

To generate additional revenues in the growing CDN market, telecommunication companies are exploring horizontal cooperation at the network layer as a means to reduce the costs of market entry [Rayburn 2011b]. This research explores the potential success and the sustainability of such a coalition. In a first step, the CDN infrastructure properties associated with market success are explored. In a second step, the potential for cooperation between telecommunication operator CDNs and new market entrants to change the current market concentration based on the infrastructure resource profile is assessed.

The results indicate that successful CDNs use content-delivery infrastructures that differ significantly from those of rivals with smaller market shares. Major differentiators are found in the number of transit connections and the average size of the connected termination-networks. Successful CDNs pay a large number of transit providers, which provides a rather small termination-network in close proximity to the edge of the internet. This strategy can contribute to improving quality parameters such as delay, jitter or latency [Krishnan et al. 2009]. Until 2010, no proprietary telecommunication carrier CDN could be found among the top ten CDNs in terms of market share [Tier1Research 2011]. The results show that a potential CDN cooperation between telecommunication carriers would change this situation. The carrier coalition would be able to reproduce the infrastructure properties that are associated with market success. Further analysis indicated that coalition members would contribute complementary infrastructure resources to the cooperation. Thus, from resource dependency theory, it can be concluded that the coalition would be stable once it was established.

> A cooperative entry into the CDN market enables telecommunication companies to replicate the infrastructure properties that are associated with market success. Complementarity resources of telecommunication companies contribute to cooperation stability.

5.2. Limitations and further research

This dissertation assessed cooperative value creation and cost reduction strategies in a disintegrated telecommunications value chain. The derived findings of this work and its limitations can serve as a vantage point for further research. It has been demonstrated that inter-firm cooperation can contribute to a firm’s sustainable competitive advantage and generate additional revenues. However, the voluntary cooperation of independent companies is just one of several possible strategic options in reacting to intra-industry competition within the ICT sector and increased inter-industry competition with other telecommunication operators. In this sense, several realized and intended mergers between cable or mobile operators could be observed in the German market [Bundeskartellamt 2013a; Bundeskartellamt 2013b]. In the case of mergers, a strong degree of organizational internalization and external growth are favored over internal growth, which can be initiated by cooperation. As a consequence, further research should address the following question:

Do larger market shares or particular market properties contribute to a superior firm performance in addressing intra- and inter-industry competition with the ICT industry?

Comparisons between telecommunication firms in the more consolidated American and the highly competitive European market can be the starting point for these analyses. Possible measures of comparison include the degree of innovation in service provisioning, average customer revenues or investments in research and infrastructure. A multiple case study approach could make a valuable contribution to a better understanding of contextual reasons of potential performance differences.

This research has demonstrated that telecommunication operators open their proprietary infrastructures to provide services to complementors, such as access network competitors at downstream value-added steps or OTT service providers. In following this strategy, companies aim to position themselves as an intermediary in a value network [Nalebuff/Brandenburger 1996, 17]. Thus, further research should direct attention to the following research question:

How can telecommunication companies or firm-coalitions positions themselves as an intermediary in an ICT value network?

Section 3.1.5 has indicated that value network strategies require fundamentally different primary business activities than can be observed in fully integrated value chains. In these strategies, growth is a strategic imperative, not only to facilitate economies of scale in production but to foster demand-side economies of scale, which are generated by positive network effects [Varian/Shapiro 1999, 14]. Possible assessment dimensions of value networks include success factors of network promotion, customer expectation management and the network's technical infrastructure characteristics. In the research field of market-driven broadband deployment, it would be worthwhile to assess the determinants of firm profitability for a national aggregator of distributed physical networks who sells a *Bitstream Access* to service providers. Further research should also evolve a better understanding for performance differences between platforms of leading OTT service providers and telecommunication companies. In this context, the theory of two-sided markets can be employed to explore the impact of pricing on platform success [Beltrán 2012; Hau et al. 2011; Rochet/Tirole 2003; Varian/Shapiro 1999, 173ff].

This research has demonstrated that managers choose cooperation strategies in response to contingent organizational and environmental conditions. Moreover, evidence was provided that contingency factors such as organizational complexity and regulatory obligations inhibit strategies such as, for example, co-investments or advanced knowledge sharing routines.

Thus, future research should be directed at organizational efforts that aim to change unfavorable internal and external preconditions to increase profitability. In this sense, internal preconditions for inter- and intra-industry cooperation could be improved by addressing the following question:

How can national telecommunication operators establish more trustful cooperative relationships with their partners and establish advanced knowledge sharing routines without increasing organizational complexity and violating regulatory interests?

Possible measures of comparison include cooperation goals, resources, employee capabilities and value creation activities. Assessments could be conducted by means of qualitative and quantitative cross-sectorial analyses to identify distinct characteristics of trustful relationships and advanced knowledge sharing routines.

Particular attention should also be paid to organizational efforts that aim to influence the company's environment. This is due to the fact, that companies that engage in complex cooperative and competitive relationships often underappreciate the effect of changing environmental rules and conditions [Nalebuff/Brandenburger 1996, 195]. A gradual and ongoing development will require telecommunication companies to reevaluate their organization's environment continuously and initiate changes as applicable: Telecommunication regulation that governs vertical business relationships will eventually need to fade away as competition grows [Shapiro/Varian 1999, 312].

Taking another step in deregulating the telecommunication market, the German regulator has recently acknowledged geographical differences in the competition intensity of the *Bitstream Access* market and, for the first time, proposed to release the incumbent in certain German cities from ex-ante regulation [Bundesnetzagentur 2014]. This and future deregulation market analyses will require an unprecedented use of geographical information systems for corporate and regulatory decision support [BEREC 2014]. In Section 4.2, this research has proposed a geographical synergy evaluation model for co-investment decision support in rural broadband deployment. Building on this contribution, further research should explore the preconditions for deregulation at higher rungs of the LoI, such as the *Central Office Access* [cf. Section 2.3.2]. Moreover, cost savings from central office closure should be explored. Both aspects can be elucidated by assessing the following question:

What savings can be achieved through the reduction of central offices, as the incumbent is migrating infrastructure to fiber access networks, and where are central offices no longer required for co-location?

In addressing the question, future models should consider auxiliary conditions such as the maximum line length of fiber cables and network redundancy requirements. Moreover, this research has shown that feeder cable calculation improves if federal states exhibit a large number of communities with narrow boundaries, that have not been consolidated for administrative purposes. Thus, future models can improve accuracy by basing calculations on smaller entities of settlement structures, similar to those found in the national Breitbandatlas [BMWi 2014].

It has been postulated that companies in industries with large fixed costs and low marginal costs should enjoy considerable antitrust freedom in differential pricing to recover their costs [Shapiro/Varian 1999, 317]. Accepting this premise, telecommunication companies are allowed to recover their infrastructure investments through versioning and differential pricing for transport services with improved quality parameters. In this sense, CDN carrier coalitions, cooperative OTT and telecommunication services or QoS interconnection can contribute to this cost recovery. However, proponents of the strict definition of net neutrality, which demands that no service be speeded up, slowed down or blocked based on its source, ownership or destination, fear that these novel services hinder service innovation on the internet [Krämer et al. 2013]. Thus, further research should shed light on the following question:

How does the availability of superior transport classes affect internet service innovation and the competitiveness of start-up companies?

Possible assessments could investigate whether internet start-up companies whose business models involves the provisioning of quality sensitive services, such as VoIP, video delivery or online gaming, experience technological market entry barriers. More precisely, it could be explored whether cloud-based, pay-per-use CDN services, which are regularly used by start-up companies, exhibit inferior quality parameters over alternative CDN services [cf. Amazon CloudFrontCDN 2014]. Finally, further research should assess the financial advantages and disadvantages of using quality improving mechanisms in internet start-up companies.

6. Appendices

6.1.1. Supplementary material for the analysis of expert interviews

Number	Company	Interview Date	Position
1	National carrier 1	14.12.2011	Cooperation & Regulation Technology
2	National carrier 1	14.12.2011	Quality Management & Common Processes
3	National carrier 1	14.12.2011	Kooperationsmanagement
4	National carrier 2	19.01.2012	Head of Software Development Access
5	Metropolitan carrier 1	27.01.2012	Bereichsleiter zentrale Planung
6	National carrier 3	31.01.2012	Fixed Access Design & Capacity
7	National carrier 3	31.01.2012	Senior Network Architect
8	National carrier 3	31.01.2012	Analytist
9	Metropolitan carrier 2	01.02.2012	IT & Billing
10	Metropolitan carrier 2	01.02.2012	Regulierung
11	Metropolitan carrier 2	01.02.2012	Technik
12	Metropolitan carrier 2	01.02.2012	Technik
13	Metropolitan carrier 2	01.02.2012	Regulierung und Vertreter der Geschäftsführung
14	Business carrier 1	03.02.2012	Director Data & Managed Services
15	Regional carrier 1	08.02.2012	Stellvertretende Geschäftsführung
16	Regional carrier 1	08.02.2012	Senior Network Consultant
17	National carrier 4	08.02.2012	Head of Regulatory and Convergence
18	National carrier 4	08.02.2012	Head of Strategy
19	Metropolitan carrier 3	09.02.2012	Bereichsleiter Technik
20	National carrier 1	10.02.2012	Zentrum Wholesale /Wholebuy (Regulierung)
21	National carrier 1	10.02.2012	Zentrum Wholebuy
22	National carrier 1	10.02.2012	Zentrum Wholesale /Wholebuy
23	National carrier 1	10.02.2012	Zentrum Wholesale /Wholebuy
24	National carrier 1	10.02.2012	Process & Quality Management
25	Business carrier 2	13.02.2012	Leiter Regulierung & Unternehmensentwicklung
26	Metropolitan carrier 3	13.02.2012	Bereichsleiter Expansions- u. Kooperationsmanagement
27	Cable operator 1	30.04.2012	Geschäftsführer
28	Cable operator 1	30.04.2012	Leiter Technik

29	Cable operator 2	27.07.2012	Director Technology, Products & Services
30	Business carrier 3	27.07.2012	Leiter aktives Netz
31	Business carrier 3	27.07.2012	Leiter Marketing
32	Regional carrier 2	10.10.2012	Geschäftsführer

Table 6-1: Information on conducted expert interviews

Category	Question
Tätigkeitsbereich des Experten	Was ist Ihr aktueller Tätigkeitsbereich im Unternehmen?
	Arbeiten Sie mit anderen Telekommunikationsfirmen zusammen?
	Tragen Sie Verantwortung für Aufbau oder die Beendigung von Kooperationen?
	Berücksichtigen Sie bei Ihrer Arbeit Anforderungen aus den Bereichen Marketing, Produktentwicklung oder Rechnungslegung?
	Berücksichtigen Sie bei Ihrer Arbeit Anforderungen aus dem Bereich Netzwerk Management?
	Berücksichtigen Sie bei Ihrer Arbeit Anforderungen aus dem Aufbau und der Wartung von physischer Infrastruktur?
Breitband-Ausbau in Deutschland	Nach welchen Kriterien werden heute geeignete Gebiete für den Breitbandausbau identifiziert?
	Welche Firmen sind aus Ihrer Sicht besonders erfolgreich beim Ausbau von Breitband-Infrastrukturen?
	Gibt es beim Breitbandausbau knappe Ressourcen bzw. knappes Know-How, welches hauptsächlich bei einem Unternehmen konzentriert ist?
	In welchen Bereichen sehen Sie beim Breitbandausbau am ehesten Potenzial zur Realisierung von Skaleneffekten?
	Wie lange werden aus Ihrer Sicht die Leistungsmerkmale von FTTC-Lösungen den Ansprüchen der Endkunden genügen?
Wertschöpfung in der Telekommunikation	Welche wertschöpfenden Aktivitäten würden Sie als Kernkompetenz Ihres Unternehmens bezeichnen?
	In welchen Bereichen sehen Sie Potenzial für die Ausweitung der aktuellen Unternehmensaktivitäten?
	Welche Wertschöpfungsaktivitäten würden Sie unter bestimmten Voraussetzungen auch von anderen Unternehmen einkaufen?
	Welche Eigenschaften müsste ein Unternehmen aufweisen, von denen Ihr Unternehmen Produkte und Dienstleistungen einkauft?
	Wo sehen Sie die Vorteile/Nachteile eines Unternehmens, das die gesamte Wertschöpfungskette der Telekommunikationsindustrie abdeckt?
	Unter welchen Voraussetzungen würde Ihr Unternehmen eher mit einem anderen Unternehmen kooperieren, als eine wertschöpfende Aktivität selbst durchzuführen?

	In welchen Bereichen wird Ihr Unternehmen auf absehbare Zeit keine Kooperationen eingehen?
Kooperationen	Wo sehen sie die Hauptherausforderungen für FTTX-Kooperationen?
	Wie würden Sie im Allgemeinen die Kooperationsbereitschaft in der Telekommunikationsindustrie beschreiben?
	Welche Faktoren spielen bei der Wahl eines Kooperationspartners eine Rolle?
	Wie groß schätzen Sie die Gefahr ein, dass ein Kooperationspartner das in der Kooperation erlangte Wissen zu ihrem Nachteil nutzt?
	Wie groß schätzen Sie die Gefahr ein, dass potenzielle Kooperationspartner Ihrem Unternehmen opportunistisches Verhalten unterstellen?
Kooperationsanbahnung	Welche Abteilungen sind am Entscheidungsprozess für die Realisierung von Breitbandausbauprojekten beteiligt?
	Welche Analysen werden von den beteiligten Abteilungen beigetragen?
	Welche Daten werden für die Entscheidungsfindung genutzt?
	Welche Risiken werden bewertet?
	Nach welchen Kriterien wird entschieden, dass eine Kooperation einer Eigenentwicklung vorzuziehen ist?
	Wer ist an den Verhandlungen beteiligt?
	Welches Vorgehen hat sich in der Verhandlungsphase von Kooperationen als besonders geeignet erwiesen?
	Welche Punkte führen im Verhandlungsprozess zu Problemen?
Kooperationsgestaltung	Von welchen Faktoren wird die Wahl der Kooperationstiefe, das heißt der höchsten gemeinsamen Wertschöpfungsstufe, beeinflusst?
	Führt die Wahl bestimmter Technologien zu Problemen bei der Kooperationsgestaltung?
	Wie werden Kooperationen in Ihrem Unternehmen gemanagt?
	Welche Rolle spielt aus Ihrer Sicht die Wahl einer bestimmten Netzarchitektur (PMP/P2P) bei der Festlegung der Kooperationsbedingungen.
	Welche Informationen werden im Rahmen einer Kooperation bereitgestellt?
Erfolgsmessung von Breitbandprojekten	Welche Kennzahlen werden für die Erfolgsmessung von Breitbandprojekten genutzt?
	Welche nicht direkt messbaren Faktoren werden für die Beurteilung des Erfolgs von Breitbandprojekten verwendet?
	Wann lässt sich beurteilen, ob ein Ausbauprojekt erfolgreich war?
	Welche bereits durchgeführten Breitbandprojekte würden Sie als erfolgreich bezeichnen?
	Welche bereits durchgeführten Kooperationen Ihres Unternehmens waren besonders erfolgreich?

Table 6-2: Question catalogue for semi-structured expert-interviews

6.1.2. Supplementary material for municipal broadband adoption analysis

The following survey was developed and conducted in cooperation with the Verband Kommunaler Unternehmen (VKU).

Umfrage: Kooperationen bei Breitbandaktivitäten kommunaler Unternehmen in Deutschland

Name des Unternehmens:___________________________________

E-Mail-Adresse: ____

Bitte senden Sie den ausgefüllten Fragebogen spätestens bis zum <u>12.04.13</u> per Fax an den VKU:

+49 30 [redacted]

Für Rückfragen und Anregungen stehen Ihnen im VKU Herr [redacted] oder Herr Limbach vom Fachgebiet Informations- und Kommunikationsmanagement der TU Berlin ([redacted]) gern zur Verfügung.

Im Hinblick auf die Nutzung von Synergien beim deutschen Breitbandausbau wird der branchenübergreifenden Zusammenarbeit von kommunalen Unternehmen und Telekommunikationsunternehmen eine zentrale Rolle zugewiesen. Aufgrund der Vielzahl an potenziellen Partnern mit unterschiedlichen Kompetenzen, Ressourcenausstattungen, Strategien und Prozessen gestalten sich die Anbahnung und das Management der Zusammenarbeit in der Praxis jedoch häufig schwierig. Ziel unserer Untersuchung ist es daher, den strategischen Fit zwischen kommunalen Unternehmen und Telekommunikationsunternehmen zu ermitteln und die Erfolgsfaktoren einer nachhaltigen Zusammenarbeit wissenschaftlich abgesichert aufzuzeigen.

- Ist Ihr Unternehmen im Breitbandgeschäft tätig oder plant es im Breitbandgeschäft tätig zu werden?

☐ Bereits tätig ☐ Tätigkeit geplant ☐ Tätigkeit nicht geplant

Erläuterung: Bitte beantworten Sie die Fragen 2-11 nur, wenn Sie bei Frage 1 mit „Bereits tätig“ oder mit „Tätigkeit geplant“ geantwortet haben.

- Welche Bedeutung haben folgende Ziele für das Breitbandgeschäft Ihres Unternehmens?
  Wie groß ist der erwartete Mehrwert von Kooperationen im Hinblick auf die Erfüllung dieser Ziele?

	Bedeutung des Ziels	**Mehrwert durch Kooperation**
	Keine Bedeutung – Sehr große Bedeutung	Kein Mehrwert – Sehr großer Mehrwert
Zugang zu Kapital	□1–□2–□3–□4–□5–□6–□7	□1–□2–□3–□4–□5–□6–□7
Kostenoptimierte Erschließung von Haushalten	□1–□2–□3–□4–□5–□6–□7	□1–□2–□3–□4–□5–□6–□7
Flächendeckende Erschließung von Haushalten	□1–□2–□3–□4–□5–□6–□7	□1–□2–□3–□4–□5–□6–□7
Zugang zu Know-How in der Netzwerkplanung	□1–□2–□3–□4–□5–□6–□7	□1–□2–□3–□4–□5–□6–□7
Zugang zu Vertriebswegen	□1–□2–□3–□4–□5–□6–□7	□1–□2–□3–□4–□5–□6–□7
Zugang zu Marketing-Know-How	□1–□2–□3–□4–□5–□6–□7	□1–□2–□3–□4–□5–□6–□7
Erweiterung des Diensteangebots	□1–□2–□3–□4–□5–□6–□7	□1–□2–□3–□4–□5–□6–□7
Breitere Vermarktung der bestehenden Angebote	□1–□2–□3–□4–□5–□6–□7	□1–□2–□3–□4–□5–□6–□7

- Welche Bedeutung haben folgende Geschäftsaktivitäten für die Ziele Ihres Unternehmens im Breitbandgeschäft aktuell oder zukünftig?
  Wie bewerten Sie das Potenzial zur Kooperation bezüglich dieser Aktivitäten?
  Werden die Aktivitäten in Ihrem Unternehmen mit dem Ziel der Eigennutzung oder im Hinblick auf den Vertrieb am Markt durchgeführt?

	Bedeutung der Aktivität für Ziele im Breitbandgeschäft	**Kooperationspotenzial für Zielerfüllung**	**Nutzung**
	Keine Bedeutung – Sehr große Bedeutung	Kein Potenzial – Sehr großes Potenzial	*Mehrfachnennungen pro Zeile sind möglich*
Leerrohrverlegung	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐ Eigennutzung ☐ Vertrieb am Markt
Verlegung passiver Glasfasernetze (FTTC)	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐ Eigennutzung ☐ Vertrieb am Markt
Verlegung passiver Glasfasernetze (FTTB)	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐ Eigennutzung ☐ Vertrieb am Markt
Verlegung passiver Glasfasernetze (FTTH)	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐ Eigennutzung ☐ Vertrieb am Markt
Verlegung passiver Glasfasernetze (HFC)	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐ Eigennutzung ☐ Vertrieb am Markt
Aufbau von Mobilfunknetzen	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐ Eigennutzung ☐ Vertrieb am Markt
Betrieb von Glasfasernetzen	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐ Eigennutzung ☐ Vertrieb am Markt
Verfügbarkeit von BSA Wholesale-Diensten	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐ Eigennutzung ☐ Vertrieb am Markt
Verfügbarkeit von White-Label Diensten (z.B. IPTV)	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐ Eigennutzung ☐ Vertrieb am Markt
Bereitstellung von Endkunden-Diensten	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	
Sammlung von Grundstücks-eigentümer-erklärungen	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐ Eigennutzung ☐ Vertrieb am Markt

- Welche Bedeutung hat die Nutzung bereits existierender Infrastrukturen Ihres Unternehmens für die Erstellung von Breitbandnetzen?
  Wie bewerten sie die Chancen für eine Nutzung dieser Infrastrukturen durch TK-Unternehmen?
  Wie hoch schätzen Sie das Einsparpotenzial durch Synergien mit existierenden Infrastrukturen im Vergleich zur Neuerstellung ein?

<table>
<tr><th></th><th>Nutzbarkeit existierende Infrastrukturen</th><th>Vermarktbarkeit an TK-Unternehmen</th><th>Einsparpotenzial durch Synergien</th></tr>
<tr><td></td><td>Keine Bedeutung – Sehr große Bedeutung</td><td>Keine Nachfrage – Sehr große Nachfrage</td><td>in Prozent der Gesamtinvestitions-kosten</td></tr>
<tr><td>Vorhandene Leerrohre</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐ – ☐ – ☐ – ☐ – ☐
<10% | <25% | <50% | <75% | >75%</td></tr>
<tr><td>Vorhandene Steuerleitungen auf Glasfaserbasis</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐ – ☐ – ☐ – ☐ – ☐
<10% | <25% | <50% | <75% | >75%</td></tr>
<tr><td>Mitverlegung mit Stromleitungen</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐ – ☐ – ☐ – ☐ – ☐
<10% | <25% | <50% | <75% | >75%</td></tr>
<tr><td>Mitverlegung mit Gasleitungen</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐ – ☐ – ☐ – ☐ – ☐
<10% | <25% | <50% | <75% | >75%</td></tr>
<tr><td>Mitverlegung mit Wasserleitungen</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐ – ☐ – ☐ – ☐ – ☐
<10% | <25% | <50% | <75% | >75%</td></tr>
<tr><td>Mitverlegung mit Abwasserkanälen</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐ – ☐ – ☐ – ☐ – ☐
<10% | <25% | <50% | <75% | >75%</td></tr>
<tr><td>Stillgelegte Leitungen (Gas, Wasser, Abwasser)</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐ – ☐ – ☐ – ☐ – ☐
<10% | <25% | <50% | <75% | >75%</td></tr>
<tr><td>Verlegung in Gasleitungen</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐ – ☐ – ☐ – ☐ – ☐
<10% | <25% | <50% | <75% | >75%</td></tr>
<tr><td>Verlegung in Trinkwasserleitungen</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐ – ☐ – ☐ – ☐ – ☐
<10% | <25% | <50% | <75% | >75%</td></tr>
<tr><td>Verlegung in Abwasserkanälen</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐ – ☐ – ☐ – ☐ – ☐
<10% | <25% | <50% | <75% | >75%</td></tr>
<tr><td>Nutzung von Gebäuden/Masten für Mobilfunkantennen</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐1–☐2–☐3–☐4–☐5–☐6–☐7</td><td>☐ – ☐ – ☐ – ☐ – ☐
<10% | <25% | <50% | <75% | >75%</td></tr>
</table>

- Wie wirken sich folgende Entwicklungen auf die Breitbandaktivitäten Ihres Unternehmens gegenwärtig und zukünftig aus? Inwiefern bestimmen diese die Kooperationsbestrebungen Ihres Unternehmens?

	Gegenwärtige Auswirkung	**Auswirkung in den kommenden 5 Jahren**	**Auswirkung auf gegenwärtige Kooperations-bestrebungen**
	Sehr ungünstig/ aktivitäts-hemmend … Sehr günstig/ aktivitäts-fördernd	Sehr ungünstig/ aktivitäts-hemmend … Sehr günstig/ aktivitäts-fördernd	Sehr ko-operations-hemmend … Sehr ko-operations-fördernd
Preis-/Renditeerwartung	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7
Verfügbarkeit von Fremdfinanzierungs-möglichkeiten	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7
Verfügbarkeit von und Zugang zu Fördermitteln	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7
Unterstützung seitens politischer Entscheidungsträger	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7
Bestehende regulatorische Rahmenbedingungen der TK-Wirtschaft	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7
Bestehende regulatorische Rahmenbedingungen der Energiewirtschaft	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7
Wettbewerbssituation	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7
Technologische Entwicklungen	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7	☐1-☐2-☐3-☐4-☐5-☐6-☐7

- Welche Bedeutung hat das Breitbandgeschäft im Vergleich zu anderen Geschäftsfeldern in Ihrem Unternehmen gegenwärtig und zukünftig?

	Gegenwärtige Bedeutung	**Bedeutung in den kommenden 5 Jahren**
	Keine Bedeutung – Sehr große Bedeutung	Keine Bedeutung – Sehr große Bedeutung
Umsatzanteil	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$
Anteil an Investitionen	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$
Verankerung in der Unternehmensstrategie	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$
Konkurrenz zu anderen (Infrastruktur-) Projekten, z.B. Energieerzeugung	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$
Anteil an dedizierten Mitarbeitern	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$
Standardisierung der Prozesse	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$
Bindung/Gewinnung von Kunden auch für das Kerngeschäft	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$

- Welche Bedeutung haben die folgenden Anforderungen an Kooperationspartner jeweils auf den unterschiedlichen Wertschöpfungsebenen?

Hinweis zur Auswertung: Ihre Angaben werden im Kontext der zuvor genannten Aktivitäten Ihres Unternehmens interpretiert.

	Erwartungen an Partner der Asset-Ebene (Leerrohre und Dark Fiber)	**Erwartungen an Partner der Netzwerk-Ebene (Netzbetrieb)**	**Erwartungen an Partner der Service-Ebene (Dienste)**
	Keine Bedeutung – Sehr große Bedeutung	Keine Bedeutung – Sehr große Bedeutung	Keine Bedeutung – Sehr große Bedeutung
Übernahme des initialen Investitionsrisikos	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$
Bereitstellung von Kapital	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$
Vollständige Übernahme des Auslastungsrisikos	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$
Angemessen hohe Zahlung für Vermietung/ Verpachtung	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$	$\square_1-\square_2-\square_3-\square_4-\square_5-\square_6-\square_7$

	Erwartungen an Partner der Asset-Ebene (Leerrohre und Dark Fiber)	**Erwartungen an Partner der Netzwerk-Ebene (Netzbetrieb)**	**Erwartungen an Partner der Service-Ebene (Dienste)**
	Keine Bedeutung … Sehr große Bedeutung	Keine Bedeutung … Sehr große Bedeutung	Keine Bedeutung … Sehr große Bedeutung
Akzeptanz von nicht-exklusiven Verträgen	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Akzeptanz von langfristigen Nutzungsdauern (>20 Jahre)	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Bereitstellung eigener Infrastrukturen	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Bereitstellung eines erprobten Umsetzungs-konzepts	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Gewährleistung der TV-Grundversorgung	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Akzeptanz eines Preismodells bei dem das Eigentum nach der Vertrags-laufzeit an den Partner übergeht	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Möglichkeit eines eigenen Markenauftritts	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Existenz von komplementären Kompetenzen	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Gemeinsame technische Standards	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Langjährige Erfahrungen/ Referenzen	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Ähnliche Größe des Partner-unternehmens	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Dediziertes Management für bestehende Kooperationen	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$

- Auf welcher Ebene haben Sie schon Kooperationen realisiert und welcher Unternehmenstyp wäre (auch zukünftig) jeweils der bevorzugte Kooperationspartner?

	Partner der Asset-Ebene (Leerrohre und Dark Fiber)	**Partner der Netzwerk-Ebene (Netzbetrieb)**	**Partner der Service-Ebene (Dienste)**
Bisherige Kooperations-partner (Mehrfachnennung pro Ebene ist möglich)	☐ Keine Kooperation - eigenständige Durchführung	☐ Keine Kooperation - eigenständige Durchführung	☐ Keine Kooperation - eigenständige Durchführung
	☐ Verbundenes TK-(Tochter)Unternehmen ☐ Anderes kommunal beherrschtes (TK-)Unternehmen ☐ Privatwirtschaftliches TK-Unternehmen ☐ Privatwirtschaftliches Unternehmen außerhalb der TK-Branche	☐ Verbundenes TK-(Tochter)Unternehmen ☐ Anderes kommunal beherrschtes (TK-)Unternehmen ☐ Privatwirtschaftliches TK-Unternehmen ☐ Privatwirtschaftliches Unternehmen außerhalb der TK-Branche	☐ Verbundenes TK-(Tochter)Unternehmen ☐ Anderes kommunal beherrschtes (TK-)Unternehmen ☐ Privatwirtschaftliches TK-Unternehmen ☐ Privatwirtschaftliches Unternehmen außerhalb der TK-Branche
Zukünftig bevorzugter Kooperations-partner (Mehrfachnennung pro Ebene ist möglich)	☐ Keine Kooperation - eigenständige Durchführung	☐ Keine Kooperation - eigenständige Durchführung	☐ Keine Kooperation - eigenständige Durchführung
	☐ Verbundenes TK-(Tochter)Unternehmen ☐ Anderes kommunal beherrschtes (TK-)Unternehmen ☐ Privatwirtschaftliches TK-Unternehmen ☐ Privatwirtschaftliches Unternehmen außerhalb der TK-Branche	☐ Verbundenes TK-(Tochter)Unternehmen ☐ Anderes kommunal beherrschtes (TK-)Unternehmen ☐ Privatwirtschaftliches TK-Unternehmen ☐ Privatwirtschaftliches Unternehmen außerhalb der TK-Branche	☐ Verbundenes TK-(Tochter)Unternehmen ☐ Anderes kommunal beherrschtes (TK-)Unternehmen ☐ Privatwirtschaftliches TK-Unternehmen ☐ Privatwirtschaftliches Unternehmen außerhalb der TK-Branche

- In welchem Umfang hat Ihr Unternehmen bisher Erfahrungen im Breitbandausbau gesammelt?

	Bereitstellung und Neuverlegung von Leerrohren für TK-Zwecke	**Verlegung von Glasfaser, COAX und Kupferleitungen**
Anzahl (#) angeschlossener Haushalte (Theoretische Anzahl an Kunden durch KVz- oder Haus-Erschließung ohne Resale)	☐ # < 500	☐ # < 500
	☐ 500 ≤ # < 2.500	☐ 500 ≤ # < 2.500
	☐ 2.500 ≤ # < 5.000	☐ 2.500 ≤ # < 5.000
	☐ 5.000 ≤ # < 10.000	☐ 5.000 ≤ # < 10.000
	☐ 10.000 ≤ # < 25.000	☐ 10.000 ≤ # < 25.000
	☐ 25.000 ≤ # < 50.000	☐ 25.000 ≤ # < 50.000
	☐ 50.000 ≤ # < 75.000	☐ 50.000 ≤ # < 75.000
	☐ 75.000 ≤ # < 125.000	☐ 75.000 ≤ # < 125.000
	☐ 125.000 ≤ # < 200.000	☐ 125.000 ≤ # < 200.000
	☐ 200.000 ≤ #	☐ 200.000 ≤ #

- In welchem Umfang plant Ihr Unternehmen in den kommenden 5 Jahren zusätzliche Haushalte anzuschließen?

	Bereitstellung und Neuverlegung von Leerrohren für TK-Zwecke	**Verlegung von Glasfaser, COAX und Kupferleitungen**
Anzahl (#) zusätzlich angeschlossener Haushalte (Theoretische Anzahl an Kunden durch KVz- oder Haus- Erschließung ohne Resale)	☐ # < 500	☐ # < 500
	☐ 500 ≤ # < 2.500	☐ 500 ≤ # < 2.500
	☐ 2.500 ≤ # < 5.000	☐ 2.500 ≤ # < 5.000
	☐ 5.000 ≤ # < 10.000	☐ 5.000 ≤ # < 10.000
	☐ 10.000 ≤ # < 50.000	☐ 10.000 ≤ # < 50.000
	☐ 50.000 ≤ # < 100.000	☐ 50.000 ≤ # < 100.000
	☐ 100.000 ≤ # < 200.000	☐ 100.000 ≤ # < 200.000
	☐ 200.000 ≤ #	☐ 200.000 ≤ #

- Abschließende Einschätzungen

a) Welcher Aspekt des kooperativen Breitbandausbaus ist zentral im Hinblick auf einen erfolgreichen Ausbau?

....

....

....

b) Welchem Aspekt des kooperativen Breitbandausbaus sollte mehr Beachtung geschenkt werden?

....

....

....

c) Welcher Aspekt des kooperativen Breitbandausbaus wird in den kommenden 5 Jahren über den Ausbauerfolg entscheiden?

d) Welche Chancen und Risiken sehen Sie im Hinblick auf Kooperationen unter kommunalen Unternehmen?

Chancen:

Risiken:

Erläuterung: Bitte beantworten Sie Frage 12 nur, wenn Sie bei Frage 1 mit „Tätigkeit nicht geplant“ geantwortet haben.

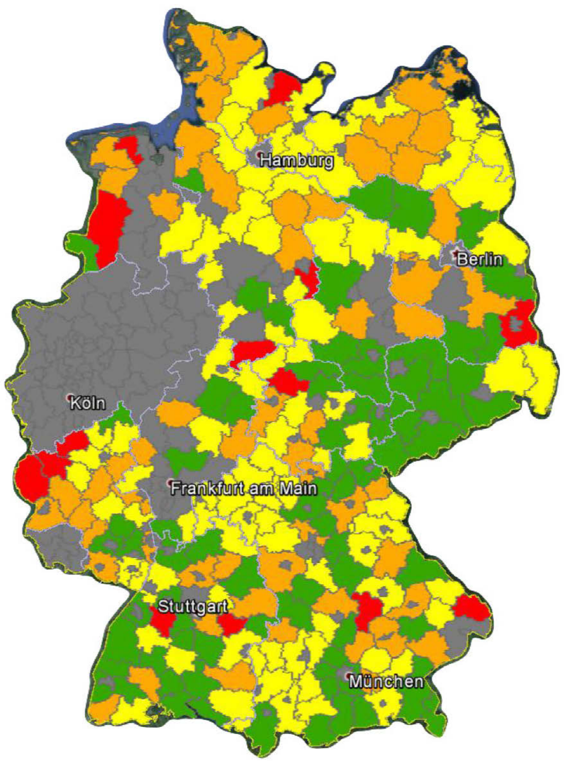
- Inwiefern haben folgende Faktoren die Entscheidung Ihres Unternehmens gegen eine Aktivität im Breitbandmarkt beeinflusst? Wie wird sich der Einfluss dieser Faktoren auf die Entscheidung Ihres Unternehmens in den kommenden 5 Jahren ändern? Welche einschränkenden Faktoren könnten durch eine geeignete, strategische Kooperation kompensiert werden?

	Einfluss des Faktors	**Einfluss in den kommenden 5 Jahren**	**Potenzial zur Kompensation durch strategische Kooperation**
	Kein Einfluss – Sehr großer Einfluss	Sehr ungünstig/ aktivitäts-hemmend – Sehr günstig/ aktivitäts-fördernd	Kein Potenzial – Sehr großes Potenzial
Fehlende Marktkenntnisse	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Mangelndes technisches Know-How	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Fehlende Synergien zu bestehenden Geschäftsfeldern	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Regulatorische Einschränkungen	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Unzureichendes Startkapital	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Mangel an Förder-mitteln (Verfügbarkeit oder Zugang)	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Fehlende Unterstützung seitens politischer Entscheidungs-träger	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$
Ungünstige technologische Entwicklungen	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$	☐$_1$–☐$_2$–☐$_3$–☐$_4$–☐$_5$–☐$_6$–☐$_7$

	Einfluss des Faktors	Einfluss in den kommenden 5 Jahren	Potenzial zur Kompensation durch strategische Kooperation
	Kein Einfluss … Sehr großer Einfluss	Sehr ungünstig/ aktivitäts-hemmend … Sehr günstig/ aktivitäts-fördernd	Kein Potenzial … Sehr großes Potenzial
Geringe Rendite-erwartungen im Vergleich zu Opportunitäten in bestehenden Geschäftsfeldern	□1–□2–□3–□4–□5–□6–□7	□1–□2–□3–□4–□5–□6–□7	□1–□2–□3–□4–□5–□6–□7
Mangelnde Endkunden-nachfrage	□1–□2–□3–□4–□5–□6–□7	□1–□2–□3–□4–□5–□6–□7	□1–□2–□3–□4–□5–□6–□7
Bestehende Nachfrage wird durch anderen Anbieter bereits bedient	□1–□2–□3–□4–□5–□6–□7	□1–□2–□3–□4–□5–□6–□7	□1–□2–□3–□4–□5–□6–□7

6.1.3. Supplementary material for the assessment of synergistic effects in rural broadband deployment

The subsequent pages depict the geographic preconditions for improving rural broadband deployment in Germany with a trench-optimized network topology that takes into account Deutsche Telekom and railroad infrastructures. The analysis focuses on rural communities that do not host a Deutsche Telekom central office and that exhibit a population density of 280 or less inhabitants per square kilometer. The presented graphics display the results of a theoretical 100% fiber deployment scenario (a detailed scenario description is provided in Section 4.2.3). The results indicate the geographic regions where local authorities should aggregate customer demand in larger tender areas to improve preconditions for the co-deployment of broadband infrastructures. Counties that are colored in green exhibit a high percentage of rural communities in close proximity to railroad infrastructures. In contrast, grey counties indicate a low percentage of rural communities in close proximity to railroad infrastructures. Yellow, orange and red colored counties exhibit intermediate preconditions for synergy utilization (for details, cf. Section 4.2.5).

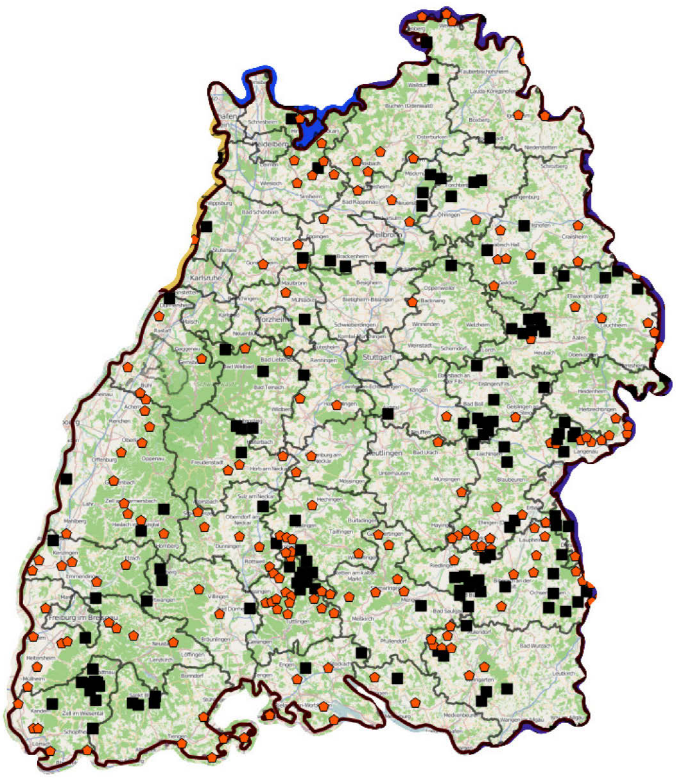


[Google Earth 2014]

<= 5%	>5% & <=25%	>25% & <=45%	>45% & <=65%	> 65%
Percentage of all rural communities in a county that exhibit a shorter fiber cable trench length to the next railroad than to the next DTAG central office				

Table 6-3: Geographic preconditions for improving rural broadband deployment with railroad infrastructures

The subsequent tables depict the geographic preconditions for aggregating rural broadband demand. The results are presented on a federal state level[14] and list the top 10 counties with favorable preconditions for synergy utilization in a decreasing order by synergy density (cf. Section 4.2.5). Orange labels indicate the position of a rural community, which is associated with an optimized network topology that originates at a railroad. Similarly, black labels indicated the position of rural communities, which are associated with an optimized network topology that originates at a Deutsche Telekom fiber backbone.



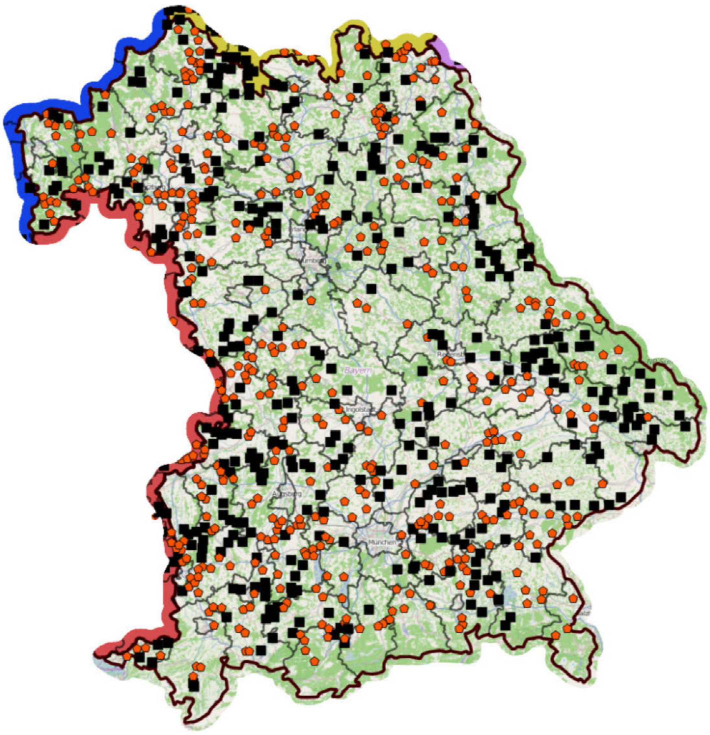
[OpenStreetMap 2014]

Community in Railroad network — Community in DTAG network

Top 10 counties by percentage of rural communities in an optimized network topology that originates at a railroad
Böblingen
Heidenheim
Reutlingen
Tübingen
Sigmaringen
Emmendingen
Rottweil
Breisgau-Hochschwarzwald
Rastatt
Ortenaukreis

Table 6-4: Geographic preconditions for synergy utilization in Baden-Württemberg

[14] Only federal states where more than 5% of all rural communities exhibit a shorter fiber cable trench length to the next railroad than to the next Deutsche Telekom infrastructure are depicted [cf. Table 6-3]

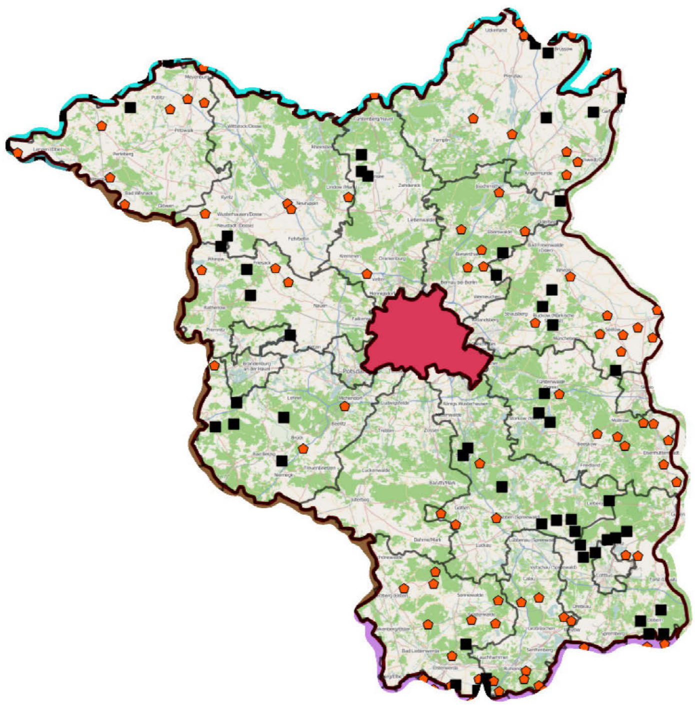


[OpenStreetMap 2014]

⬟ Community in Railroad network ■ Community in DTAG network

Top 10 counties by percentage of rural communities in an optimized network topology that originates at a railroad
Lichtenfels
Dingolfing-Landau
Miesbach
Berchtesgadener Land
Starnberg
Dachau
Garmisch-Partenkirchen
Altötting
Pfaffenhofen a.d.Ilm
Cham

Table 6-5: Geographic preconditions for synergy utilization in Bavaria



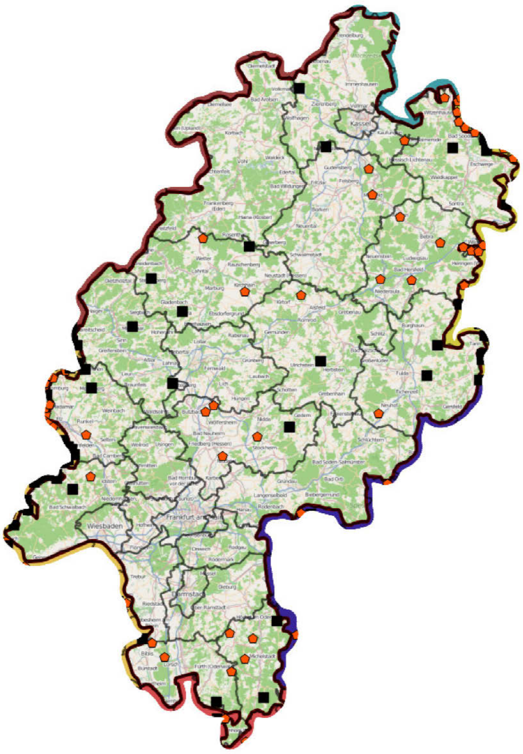
[OpenStreetMap 2014]

Community in Railroad network

Community in DTAG network

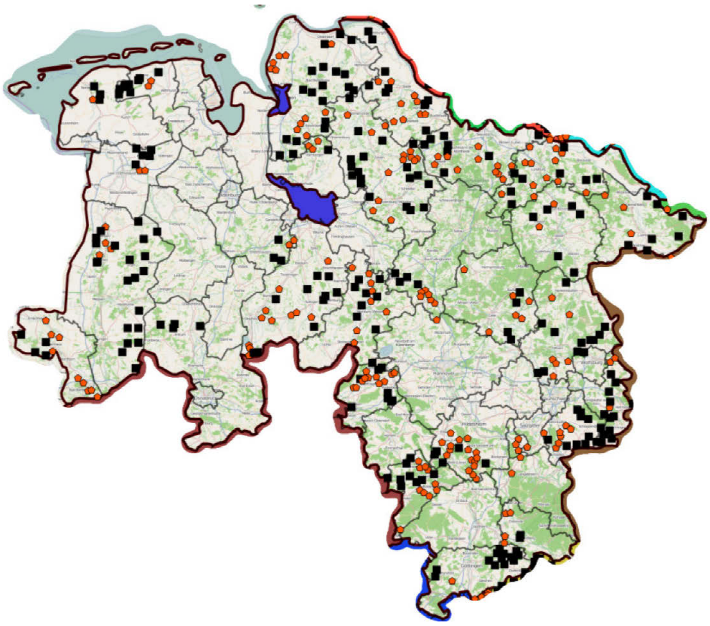
Top 10 counties by percentage of rural communities in an optimized network topology that originates at a railroad
Prignitz
Ostprignitz-Ruppin
Elbe-Elster
Barnim
Oberspreewald-Lausitz
Oder-Spree
Märkisch-Oderland
Havelland
Uckermark
Potsdam-Mittelmark

Table 6-6: Geographic preconditions for synergy utilization in Brandenburg

<table>
<tr><td rowspan="11">
[OpenStreetMap 2014]

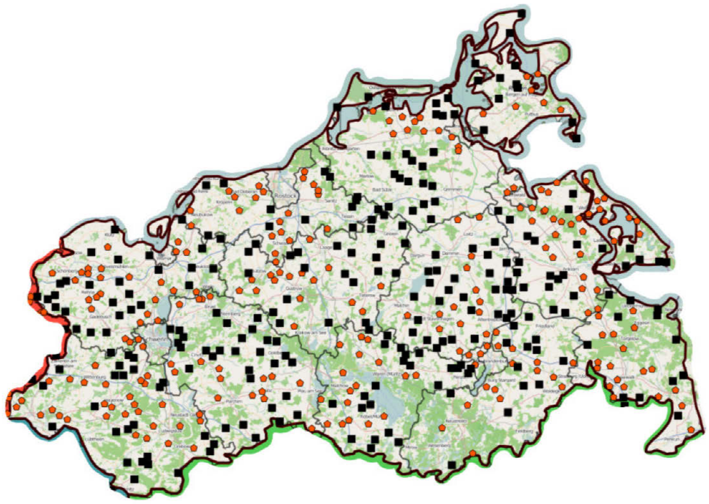
Community in Railroad network   Community in DTAG network</td><td>Top 10 counties by percentage of rural communities in an optimized network topology that originates at a railroad</td></tr>
<tr><td>Hersfeld-Rotenburg</td></tr>
<tr><td>Wetteraukreis</td></tr>
<tr><td>Bergstraße</td></tr>
<tr><td>Schwalm-Eder-Kreis</td></tr>
<tr><td>Odenwaldkreis</td></tr>
<tr><td>Kassel</td></tr>
<tr><td>Werra-Meißner-Kreis</td></tr>
<tr><td>Vogelsbergkreis</td></tr>
<tr><td>Rheingau-Taunus-Kreis</td></tr>
<tr><td>Marburg-Biedenkopf</td></tr>
</table>

Table 6-7: Geographic preconditions for synergy utilization in Hesse

<table>
<tr><td rowspan="11">
[OpenStreetMap 2014]

Community in Railroad network   Community in DTAG network</td><td>Top 10 counties by percentage of rural communities in an optimized network topology that originates at a railroad</td></tr>
<tr><td>Goslar</td></tr>
<tr><td>Hildesheim</td></tr>
<tr><td>Osterholz</td></tr>
<tr><td>Grafschaft Bentheim</td></tr>
<tr><td>Soltau-Fallingbostel</td></tr>
<tr><td>Lüneburg</td></tr>
<tr><td>Osterode am Harz</td></tr>
<tr><td>Celle</td></tr>
<tr><td>Harburg</td></tr>
<tr><td>Schaumburg</td></tr>
</table>

Table 6-8: Geographic preconditions for synergy utilization in Lower Saxony



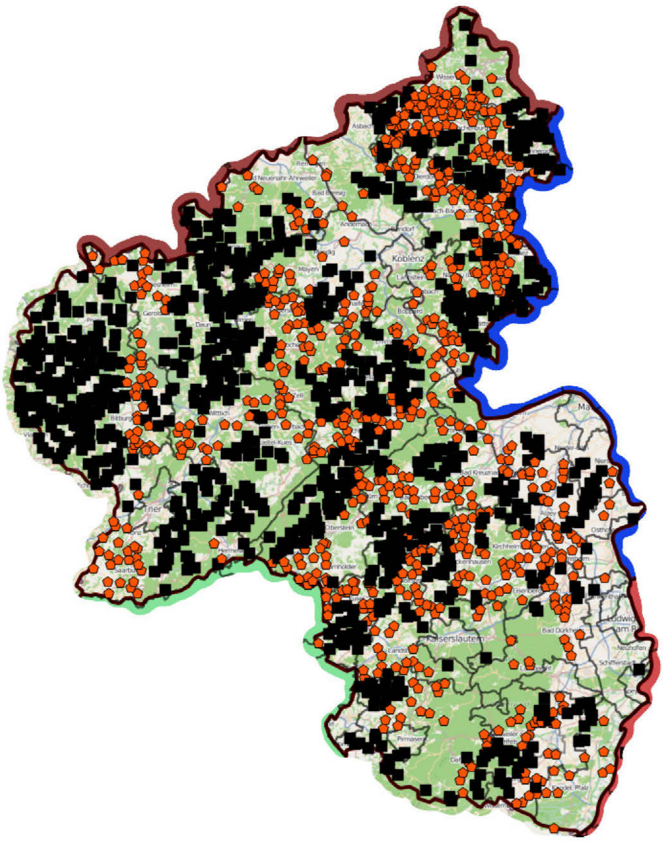
[OpenStreetMap 2014]

Top 10 counties by percentage of rural communities in an optimized network topology that originates at a railroad
Uecker-Randow
Mecklenburg-Strelitz
Bad Doberan
Ostvorpommern
Ludwigslust
Nordwestmecklenburg
Müritz
Güstrow
Parchim
Rügen

Community in Railroad network

Community in DTAG network

Table 6-9: Geographic preconditions for synergy utilization in Mecklenburg-Vorpommern



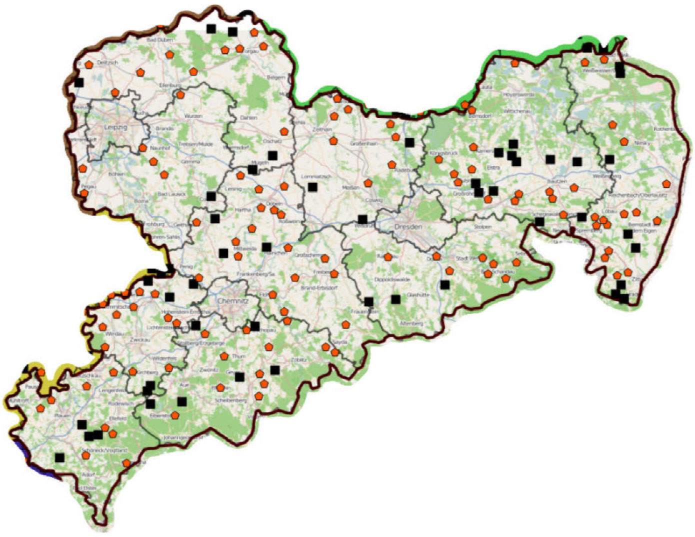
[OpenStreetMap 2014]

Community in Railroad network

Community in DTAG network

Top 10 counties by percentage of rural communities in an optimized network topology that originates at a railroad
Bad Dürkheim
Donnersbergkreis
Kaiserslautern
Altenkirchen (Westerwald)
Germersheim
Westerwaldkreis
Alzey-Worms
Cochem-Zell
Mayen-Koblenz
Südliche Weinstraße

Table 6-10: Geographic preconditions for synergy utilization in Rhineland-Palatinate



[OpenStreetMap 2014]

Community in Railroad network

Community in DTAG network

Top 10 counties by percentage of rural communities in an optimized network topology that originates at a railroad
Landkreis Leipzig
Landkreis Meißen
Sächsische Schweiz-Osterzgebirge
Vogtlandkreis
Nordsachsen
Landkreis Zwickau
Erzgebirgskreis
Landkreis Görlitz
Landkreis Bautzen
Landkreis Bad Dürkheim

Table 6-11: Geographic preconditions for synergy utilization in Saxony

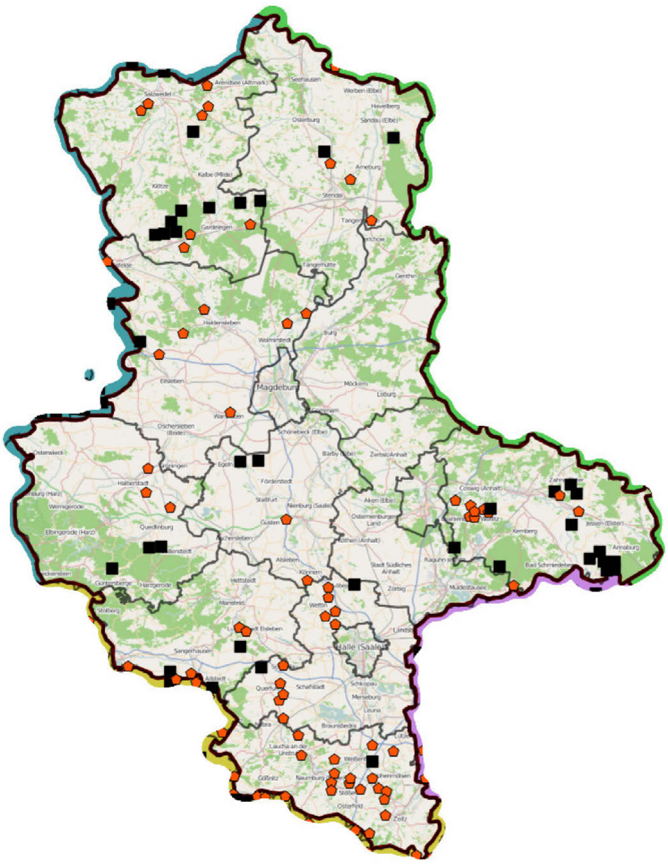
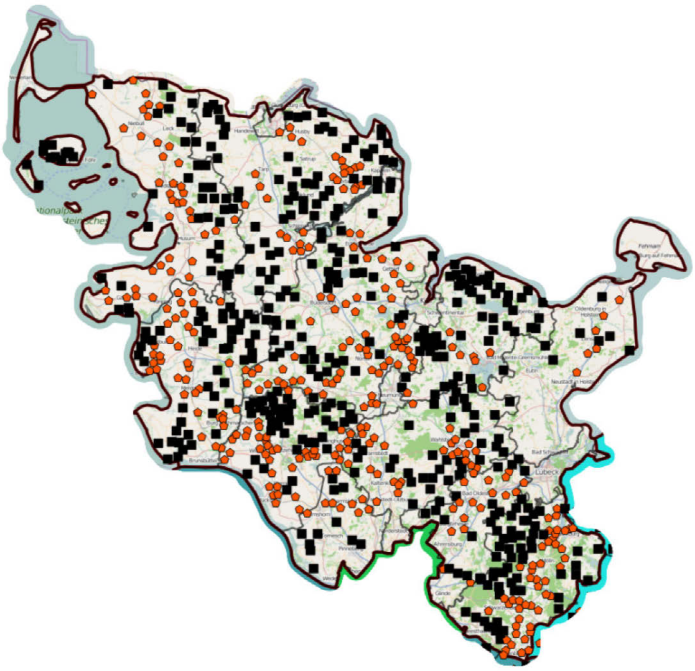
<table>
<tr><td rowspan="10">
[OpenStreetMap 2014]
Community in Railroad network
Community in DTAG network</td><td>Top 9 counties by percentage of rural communities in an optimized network topology that originates at a railroad</td></tr>
<tr><td>Burgenlandkreis</td></tr>
<tr><td>Börde</td></tr>
<tr><td>Saalekreis</td></tr>
<tr><td>Mansfeld-Südharz</td></tr>
<tr><td>Stendal</td></tr>
<tr><td>Harz</td></tr>
<tr><td>Altmarkkreis Salzwedel</td></tr>
<tr><td>Wittenberg</td></tr>
<tr><td>Salzlandkreis</td></tr>
</table>

Table 6-12: Geographic preconditions for synergy utilization in Saxony-Anhalt



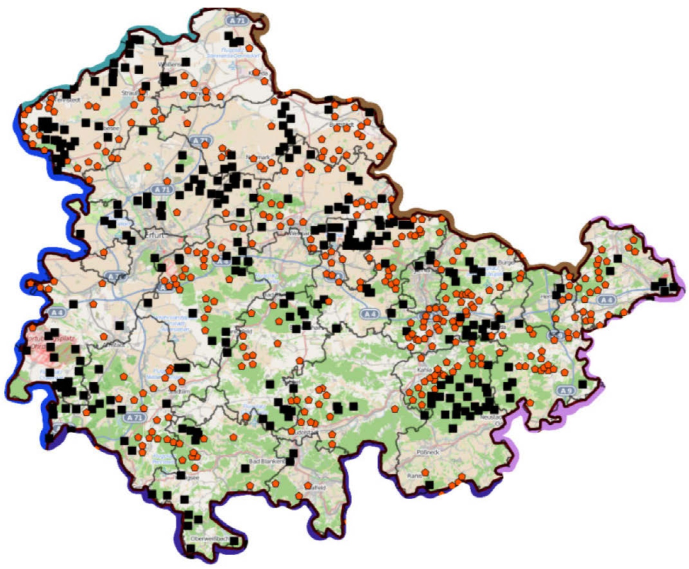
[OpenStreetMap 2014]

Community in Railroad network

Community in DTAG network

Top 10 counties by percentage of rural communities in an optimized network topology that originates at a railroad
Rendsburg-Eckernförde
Stormarn
Ostholstein
Steinburg
Pinneberg
Herzogtum Lauenburg
Nordfriesland
Segeberg
Dithmarschen
Schleswig-Flensburg

Table 6-13: Geographic preconditions for synergy utilization in Schleswig-Holstein



[OpenStreetMap 2014]

Community in Railroad network

Community in DTAG network

Top 10 counties by percentage of rural communities in an optimized network topology that originates at a railroad
Saalfeld-Rudolstadt
Altenburger Land
Greiz
Kyffhäuserkreis
Saale-Holzland-Kreis
Sömmerda
Sonneberg
Nordhausen
Saale-Orla-Kreis
Schmalkalden-Meiningen

Table 6-14: Geographic preconditions for synergy utilization in Thuringia

6.1.4. Supplementary material for the CDN business model analysis

Name	Business Model	Number of Transit connections 2011	Name	Business Model	Number of Transit connections 2011
Akamai	Classic	53	Mirror image	White Label	1
Amazon.com	Classic	34	NTT	Inhouse	10
AT&T	Inhouse	18	Orange France	Inhouse	16
BitGravity, Inc.	Classic	46	PCCW Global	Inhouse	8
British telecom	Inhouse	45	Savvis	Classic	24
CacheFly	Classic	28	TeliaSonera	Inhouse	18
CDNetworks	Classic	71	Telstra International	Inhouse	34
ChinaCache	Classic	22	Velocix	White Label	1
Cotendo	Classic	13	Verizon Business	Inhouse	1
EdgeCast	White Label	67	Voxel dot Net, Inc.	Classic	49
Fastweb	Classic	37	ISP that have announced CDNs		
Highwinds	Classic	53	Bell Canada	ISP	20
Internap	White Label	45	Deutsche Telekom	ISP	1
KPN	Inhouse	3	France Telecom	ISP	6
Level 3	Classic	17	Telecom Italia	ISP	11
Limelight Networks	Classic	11	Telefonica	ISP	63

Table 6-15: Commercial providers of the current CDN market

6.1.5. Complete list of publications

Title	Authors	Journal/Conference	Reference
Analysis of QoS platform cooperation strategies	Wulf, J., Limbach, F. and Zarnekow, R.	21th European Regional Conference of the International Telecommunications Society, 2010	[Wulf et al. 2010c]
Revenue distribution in a quality-centric Internet interconnection market	Limbach, F., Wulf, J., Zarnekow, R. and Düser, M.	17th Americas Conference on Information Systems (AMCIS), 2011	[Limbach et al. 2011a]
A typology of cooperation strategies in the telecommunications industry – An exploratory analysis and theoretical foundations	Limbach, F., Wulf, J., Zarnekow, R., Düser, M.	22nd European Regional ITS Conference Budapest, 2011	[Limbach et al. 2011b]
Kooperationstreiber in der Telekommunikationswirtschaft	Limbach, F., Wulf, J., Zarnekow, R., Düser, M.	4th Workshop on Services, Platforms, Innovations and Research for new Infrastructures in Telecommunications (SPIRIT 2011) auf der INFORMATIK, 2011	[Limbach et al. 2011c]
Economics of a Quality-of-Service interconnection market - A simulation-based analysis of a market scenario	Wulf, J., Limbach, F., Zarnekow, R. and Düser, M.	International Conference on Information Systems (ICIS 2011), Shanghai, 2011	[Wulf et al. 2011]
Wettbewerb und Kooperation im Content Delivery Markt.	Limbach, F., Wulf, J., Zarnekow, R. and Düser, M.	Proceedings of Multikonferenz Wirtschaftsinformatik (MKWI 2012, Braunschweig)	[Limbach et al. 2012a]
Business models and competition in the content delivery network market – An infrastructure analysis	Limbach, F., Wulf, J., Zarnekow, R. and Düser, M.	Proceedings of the 20th European Conference on Information Systems (ECIS)	[Limbach et al. 2012b]
Co-opetition in next-generation access provisioning: An analysis of the German broadband market	Limbach, F., Wulf, J., Zarnekow, R. and Düser, M.	23nd European Regional ITS Conference Vienna, 1-4 July 2012	[Limbach et al. 2012c]
Cooperative private Next-Generation Access deployment – A relational view	Limbach, F., Zarnekow, R. and Düser, M.	Proceedings of the 46th Hawaii International Conference on System Sciences (HICSS)	[Limbach et al. 2013a]
Towards Cross-Industry Information Infrastructure Provisioning - A Resource-Based Perspective	Limbach, F., Kübel, H., Zarnekow, R. and Düser, M. (2013)	17th International Conference on Intelligence in Next Generation Networks (IEEE ICIN 2013, Venice, Italy)	[Limbach et al. 2013b]
Kooperativer Breitbandausbau in Deutschland : Eine Expertenbefragung unter Unternehmensführern und Kooperationsverantwortlichen der deutschen Telekommunikationsbranche	Limbach, F., Kübel, H. and Zarnekow, R. (2013)	Research Papers in Information Systems Management	[Limbach et al. 2013c]

Shared Domain Knowledge in Strategic Green IS Alignment: An Analysis from the Knowledge-Based View	Löser, F., Erek, K., Zarnekow, R. and Limbach, F. (2013).	Proceedings of the 46th Hawaii International Conference on System Sciences (HICSS), 3515-3524.	[Löser et al. 2013]
Topics and Applied Theories in IT Service Management	Pröhl, T., Erek, K., Limbach, F. and Zarnekow, R. (2013)	Proceedings of the 46th Annual Hawaii International Conference on System Sciences [01/07-10/2013]. Computer Society Press, 1367-1375.	[Pröhl et al. 2013]
Business Models of Developer Platforms in the Telecommunications Industry – an Explorative Case Study Analysis	Kübel, H., Limbach, F. and Zarnekow, R. (2014)	Proceedings of the 46th Hawaii International Conference on System Sciences (HICSS), 3919-3928	[Kübel et al. 2014]
Cooperative next-generation access provisioning – Evidence from the German broadband market	Limbach, F. and Zarnekow, R. (2014)	Proceedings of the Multikonferenz Wirtschaftsinformatik, Paderborn (MKWI 2014)	[Limbach/Zarnekow 2014]
An Empirical Contingency Perspective on Cooperative Municipal Broadband Adoption	Limbach, F., Kübel, H. and Zarnekow, R. (2014)	Proceedings of the International Conference on Information Systems (AMCIS 2014)	[Limbach et al. 2014a]
Improving rural broadband deployment with synergistic effects between multiple fixed infrastructures	Limbach, F., Kübel, H. and Zarnekow, R. (2014)	Under review Telecommunication Policy 2014	[Limbach et al. 2014b]
Cooperative service provisioning with OTT service providers – An explorative analysis of telecommunication business models	Limbach, F. (2014)	Proceedings of the 2014 ITS European Regional Conference	[Limbach 2014]

Table 6-16: Complete list of publications

References

[Abdallah/Wadhwa 2009]

Abdallah, F., Wadhwa, A. (2009): Collaborating with your rivals: Identifying sources of coopetitive performance, DRUID Conference 2009, Copenhagen, Denmark.

[Acquisti/Gross 2006]

Acquisti, A., Gross, R. (2006): Imagined Communities: Awareness, Information Sharing, and Privacy on the Facebook, Privacy enhancing technologies: Springer, Berlin Heidelberg, Germany, pp. 36-58.

[Adobe Labs 2011]

Adobe Labs (2011): Cirrus - Use RTMFP for developing real-time collaboration applications, http://labs.adobe.com/technologies/cirrus/, retrieved 2011-12-21.

[Aidi et al. 2012]

Aidi, L., Markendahl, J., Tollmar, K., Blennerud, G. (2012): Competing or Aligning? Assessment for Telecom Operator's strategy to address OTT TV/Video Services, 19th International Telecommunication Society (ITS) Biennial Conference, Bangkok, Thailand.

[Akamai 2013]

Akamai (2013): Akamai Introduces New Elements to Aura Network Solutions Family, http://www.akamai.com/html/about/press/releases/2013/press_052913.html, retrieved 2013-01-28.

[Amazon CloudFrontCDN 2014]

Amazon CloudFrontCDN (2014): AWS | Amazon CloudFront CDN Netzwerk für die Bereitstellung von Inhalten und Streaming, http://aws.amazon.com/de/cloudfront/, retrieved 2013-11-28.

[Amit/Zott 2001]

Amit, R., Zott, C. (2001): Value Creation in E-Business, Strategic Management Journal, 22(6-7), pp. 493-520.

[Analysys Mason 2008]

Analysys Mason (2008): The costs of deploying fibre-based next-generation broadband infrastructure, Final report for the Broadband Stakeholder Group Ref:12726-37, http://www.analysysmason.com/PageFiles/5766/Analysys-Mason-final-report-for-BSG-(Sept2008).pdf, retrieved 2014-11-25.

[Analysys Mason 2011]

Analysys Mason (2011): Public Report - Overview of recent changes in the IP interconnection ecosystem, http://www.analysysmason.com/About-Us/News/Insight/Insight_Internet_connection_Jun2011/Related-report-download/, retrieved 2014-07-12.

[Andrews 1997]

Andrews, K.R. (1997): The Concept of Corporate Strategy, In: Foss, N. J. (Ed.), Resources, firms, and strategies: a reader in the resource-based perspective, Oxford University Press, Oxford, UK, pp. 52-59.

[AT&T 2014a]

AT&T (2014): AT&T Introduces Sponsored Data for Mobile Data Subscribers and Businesses, http://www.att.com/gen/press-room?pid=25183, retrieved 2014-02-05.

[AT&T 2014b]

AT&T (2014): AT&T Apis | Build Speech, Messaging, & Payment into Your Mobile App, from https://developer.att.com/apis, retrieved 2014-03-25.

[Bae/Gargiulo 2004]

Bae, J., Gargiulo, M. (2004): Partner Substitutability, Alliance Network Structure, and Firm Profitability in the Telecommunications Industry, The Academy of Management Journal, 47(6), pp. 843-859.

[Bakos/Barrie 1997]

Bakos, J.Y., Barrie, N. (1997): Ownership and Investment in Electronics Networks, Information System Research, 8(4), pp. 321-341.

[Bakos/Brynjolfsson 1999]

Bakos, Y., Brynjolfsson, E. (1999): Bundling Information Goods: Pricing, Profits, and Efficiency, Management Science, 45(12), pp. 1613-1630.

[Bango 2012]

Bango (2012): Bango Launches Billing on Google Play, http://news.bango.com/2012/12/10/bango-launches-billing-on-google-play/, retrieved 2014-02-18.

[Barney 1991]

Barney, J. (1991): Firm resources and sustained competitive advantage, Journal of Management, 17(1), pp. 99-120.

[Bask et al. 2010]

Bask, A.H., Tinnilä, M., Rajahonka, M. (2010): Matching Service Strategies, Business Models and Modular Business Processes, Business Process Management Journal 16(1), pp. 153-180.

[Bauer 2010]

Bauer, J.M. (2010): Regulation, public policy, and investment in communications infrastructure, Telecommunications Policy, 34(1-2), pp. 65-79.

[BBB 2014]

Breitbandbüro des Bundes (2014): Breitband-Ausschreibungen, https://www.breitbandausschreibungen.de/publicOverview, retrieved 2014-09-12.

[Beltrán 2012]

Beltrán, F. (2012): Using the economics of platforms to understand the broadband-based market formation in the New Zealand Ultra-Fast Broadband Network, Telecommunications Policy, 36(9), pp. 724-735.

[Benbasat et al. 1987]

Benbasat, I., Goldstein, D.K., Mead, M. (1987): The case research strategy in studies of information systems, MIS Quarterly, pp. 369-386.

[Benbasat/Zmud 2003]

Benbasat, I., Zmud, R.W. (2003): The identity crisis within the IS discipline: Defining and communicating the discipline's core properties, MIS Quarterly, 27(2), pp. 183-194.

[BEREC 2010]

Body of European Regulators for Electronic Communications (2010): Next Generation Access – Implementation Issues and Wholesale Products (BoR (10) 08), BEREC Report, http://berec.europa.eu/eng/document_register/subject_matter/berec/reports/169-next-generation-access-implementation-issues-and-wholesale-products, retrieved 2013-01-31.

[BEREC 2012a]

Body of European Regulators for Electronic Communications (2012): Revised BEREC Common Position on Best Practice in Remedies on the Market for Wholesale Broadband Access (Including Bitstream Access) imposed as a Consequence of a Position of significant Market Power in the relevant Market (BoR (12) 128), , BEREC Report, http://berec.europa.eu/eng/document_register/subject_matter/berec/regulatory_best_practices/common_approaches_positions/1126-revised-berec-common-position-on-best-practice-in-remedies-on-the-market-for-wholesale-broadband-access-including-bitstream-access-imposed-as-a-consequence-of-a-position-of-significant-market-power-in-the-relevant-market, retrieved 2012-02-04.

[BEREC 2012b]

Body of European Regulators for Electronic Communications (2012): BEREC report on Co-investment and SMP in NGA networks (BoR (12) 41), http://berec.europa.eu/files/document_register/2012/8/bor_12_41.pdf, retrieved 2014-06-05.

[BEREC 2014]

Body of European Regulators for Electronic Communications (2014): BEREC report on the public consultation of the Draft review of the BEREC Common Position on geographical aspects of market analysis (definition and remedies), http://berec.europa.eu/eng/document_register/subject_matter/berec/download/0/4440-berec-report-on-the-public-consultation-_0.pdf, retrieved 2014-22-24.

[Bertin et al. 2011]

Bertin, E., Crespi, N., L'Hostis, M. (2011): A few myths about Telco and OTT models, 15th International Conference on Intelligence in Next Generation Networks (ICIN), Berlin, Germany, pp. 6-10.

[BITKOM 2014]

Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e.V. (2014): Presseinformation - Markt für Cloud Computing wächst ungebrochen, BITKOM Report, http://www.bitkom.org/files/documents/BITKOM_Presseinfo_Cloud-Markt_B2B_05_11_2014.pdf, retrieved 2014-10-20.

[BMVI 2014]
Bundesministerium für Verkehr und digitale Infrastruktur (2014): Kursbuch Netzausbau, BMVI Report, http://www.bmvi.de/SharedDocs/DE/Publikationen/Digitales/kursbuch-netzausbau.pdf?__blob=publicationFile, retrieved 2014-10-09.

[BMWi 2009]
Bundesministerium für Wirtschaft und Energie (2009): Breitbandstrategie der Bundesregierung, BMWi Report, http://www.bmwi.de/DE/Mediathek/publikationen,did=290012.html, retrieved 2012-09-13.

[BMWi 2014]
Bundesministerium für Wirtschaft und Energie (2014): Breitbandatlas, http://www.zukunft-breitband.de/DE/breitbandatlas.html, retrieved 2014-02-20.

[Bouckaert et al. 2010]
Bouckaert, J., van Dijk, T., Verboven, F., (2010): Access regulation, competition, and broadband penetration: An international study, Telecommunications Policy, 34(11), pp. 661-671.

[Bouras et al. 2009]
Bouras, C., Gkamas, A., Papagiannopoulos, J., Theophilopoulos, G., Tsiatsos, T. (2009): Broadband municipal optical networks in Greece: A suitable business model, Telematics and Informatics, 26(4), pp. 391-409.

[Bourreau et al. 2010]
Bourreau, M., Doğan, P., Manant, M. (2010): A critical review of the “ladder of investment” approach, Telecommunications Policy, 34(11), pp. 683-696.

[Briegleb 2008]
Briegleb, V. (2008): Arcor testet VDSL in Thüringer Gemeinde, http://www.heise.de/netze/meldung/Arcor-testet-VDSL-in-Thueringer-Gemeinde-217119.html, retrieved 2014-07-12.

[Bucklin/Sengupta 1993]
Bucklin, L.P., Sengupta, S. (1993): Organizing Successful Co-Marketing Alliances, Journal of Marketing, 57(2), pp.32-46.

[Budde 2012]
Budde, O. (2012): Produktlebenszyklusmodell für die Telekommunikationswirtschaft, 1st ed., Apprimus Verlag, Aachen, Germany.

[Bundeskartellamt 2010]
Bundeskartellamt (2010): Hinweise zur wettbewerbsrechtlichen Bewertung von Kooperationen beim Glasfaserausbau in Deutschland, Bundeskartellamt Report, http://www.bundeskartellamt.de/wDeutsch/download/pdf/Stellungnahmen/100119Hinweise_Breitbandkooperation.pdf, retrieved 2013-08-28.

[Bundeskartellamt 2013a]
Bundeskartellamt (2013): Jahresbericht 2013, Bundeskartellamt Report, http://www.bundeskartellamt.de/SharedDocs/Publikation/DE/Jahresbericht/Jahresbericht_2013.pdf?__blob=publicationFile&v=7, retrieved 2014-11-24.

[Bundeskartellamt 2013b]
Bundeskartellamt (2013): Untersagung des Erwerbs der Tele Columbus durch die Kabel Deutschland, htttp://www.bundeskartellamt.de/SharedDocs/Entscheidung/DE/Fallberichte/Fusionskontrolle/2013/B7-70-12.pdf?__blob=publicationFile&v=4, retrieved 2014-11-24.

[Bundesnetzagentur 2013a]
Bundesnetzagentur (2013): Tätigkeitsbericht Telekommunikation 2012/2013, Bundesnetzagentur Report, http://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Allgemeines/Bundesnetzagentur/Publikationen/Berichte/2013/131216_TaetigkeitsberichtTelekommunikation2012-2013.pdf?__blob=publicationFile, retrieved 2014-01-17.

[Bundesnetzagentur 2013b]
Bundesnetzagentur (2013): Genehmigung von Entgelten für den Zugang zur Teilnehmeranschlussleitung (monatliche Überlassungsentgelte), BK 3c-13/002, Beschlusskammer 3 der Bundesnetzagentur. http://beschlussdatenbank.bundesnetzagentur.de/index.php?lr=view_bk_overview&getfile=1&file=5929, retrieved 2014-03-12.

[Bundesnetzagentur 2014]
Bundesnetzagentur (2014): Konsultationsentwurf für Massenmarktprodukte auf der Vorleistungsebene an festen Standorten zentral bereitgestellter Zugang, BK 1-14/001, Bundesnetzagentur Report, http://www.bundesnetzagentur.de/DE/Service-Funktionen/Beschlusskammern/1BK-Geschaeftszeichen-Datenbank/BK1-GZ/2014/2014_001bis100/BK1-14-001/Konsultationsentwurf_bf.pdf?__blob=publicationFile&v=2, retrieved 2014-11-14.

[Buyya et al. 2008]
Buyya, R., Pathan, M., Vakali, A. (2008): Content delivery networks: Perspectives, design and prospects, Springer, Berlin, Germany.

[Bygstadt et al. 2007]
Bygstad, B., Lanestedt, G., Choudrie, J. (2007): Successful Broadband Projects in the Public Sector - a Service Innovation Perspective, In Proceedings of the 40th Hawaii International Conference on System Sciences (HICSS), Waikoloa, Hawaii, pp.103-109.

[CAIDA 2011]
Center for Applied Internet Data Analysis (2011): The CAIDA AS Relationships Dataset, http://www.caida.org/data/active/as-relationships/, retrieved 2011-11-22.

[Camponovo/Pigneur 2003]
Camponovo, G., Pigneur, Y. (2003): Business Model Analysis Applied to Mobile Business, 5th International Conference On Enterprise Information Systems (ICEIS), Angers, France.

[Carter et al. 2011]
Carter, K.C., Elixmann, D., Marcus, J.S. (2011): Unternehmensstrategische und regulatorische

Aspekte von Kooperationen beim NGA-Breitbandausbau (WIK Diskussionsbeitrag 356), WIK, Bad Honnef, Germany.

[Cave 2006]
Cave, M. (2006): Encouraging infrastructure competition via the ladder of investment, Telecommunications Policy, 30(3), pp. 223-237.

[Cave 2014]
Cave, M. (2014): The ladder of investment in Europe, in retrospect and prospect, Telecommunications Policy, 38(8-9), pp. 674-683.

[Cave et al. 2006]
Cave, M.E., Prosperetti, L., Doyle, C. (2006): Where are we going? Technologies, markets and long-range public policy issues in European communications, Information Economics and Policy, 18(3), pp. 242–255.

[Chandler 1962]
Chandler, A.D. (1962): Strategy and Structure - Chapters in the History of the Industrial Enterprise, MIT Press, Cambridge, USA.

[Chatzi et al. 2013]
Chatzi S., Lazaro, J.A., Prat, J., Tomkos, I. (2013): A techno-economic study on the outside plant cost of current and next-generation Fiber-to-the-X deployments, Fiber and Integrated Optics, 32(1), pp. 12-27.

[Child/Faulkner 1998]
Child, J., Faulkner D. (1998): Strategies of Cooperation. Managing Alliances, Networks, and Joint Ventures, 1st ed., Oxford University Press, Oxford, UK.

[Choudrie et al. 2004]
Choudrie, J., Papazafeiropoulou, A., Light, B. (2004): E-Government Policies for Broadband Adoption: The Case of the UK Government, In Proceedings of the 10th Americas Conference on Information Systems 2004 (AMCIS), New York, USA, Paper 135.

[Christofides 1975]
Christofides, N. (1975): Graph theory: An algorithmic approach, Academic Press, London, UK.

[Cisco 2014]
Cisco (2014): The Zettabyte Era: Trends and Analysis, Cisco Report, http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/VNI_Hyperconnectivity_WP.pdf, retrieved 2014-01-17.

[Combs/Ketchen 1999]
Combs, J.G., Ketchen, D.J. (1999): Explaining interfirm cooperation and performance: toward a reconciliation of predictions from the resource-based view and organizational economics, Strategic Management Journal, 20(9), pp. 867-888.

[Corbin/Strauss 2008]
Corbin, J., Strauss, A. (2008): Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory, 3rd ed, Sage Publications, Los Angeles, USA.

[Czernich et al. 2011]

Czernich, N., Falck, O., Kretschmer, T., Woessmann, L. (2011): Broadband Infrastructure and Economic Growth, The Economic Journal, 121(552), pp. 505-532.

[Datta/Agarwal 2004]

Datta, A., Agarwal, S. (2004): Telecommunications and economic growth: a panel data approach, Applied Economics, 36(15), pp. 1649-1654.

[DeveloperGarden 2014]

DeveloperGarden (2014): Apis and Developer Services | Developer Garden Deutsche Telekom, from https://www.developergarden.com, retrieved 2014-03-26.

[Dialog Consult/VATM 2014]

Dialog Consult, VATM (2014): 16. TK-Marktanalyse Deutschland 2014, Dialog Consult Report, http://www.vatm.de/fileadmin/publikationen/studien/2014/marktstudie-2014.pdf, retrieved 2014-01-17.

[Dimitropoulos et al. 2007]

Dimitropoulos, X., Krioukov, D., Fomenkov, M., Huffaker, B., Hyun, Y., Riley, G., Claffy, K.C. (2007): AS relationships: Inference and Validation, ACM SIGCOMM Computer Communication Review, 37(1), pp. 29–40.

[Dippon/Train 2000]

Dippon, C.M., Train, K.E. (2000): The cost of the local telecommunication network: A comparison of minimum spanning trees and the HAI model, Telecommunications Policy, 24(3), pp. 253-262.

[Distaso et al. 2006]

Distaso, W., Lupi, P., Manenti, F.M. (2006): Platform Competition and Broadband Uptake: Theory and Empirical Evidence from the European Union, Information Economics and Policy, 18(1), pp. 87–106.

[Dowling et al. 1996]

Dowling, M.J., Roering, W.D., Carlin, B.A., Wisnieski, J. (1996): Multifaceted relationships under coopetition, Journal of Management Inquiry, 5(2), pp. 155–167.

[DSLWeb 2014]

DSLWeb (2014): DSL Geschwindigkeit - wie schnell surft Deutschland wirklich?, Ehninger AG, http://www.dslweb.de/impressum.htm, retrieved 2014-03-01.

[Dubé/Paré 2003]

Dubé, L., Paré, G. (2003): Rigor in Information Systems Positivist Case Research: Current Practices, Trends and Recommendations, MIS Quarterly, 27(4), pp. 597-635.

[Dyer/Singh 1998]

Dyer, J.H., Singh, H. (1998): The Relational View: Cooperative Strategy and Sources of Interorganizational Competitive Advantage, Academy of Management Review, 23(4), pp. 660-679.

[European Commission 2006]
European Commission (2006): Annex to the European electronic communications regulation and markets 2005: 11th Report (Commission staff working paper, Com 2006-68 final), European Commission, Brussels.

[European Commission 2009]
European Commission (2009): Community guidelines for the application of state aid rules in relation to rapid deployment of broadband networks, Official Journal of the European Union, C notification 2009/C 235/04 , http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52009XC0930(02)&from=en, retrieved 2012-10-02.

[European Commission 2010a]
European Commission (2010): A digital agenda for Europe, European Commission, Brussels, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0245:FIN:EN:PDF, retrieved 2013-09-02.

[European Commission 2010b]
European Commission (2010): Spain - Optical fibre Catalonia (Xarxa Oberta), State aid notification 407/2009 , European Commission, Brussels, http://ec.europa.eu/competition/state_aid/cases/232264/232264_1132944_78_1.pdf, retrieved 2014-05-12.

[European Commission 2011]
European Commission (2011): Broadband coverage in Europe in 2011 - Mapping progress towards the coverage objectives of the Digital Agenda, DG Communications Report, http://ec.europa.eu/digital-agenda/sites/digital-agenda/files/BCE%202011%20Research%20Report%20Final%20-%20Format%20No%20Image%2020121001.pdf, retrieved 2012-07-22.

[European Commission 2012a]
European Commission (2012): Italy –Bulgas – Fibersar – NGA Sardegna, State aid notification SA.34732 (2012/N), European Commission, Brussels, http://ec.europa.eu/competition/state_aid/cases/244582/244582_1390156_60_2.pdf, retrieved 2014-05-13.

[European Commission 2012b]
European Commission (2012): Support for the preparation of an impact assessment to accompany an EU initiative on reducing the cost of high-speed broadband infrastructure deployment, The Publications Office of the European Union, Luxembourg, http://ec.europa.eu/information_society/newsroom/cf/dae/document.cfm?doc_id=1877, retrieved 2014-08-13.

[European Commission 2012c]
European Commission (2012): Digital Agenda for Europe Scoreboard 2012, Publications Office of the European Union, Luxembourg, https://ec.europa.eu/digital-agenda/sites/digital-agenda/files/KKAH12001ENN-PDFWEB_1.pdf, retrieved 2014-01-23.

[European Commission 2013a]

European Commission (2013): Ireland – Next generation(backhaul) network(NGN) alongside a gas pipeline in Galway and Mayo, State aid notification SA.33656 (2012/NN), European Commission , Brussels, http://ec.europa.eu/competition/state_aid/cases/243213/243213_1504550_221_2.pdf, retrieved 2014-05-13.

[European Commission 2013b]

European Commission (2013): EU guidelines for the application of state aid rules in relation to the rapid deployment of broadband networks, Official Journal of the European Union, notification 2013/C 25/01 , http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2013:025:0001:0026:EN:PDF, retrieved 2014-05-13.

[European Commission 2013c]

European Commission (2013): Regulation of the European Parliament and of the council on measures to reduce the cost of deploying high-speed electronic communications networks European Commission Report 2013/0080, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0147:FIN:EN:PDF, retrieved 2014-01-13.

[Eisenhardt/Martin 2000]

Eisenhardt, K.M., Martin, J.A. (2000): Dynamic capabilities: what are they?, Strategic Management Journal, 21(10-11), pp. 1105-1121.

[Elixmann et al. 2010]

Elixmann, D., Ilic, D., Neumann, K.H., Plückebaum, T. (2010): The Economics of Next Generation Access - Final Report, WIK-Consult GmbH, Bad Honnef, Germany.

[E-Plus 2014]

E-Plus (2014): WhatsApp SIM Prepaid – kostenlos WhatsAppen, https://www.eplus.de/whatsapp/, retrieved 2014-03-19.

[Erek 2012]

Erek, K. (2012): Gestaltungsansätze und Handlungsempfehlungen für IT-Organisationen, Universitätsverlag TU Berlin, Berlin, Germany.

[Eskelinen et al. 2008]

Eskelinen, H., Frank, F., Hirvonen, T. (2009): Does strategy matter? A comparison of broadband rollout policies in Finland and Sweden, Telecommunications Policy, 32(6), pp. 412-421.

[Falch/Henten 2008]

Falch, M., Henten, A. (2008): Investment dimensions in a universal service perspective: next generation networks, alternative funding mechanisms and public-private partnerships, Info, 10(5-6), pp. 33-45.

[Falch/Henten 2010]

Falch, M., Henten, A. (2010): Public private partnerships as a tool for stimulating investments in broadband, Telecommunications Policy, 34(9), pp. 496-504.

[FCC 2010]

Federal Communications Commission (2010): Connecting America: The National Broadband Plan, Government Printing Office, Washington, DC, http://www.umic.pt/images/stories/publicacoes5/national-broadband-plan.pdf, retrieved 2014-02-20.

[FCC 2014]

Federal Communications Commission (2014): New Docket established to address open internet remand – FCC Notice GN docket No. 14-28), http://transition.fcc.gov/Daily_Releases/Daily_Business/2014/db0219/DA-14-211A1.pdf, retrieved 2014-04-12.

[Fettke/Loos 2005]

Fettke, P., Loos, P. (2005): Der Beitrag der Referenzmodellierung zum Business Engineering, HMD-Praxis der Wirtschaftsinformatik, 241, pp. 18-26.

[Fink/Wilfert 1999]

Fink, D., Wilfert, A. (1999): Handbuch Telekommunikation und Wirtschaft : volkswirtschaftliche und betriebswirtschaftliche Perspektiven, Vahlen, München.

[FixedOrbit 2011]

FixedOrbit (2011): The Internet from the inside out, http://fixedorbit.com, retrieved 2011-11-23.

[Fjeldstad/Haanaes 2001]

Fjeldstad, Ø.D., Haanaes, K. (2001): Strategy Tradeoffs in the Knowledge and Network Economy, Business Strategy Review, 12(1), pp. 1-10.

[Ford et al. 2011]

Ford, G., Koutsky, T., Spiwak, L. (2011): The Frontier of Broadband Adoption Across the OECD: A Comparison of Performance, International Economic Journal, 25(1), pp. 111-123.

[Foros 2004]

Foros, Ø. (2004): Strategic Investments with Spillovers, Vertical Integration and Foreclosure in the Broadband Access Market, International Journal of Industrial Organization, 22(1), pp. 1-24.

[Fransman 2002]

Fransman, M. (2002): Mapping the evolving telecoms industry: the uses and shortcomings of the layer model, Telecommunications Policy, 26(9-10), pp. 473-483.

[Fransman 2007]

Fransman, M. (2007): Innovation in the New ICT Ecosystem, Communications & Strategies, 68(4), pp. 89-110.

[Fredebeul-Krein/Knoben 2010]

Fredebeul-Krein, M., Knoben, W. (2010): Long term risk sharing contracts as an approach to establish public-private partnerships for investment into next generation access networks, Telecommunications Policy, 34(9), pp. 528-539.

[Frieden 2005]

Frieden, R. (2005): Lessons from broadband development in Canada, Japan, Korea and the United States, Telecommunication Policy, 29(8), pp. 595-613.

[Frigo et al. 2004]

Frigo, N.J., Iannone, P.P., Reichmann, K.C. (2004): A View of Fiber to the Home Economics, IEEE Communications Magazine, 42(8), pp. 16–23.

[FTTH Council Europe 2013]

FTTH Council Europe (2013): Annual report April 2012 - April 2013, FTTH Council Report, http://www.ftthcouncil.eu/documents/Publications/FTTHCouncil_AR2012_2013_Final.pdf, retrieved 2013-04-09.

[Gao 2001]

Gao, L. (2001): On inferring autonomous system relationships in the Internet, Transactions on Networking, 9(6), pp. 733–745.

[Garcia-Santillan et al. 2012]

Garcia-Santillan, A., Moreno-Garcia, E., Carlos-Castro, J., Zamudio-Abdala, J.H., Gardñno-Trejo, J. (2012): Cognitive, Affective and Behavioral Components That Explain Attitude toward Statistics, Journal of Mathematics Research, 4(5), pp 8-16.

[George/Bock 2011]

George, G., Bock, A.J. (2011): The Business Model in Practice and Its Implications for Entrepreneurship Research, Entrepreneurship Theory and Practice, 35(1), pp. 83-111.

[Gerpott 1998]

Gerpott, T.J. (1998): Wettbewerbsstrategien im Telekommunikationsmarkt, 3rd Ed., Schäffer-Poeschel: Stuttgart.

[Gerpott 2005]

Gerpott, T.J. (2005): Unternehmenskooperationen in der Telekommunikationswirtschaft, In J. Zentes, B. Swoboda, D. Morschett (Eds.). Kooperationen, Allianzen und Netzwerke: Grundlagen-Ansätze-Perspektiven, (2nd ed.), pp. 1087-1111. Wiesbaden: Gabler.

[Gerpott 2010]

Gerpott, T.J. (2010): Unternehmenskooperationen beim Bau und bei der Nutzung von Glasfaseranschlussnetzen, Medienwirtschaft, 7(4), pp. 10-23.

[Gholami et al. 2003]

Gholami, R., Lee, S.Y.T., Heshmati, A. (2003): The Casual Relationship Between Information and Communication Technology (ICT) and Foreign Direct Investment (FDI), In Proceedings of the 11th European Conference on Information Systems (ECIS), Naples, Italy, Paper 72.

[Gillett et al. 2004]

Gillett, S.E., Lehr, W.H., Osorio, C.A. (2004): Local government broadband initiatives, Telecommunications Policy, 28(7), pp. 537-558.

[Gillett et al. 2006]
Gillett, S.E., Lehr, W.H., Osorio, C.A. (2006): Municipal electric utilities' role in telecommunications services, Telecommunications Policy, 30(8), pp. 464-480.

[Giovannetti et al. 2005]
Giovannetti, E., Neuhoff, K., Spagnolo, G. (2005): Agglomeration in Internet Co-operation Peering Agreements, Cambridge Working Papers in Economics from Faculty of Economics, University of Cambridge.

[Girres/Touya 2010]
Girres, J. F., Touya, G. (2010): Quality assessment of the French OpenStreetMap dataset, Transactions in GIS, 14(4), pp. 435-459.

[Glaser 1992]
Glaser, B.G. (1992): Basics of Grounded Theory Analysis: Emergence vs. Forcing, Mill Valley, California: Sociology Press.

[Goldmedia/BMWi 2013]
Goldmedia GmbH Strategy Consulting, Bundesministerium für Wirtschaft und Technologie (2013): Dritter Monitoringbericht zur Breitbandstrategie der Bundesregierung, http://www.bmwi.de/Dateien/BMWi/PDF/dritter-monitoringbericht-zur-breitbandstrategie/, retrieved 2014-04-12.

[Gómez-Barroso et al. 2010]
Gómez-Barroso, J.L., Feijóo, C. (2010): Unveiling the intricate public-private interplay in next generation communications, Telecommunications Policy, 34(9), pp. 487-495.

[Google 2013]
Google (2013): Google Voice, http://www.google.com/googlevoice/sprint, retrieved 2014-01-30.

[Google 2014a]
Google (2014): Accepted payment & direct carrier billing methods, https://support.google.com/googleplay/answer/2651410?hl=en, retrieved 2014-02-16.

[Google 2014b]
Google (2014): Find a Premier Sme Partner to Help Grow Your Business – Google Adwords Premier Sme Partner Programme – Google Ads., http://www.google.co.uk/ads/premiersmbpartner/advertisers-findpartner.html#tab=partner-websites-bt-com, retrieved 2014-02-19.

[Google GGC 2014]
Google GGC (2014): Peering & Content Delivery, https://peering.google.com/about/getting_ggc.html, retrieved 2014-03-03.

[Google Earth 2014]
Google Earth (2014): Google Earth, https://earth.google.de, retrieved 2014-08-03.

[Gordon et al. 2006]
Gordon, M.D., Dakshinamoorthy, V., Wang, L. (2006): The Benefits, Innovations, and Uses of

Information and Communication Technology at the Base of the Pyramid, In Proceedings of the 27th International Conference on Information Systems (ICIS), Milwaukee, USA, Paper 103.

[Grant 1991]
Grant, R.M. (1991): The Resource-Based Theory of Competitive Advantage: Implications for Strategy Formulation, California Management Review, 33(3), pp. 114-135.

[Grant 1991]
Grant, R.M. (1991): Contemporary Strategy Analysis: concepts, techniques, applications, 5th. Edition. Oxford: Blackwell.

[Grove/Baumann 2012]
Grove, N., Baumann, O. (2012): Complexity in the Telecommunications Industry: When Integrating Infrastructure and Services Backfires, Telecommunications Policy, 36(1), pp. 40-50.

[Groves et al. 2004]
Groves, R.M., Fowler, F.J., Couper, M.P., Lepkowski, J.M., Singer, E., Tourangeau, R. (2004): Survey Methodology, Hoboken, NJ: Wiley-Interscience.

[Grubesic 2008]
Grubesic, T. H. (2008): Spatial data constraints: Implications for measuring broadband. Telecommunications Policy, 32(7), pp. 490-502.

[GSMA 2014]
GSMA (2014): Gsma | Oneapi, http://www.gsma.com/oneapi/GSMA, retrieved 2014-03-25.

[Guenach et al. 2011]
Guenach, M., Maes, J., Timmers, M., Lamparter, O., Bischoff, J., Peeters, M. (2011): Vectoring in DSL Systems: Practices and Challenges. Paper presented at the Global Communications Conference (GLOBECOM), Houston, Texas, USA, http://ieeexplore.ieee.org/iel5/6132211/6133457/06133821.pdf?arnumber=6133821, retrieved 2012-12-20.

[Gulatti 1999]
Gulati, R. (1999): Network location and learning: The influence of network resources and firm capabilities on alliance formation, Strategic Management Journal, 20(5), pp. 397-420.

[Gupta et al. 2011]
Gupta, A., Jukic, B., Stahl, D. O., Whinston, A.B. (2011): An Analysis of Incentives for Network Infrastructure Investment Under Different Pricing Strategies, Information Systems Research, 22(2), pp. 215-232.

[Haklay 2010]
Haklay, M. (2010): How good is volunteered geographical information? A comparative study of OpenStreetMap and ordnance survey datasets, Environment and Planning B: Planning & Design, 37(4), pp. 682-703.

[Halaweh et al. 2008]
Halaweh, M., Fidler, C., McRobb, S. (2008): Integrating the Grounded Theory Method and Case

Study Research Methodology Within IS Research: A Possible 'Road Map', In Proceedings of the 29th International Conference on Information Systems (ICIS), Paris, France, Paper 165.

[Hao et al. 1997]
Hao, Q., Soong, B., Gunawan, J., Ong, C.B., Li, Z. (1997): A low-cost cellular mobile communication system, IEEE Journal on Selected Areas in Communications, 15(7), pp. 1315-1326.

[Hau et al. 2011]
Hau, T., Burghardt, D., & Brenner, W. (2011): Multihoming, content delivery networks, and the market for Internet connectivity, Telecommunications Policy, 35(6), pp. 532-542.

[Hau/Brenner 2009]
Hau, T., Brenner, W. (2009): Price Setting in Two-Sided Markets for Internet Connectivity, In Proceedings of the 6th International Workshop on Internet Charging and QoS Technologies: Network Economics for Next Generation Networks, Aachen, Germany, pp, 61–71.

[Hau/Brenner 2010]
Hau, T., Brenner, W. (2010): Vertical Platform Interaction on the Internet: How ISPs and CDNs Interact. In Proceedings of the 18th European Conference on Information Systems (ECIS). Pretoria, South Africa, Paper 114.

[Hekkala 2007]
Hekkala, R. (2007): Grounded Theory – the two faces of the methodology and their manifestation in IS research. In Proceedings of the 30th Information Systems Research Seminar in Scandinavia (IRIS), Tampere, Finland, pp. 314-328.

[Henver et al. 2004]
Henver, A.R., March, S.T., Park, J., Ram, S. (2004): Design Science in Information Systems Research, MIS Quarterly, 28(1), pp. 75-105.

[Hibberd 2014]
Hibberd, M. (2014): Intelligence Industry Survey 2014, http://www.telecoms.com/wp-content/blogs.dir/1/files/2014/03/IndustrySurveyReport14_latest1.pdf, retrieved 2014-03-27.

[Hoernig et al. 2010]
Hoernig, S., Jay, S., Neumann, K. H., Peitz, M., Plückebaum, T., Vogelsang, I. (2010): Architecture and competitive models in fibre networks (WIK Report). Bad Honnef: WIK.

[Hoernig et al. 2012]
Hoernig, S., Jay, S., Neumann, K.-H., Peitz, M., Plückebaum, T., Vogelsang, I. (2012): The impact of different fibre access network technologies on cost, competition and welfare, Telecommunications Policy, 36(2), pp. 96-112.

[Holtbrügge 2005]
Holtbrügge, D. (2005): Management internationaler strategischer Allianzen, In: Zentes, J.; Swoboda, B.; Morschett, D. (Ed): Kooperationen, Allianzen und Netzwerke – Grundlagen-Ansätze- Perspektiven, 2. Auflage, Wiesbaden 2005, pp. 1181-1203.

[Huang et al. 2008]
Huang, C., Wang, A., Li, J., Ross, K.W. (2008): Understanding hybrid CDN-P2P: why limelight needs its own Red Swoosh, In Proceedings of the 18th International Workshop on Network and Operating Systems Support for Digital Audio and Video (NOSSDAV), Braunschweig, Germany, pp. 75-80.

[iDate 2012]
iDate (2012): World Internet Markets - Ref: M12101 - July 2012, http://www.idate.org/2009/pages/download.php?id=1271&idl=22&t=&fic=WorldInternetMarkets_Factsheet.pdf&repertoire=fiche_etude/M12101, retrieved 2014-08-13.

[iDate 2014]
iDate (2014): World Internet Services Markets - Database & Status report. http://www.idate.org/fr/Research-store/World-Internet-Services-Markets-Database-Status-report_889.html, retrieved 2014-10-25.

[ILSR 2014]
Institute for Self-Reliance ILSR (2014): Community network map, http://www.muninetworks.org/communitymap, retrieved 2014-02-20.

[Internet Archive 2011]
Internet Archive (2011): Universal access to all knowledge. http://www.archive.org/index.php, , retrieved 2011-11-23.

[ITU 2013]
ITU Work Group SG15 (2013): ITU-T work programme - G.9701 (ex G.fast-phy) - Fast Access to Subscriber Terminals (G.fast) - Physical layer specification, http://www.itu.int/itu-t/workprog/wp_item.aspx?isn=9800, retrieved 2014-10-02.

[Jay et al. 2011]
Jay, S., Neumann, K. H., Plückebaum, T., Zoz, K. (2011): Implikationen eines flächendeckenden Glasfaserausbaus und sein Subventionsbedarf (WIK Diskussionsbeitrag 359), Bad Honnef: WIK.

[Jay et al. 2014]
Jay, S., Neumann, K., Plückebaum, T. (2014): Comparing FTTH access networks based on P2P and PMP fibre topologies, Telecommunications Policy, 38(5-6), pp. 415-425.

[Kassarjian 1977]
Kassarjian, H.H. (1977): Content Analysis in Consumer Research, Journal of Consumer Research, 4(1), pp. 8–18.

[Kelly/Rossotto 2012]
Kelly, T., Rossotto, C. M. (Eds.). (2012): Broadband strategies handbook. World Bank Publications, Washington, DC, USA.

[Khoumbati et al. 2007]
Khoumbati, K., Lal, B., Chen, H. (2007): Consumer Adoption of Broadband in Pakistan, In Proceedings of the 13th Americas Conference on Information Systems (AMCIS), Keystone, Colorado, USA, Paper 60.

[Knyphausen-Aufseß 1995]

Knyphausen-Aufseß, D. Z. (1995): Theorie der strategischen Unternehmensführung. State of the Art und neue Perspektiven, Gabler, Wiesbaden.

[Kolbe et al. 1991]

Kolbe, R.H., Burnett, M.S. (1991): Content-Analysis Research: An Examination of Applications with Directives for Improving Research Reliability and Objectivity, Journal of Consumer Research, 18(2), pp. 243–250.

[Kotakorpi 2006]

Kotakorpi, K. (2006): Access price regulation, investment and entry in telecommunications, International Journal of Industrial Organization, 24(5), pp. 1013-1020.

[Kovacs 2012]

Kovacs, A.M. (2012): Internet Peering and Transit. Tech Policy Institute, https://www.techpolicyinstitute.org/files/amkinternetpeeringandtransit.pdf, retrieved 2014-01-30.

[Krafft 2003]

Krafft, J. (2003): Vertical structure of the industry and competition: an analysis of the evolution of the info-communications industry, Telecommunications Policy, 27(8), pp. 625-649.

[Krämer et al. 2013]

Krämer, J., Wiewiorra, L., Weinhardt, C. (2013): Net Neutrality: A Progress Report, Telecommunications Policy, 37(9), pp. 794-813.

[Krämer/Schnurr 2014]

Krämer, J., Schnurr, D. (2014): A unified framework for open access regulation of telecommunications infrastructure: Review of the economic literature and policy guidelines, Telecommunications Policy, in press, DOI: http://doi.org/10.1016/j.telpol.2014.06.006.

[Krishna/Ghatak 2008]

Krishna M., Ghatak A. R. (2008). Deconstruction of the Telecommunications Value Chain of North American Markets, ICFAI Journal of Business Strategy, 5(4) pp. 40-71.

[Krishnan et al. 2009]

Krishnan, R., Madhyastha, H.V., Srinivasan, S., Jain, S., Krishnamurthy, A., Anderson, T., Gao, J. (2009): Moving beyond end-to-end path information to optimize CDN performance, In Proceedings of the 9th ACM SIGCOMM Conference on Internet Measurement, Chicago, USA, pp. 190–201.

[Kruskal 1956]

Kruskal, J. B. (1956): On the shortest spanning subtree of a graph and the traveling salesman problem, In Proceedings of the American Mathematical Society, 7(1), pp. 48-50.

[Kübel et al. 2014]

Kübel, H., Limbach, F., Zarnekow, R. (2014): Business Models of Developer Platforms in the Telecommunications Industry - an Explorative Case Study Analysis. In Proceedings of the 47th Hawaii International Conference on System Sciences (HICSS), Waikoloa, Hawaii, pp. 3919-3928.

[Labovitz et al. 2010]

Labovitz, C., Iekel-Johnson, S., McPherson, D., Oberheide, J., Jahanian, F. (2010): Internet inter-domain traffic, In Proceedings of the ACM SIGCOMM 2010 Conference, New Delhi, India, pp. 75–86.

[Landis/Koch 1977]

Landis, J.R., Koch, G.G. (1977): The Measurement of Observer Agreement for Categorical Data, Biometrics, 33(1), pp. 159-174.

[Lannoo et al. 2008]

Lannoo, B., Casier, K., Van Ooteghem, J., Wouters, B., Verbrugge, S., Colle, D., Picavet, M., Demeester, P. (2008): Economic benefits of a community driven fiber to the home rollout, In Proceedings of the 5th International Conference on Broadband Communications, Networks and Systems (BROADNETS), London, UK, pp. 436-443.

[LaRose et al. 2007]

LaRose, R., Gregg, J.L., Strover, S., Straubhaar, J., Carpenter, S. (2007): Closing the rural broadband gap: Promoting adoption of the Internet in rural America, Telecommunications Policy, vol. 31(6-7), pp. 359-373.

[Lattemann et al. 2008]

Lattemann, C., Kupke, S., Schneider, A.M., Stieglitz, S. (2008): Public Private Partnerships as an Inter-Organizational Initiative for the Diffusion of Broadband Technologies in Europe, In Proceedings of the 16th European Conference on Information Systems (ECIS), Galway, Ireland, Paper 108.

[Lee/Lee 2008]

Lee, S., Lee, S. (2008): Multiple Play Strategy in Global Telecommunication Markets: An Empirical Analysis, International Journal of Mobile Marketing, 3(2), pp. 44-53.

[Lestage et al. 2013]

Lestage, R., Flacher, D., Kim, Y., Kim, J., Kim, Y. (2013): Competition and investment in telecommunications: Does competition have the same impact on investment by private and state-owned firms?, Information Economics and Policy, 25(1), pp. 41-50.

[Li/Whalley 2002]

Li, F., Whalley, J. (2002): Deconstruction of the Telecommunications Industry: From Value Chains to Value Networks, Telecommunications Policy, 26(9), pp. 451-472.

[Limbach et al. 2011a]

Limbach, F., Wulf, J., Zarnekow, R., Düser, M. (2011): Revenue distribution in a quality-centric Internet interconnection market. Proceedings of the 17th Americas Conference on Information Systems (AMCIS), Michigan, USA, Paper 208.

[Limbach et al. 2011b]

Limbach, F., Wulf J., Zarnekow R., Düser M. (2011): A typology of cooperation strategies in the telecommunication industry – An exploratory analysis and theoretical foundations, 22nd European Regional Conference of the International Telecommunications Society (ITS), Budapest, Hungary, Retrieved June 9, 2012, from http://hdl.handle.net/10419/52177.

[Limbach et al. 2011c]
Limbach, F., Wulf J., Zarnekow R., Düser M. (2011): Kooperationstreiber in der Telekommunikationswirtschaft. 4th Workshop on Services, Platforms, Innovations and Research for new Infrastructures in Telecommunications (SPIRIT 2011), Berlin, Germany.

[Limbach et al. 2012a]
Limbach, F., Wulf, J., Zarnekow, R., Düser, M. (2012): Wettbewerb und Kooperation im Content Delivery Markt. In Proceedings of Multikonferenz der Wirtschaftsinformatik (MKWI), Braunschweig, Germany.

[Limbach et al. 2012b]
Limbach, F., Wulf, J., Zarnekow, R., Düser, M. (2012): Business models and competition in the content delivery network market – An infrastructure analysis, In Proceedings of the 20th European Conference on Information Systems (ECIS), Barcelona, Spain, Paper 173.

[Limbach et al. 2012c]
Limbach, F., Wulf, J., Zarnekow, R., Düser, M. (2012): Co-opetition in next-generation access provisioning: An analysis of the German broadband market. In Proceedings of the 23nd European Regional Conference of the International Telecommunications Society (ITS), Vienna, Austria.

[Limbach et al. 2013a]
Limbach, F., Zarnekow, R., Düser, M. (2013): Cooperative private Next-Generation Access deployment – A relational view. In Proceedings of the 46th Hawaii International Conference on System Sciences (HICSS), Wailea, Hawaii, pp. 1444-1453.

[Limbach et al. 2013b]
Limbach, F., Kübel, H., Zarnekow, R., Düser, M. (2013): Towards Cross-Industry Information Infrastructure Provisioning: A Resource-Based Perspective, In Proceedings of the 17th International Conference on Intelligence in Next Generation Networks (ICIN), Venice, Italy, pp. 70-77.

[Limbach et al. 2013b]
Limbach, F., Kübel, H., Zarnekow, R. (2013): Kooperativer Breitbandausbau in Deutschland : Eine Expertenbefragung unter Unternehmensführern und Kooperationsverantwortlichen der deutschen Telekommunikationsbranche. In Research Papers in Information Systems Management, Universitätsverlag der TU Berlin, Berlin, Germany.

[Limbach 2014]
Limbach, F. (2014): Cooperative service provisioning with OTT players – An explorative analysis of telecommunication business models, 25th European Regional Conference of the International Telecommunications Society (ITS), Brussels, Belgium.

[Limbach et al. 2014a]
Limbach, F., Kübel, H., Zarnekow, R. (2014): An Empirical Contingency Perspective on Cooperative Municipal Broadband Adoption. In Proceedings of the 20th International Conference on Information Systems (AMCIS), Savannah, USA, Paper 19.

[Limbach et al. 2014b]
Limbach, F., Kübel, H., Zarnekow, R. (2014): Improving rural broadband deployment with

synergistic effects between multiple fixed infrastructures. Telecommunication Policy (Under Review).

[Limbach/Zarnekow 2014]
Limbach, F., Zarnekow, R. (2014): Cooperative next-generation access provisioning – Evidence from the German broadband market, Multikonferenz Wirtschaftsinformatik (MKWI 2014), Paderborn, Germany.

[Löser et al. 2013]
Löser, F., Erek, K., Zarnekow, R., Limbach, F. (2013): Shared Domain Knowledge in Strategic Green IS Alignment: An Analysis from the Knowledge-Based View, In Proceedings of the 46th Hawaii International Conference on System Sciences (HICSS), Wailea, Hawaii, pp. 3515-3524.

[Markides/Williamson 1996]
Markides, C. C., Williamson, P. J. (1996): Corporate diversification and organizational structure: A resource-based view, Academy of Management Journal, 39(2), pp. 340-367.

[Marscholek et al. 2011]
Marscholek, O. (2011): Nobody wins, but nobody loses either - understanding different institutional logics in IT public-private partnerships, In Proceedings of the 19th European Conference on Information Systems (ECIS), Helsinki, Finland, Paper 70.

[Masuda/Whang 2006]
Masuda, Y., Whang, S. (2006): On the Optimality of Fixed-up-to Tariff for Telecommunications Service, Information Systems Research, 17(3), pp. 247-253.

[Matavire/Brown 2008]
Matavire, R., Brown, I. (2008): Investigating the Use of "Grounded Theory" in Information Systems Research, In Proceedings of the 2008 Annual Conference of the South African Institute of Computer Scientists and Information Technologists (SAICSIT), Port Elizabeth, South Africa, pp. 139-147.

[Mellewigt 2003]
Mellewigt, T. (2003): Management von strategischen Kooperationen: Eine ressourcenorientierte Untersuchung in der Telekommunikationsbranche (1st ed.), Gabler, Wiesbaden.

[Ménard 2004]
Ménard, C. (2004): The Economics of Hybrid Organizations, Journal of Institutional and Theoretical Economics, 160(3), pp. 345-376.

[Microsoft 2014]
Microsoft. (2014): Mobile Operator Billing, http://msdn.microsoft.com/en-us/library/windowsphone/help/jj215902%28v=vs.105%29.aspx, retrieved 2014-03-31.

[Miles/Snow 1992]
Miles, R. E., Snow, C. C. (1986): Unternehmensstrategien. McGraw-Hill, Hamburg.

[Mintzberg 1978]
Mintzberg, H. (1978): Patterns in strategy formation, Management Science, 24(9), pp. 934-948.

[Mintzberg 1994]
Mintzberg, H. (1994): Rise and fall of strategic planning, Prentice Hall, New York.

[Mölleryd 2011]
Mölleryd, B. G. (2011): Network sharing and co-investments in NGN as a way to fulfill the goal with the digital agenda, 22nd European Regional Conference of the International Telecommunications Society (ITS), Budapest, Hungary.

[Morschett 2003]
Morschett, D. (2003): Formen von Kooperationen, Allianzen und Netzwerk. In: Zentes, J.; Swoboda, B.; Morschett, D. (Eds.), Kooperationen, Allianzen und Netzwerke – Grundlagen- Ansätze- Perspektiven, 1. Auflage, Gabler, Wiesbaden, Germany, pp. 389-403.

[Murri 2013]
Murri, P. (2013): Telecom Italia's Solutions To Address Competition From OTT Players, http://globalpartnershipsprogram.telecomitalia.com/res/pdf/Newsletter_Gartner_about_GPP.pdf, retrieved 2014-01-07.

[Myers 1997]
Myers, M.D. (1997): Qualitative Research in Information Systems, MIS Quarterly, 21(2), pp. 241-242.

[Nalebuff/ Brandenburger 1996]
Nalebuff, B., Brandenburger, A. (1996). Co-opetition. Oskarshamn: ISL Förlag AB.

[Nan 2011]
Nan, N. (2011): Capturing Bottom-Up Information Technology Use Processes: A Complex Adaptive Systems Model, MIS Quarterly, 35(2), pp. 505-532.

[Neis et al. 2010]
Neis, P., Zielstra, D., Zipf, A., Struck, A. (2010): Empirische Untersuchungen zur Datenqualität von OpenStreetMap - Erfahrungen aus zwei Jahren Betrieb mehrerer OSM-Online-Dienste. In: Strobl, J., Blaschke, T., Griesebner, G. (Eds.), Angewandte Geoinformatik 2010: Beiträge zum 22. AGIT-Symposium Salzburg, Wichmann, Berlin, Germany, pp. 420-425.

[Netflix 2014]
Netflix (2014): Netflix Open Connect Content Delivery Network, https://www.netflix.com/openconnect, retrieved 2014-02-21.

[NGA-Forum 2011]
NGA-Forum (2011): Bericht des NGA-Forums, NGA-Forum Report, http://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Telekommunikation/Unternehmen_Institutionen/Breitband/NGA_NGN/NGA-Forum/sitzungen/16teSitzung/Endbericht_NGAForum_111108.pdf, retrieved 2013-01-08.

[Ni et al. 2003]
Ni, J. Tsang, D.H.K., Yeung, I.S.H., Hei, X. (2003): Hierarchical content routing in large-scale multimedia content delivery network. In Proceedings of 38th annual IEEE International Conference on Communications (ICC) , Anchorage, Alaska, pp. 854- 859.

[Norton 2011]
Norton, W.B. (2011): The Internet Peering Playbook: Connecting to the Core of the Internet. DrPeering Press, Palo Alto, USA.

[Nucciarelli et al. 2010]
Nucciarelli, A., Sadowski, B.M., Achard, P.O. (2010): Emerging models of public–private interplay for European broadband access: Evidence from the Netherlands and Italy, Telecommunications Policy, 34(9), pp. 513-527.

[OECD 2009]
Organisation for Economic Co-Operation and Development (2009): Working party on communication infrastructures and services policy – Indicators of broadband coverage, http://www.oecd.org/internet/broadband/44381795.pdf, retrieved 2014-04-30.

[Open Mobile Alliance 2014]
Open Mobile Alliance (2014): Oma Api – Inventory, http://technical.openmobilealliance.org/API/APIsInventory.aspx, retrieved 2014-03-26.

[OpenStreetMap 2012]
OpenStreetMap (2012): OpenStreetMap density of data by region, http://www.odbl.de, retrieved 2013-01-14.

[OpenStreetMap 2013]
OpenStreetMap (2013): OpenStreetMap, http://www.openstreetmap.org, retrieved 2013-01-12.

[OpenStreetMap 2014]
OpenStreetMap (2014): OpenStreetMap, http://www.openstreetmap.org, retrieved 2014-10-12.

[Orange 2013]
Orange (2013): Rich Profile Api | Get Complete Rich Profile Information for Orange Customers, http://www.orangepartner.com/content/api-rich-profile, retrieved 2014-03-28.

[Orange 2014]
Orange (2014): Api Standardisation | a Win-Win for Developers and Mobile Operators, http://www.orangepartner.com/articles/api-standardisation, retrieved 2014-03-24.

[Orlikowski/Baroudi 1991]
Orlikowski, W. J., Baroudi, J. J. (1991): Studying information technology in organizations: Research approaches and assumptions, Information Systems Research, 2(1), pp. 1-28.

[Ortiz 2010]
Ortiz, J.A. (2010): A Grounded Theory Approach to Understanding Mu-Fi Interventions on the Digital Divide, In Proceedings of the 16th Americas Conference on Information System (AMCIS), Lima, Peru, Paper 44.

[Osterwalder 2004]
Osterwalder, A. (2004): The Business Model Ontology: A Proposition in a Design Science Approach, Institut d'Informatique et Organisation. Lausanne, Switzerland, University of Lausanne

[Osterwalder et al. 2005]

Osterwalder, A., Pigneur, Y., Tucci, C.L. (2005): Clarifying Business Models: Origins, Present, and Future of the Concept, Communications of the Association for Information Systems, 16(1), pp. 1-25.

[Otley 1980]

Otley, D.T. (1980): The contingency theory of management accounting: achievement and prognosis, Accounting, Organizations and Society, 5(4), pp. 413–428.

[Ovum 2012]

Ovum (2012): Operators and OTT Players Begin an Era of Partnership in Messaging, http://ovum.com/2012/11/08/operators-and-ott-players-begin-an-era-of-partnership-in-messaging/, retrieved 2014-02-11.

[Pages/Pe 2013]

Pages, M., Pe, D. (2013): Will LTE kill DSL?, The Delta Perspective, http://www.deltapartnersgroup.com/our-insights/will-lte-kill-dsl, retrieved 24-11-2014.

[Pertusa-Ortega et al. 2010]

Pertusa-Ortega, E.M., Molina-Azorín, J.F., Claver-Cortés, E. (2010): Competitive strategy, structure and firm performance: A comparison of the resource-based view and the contingency approach, Management Decision, 48(8), pp. 1282-1303.

[Pfeffer/Salancik 1978]

Pfeffer, J., Salancik, G.R. (1978): The external control of organizations. A resource dependence perspective, New York, NY, Harper and Row.

[Piccoli/Ives 2005]

Piccoli, G., Ives, B. (2005): IT-Dependent Strategic Initiatives and Sustained Competitive Advantage: A Review and Synthesis of the Literature, MIS Quarterly, 29(4), pp. 747-776.

[Picot et al. 2003]

Picot, A., Reichwald, R., Wigand, R. (2003): Die Grenzenlose Unternehmung: Information, Organisation Und Management, in Lehrbuch zur Unternehmensführung im Informationszeitalter, 5th Ed., Picot, A., Reichwald, R., and Wigand, R. (Eds.), Gabler, Wiesbaden, Germany.

[Picot/Wernick 2007]

Picot, A., Wernick, C. (2007): The role of government in broadband access, Telecommunications Policy, 31(10-11), pp. 660-674.

[Poese et al. 2010]

Poese, I., Frank, B., Ager, B., Smaragdakis, G., Feldmann, A. (2010): Improving content delivery using provider-aided distance information. In Proceedings of the 10th ACM SIGCOMM Conference on Internet measurement, Melbourne, Australia, pp. 22-34.

[Poese et al. 2012]

Poese, I., Frank, B., Smaragdakis, G., Uhlig, S., Feldmann, A., Maggs, B. (2012): Enabling content-aware traffic engineering. ACM SIGCOMM Computer Communication Review, 42(5), pp. 21-28.

[Pöllänen/ Säily 2007]
Pöllänen, O., Säily, M. (2007): Mobile coverage investment model linked to mobile network design, Netnomics Journal, 8(1-2), pp. 49-70.

[Pöllänen/Bhebhed 2011]
Pöllänen, O., Bhebhed, L. (2011): Efficient deployment of large mobile networks – Indian case study, Netnomics Journal, 12(2), pp. 115-132.

[Porter 1980]
Porter, M. (1980): Competitive strategy: Techniques for analyzing industries and competitors, Free Press, New York.

[Porter 1985]
Porter, M.E. (1985): Competitive Advantage: Creating and Sustaining Competitive Performance, Free Press, New York, NY.

[Porter 1991]
Porter, M.E. (1991): Towards a Dynamic Theory of Strategy, Strategic Management Theory, 12(S2), pp. 95-117.

[Pousttchi et al. 2009]
Pousttchi, K., Schiessler, M., Wiedemann, D.G. (2009): Proposing a Comprehensive Framework for Analysis and Engineering of Mobile Payment Business Models, Information Systems and E-Business Management, 7(3), pp. 363-393.

[Pröhl et al. 2013]
Pröhl, T., Erek, K., Limbach, F., Zarnekow, R. (2013): Topics and Applied Theories in IT Service Management. In Proceedings of the 46th Annual Hawaii International Conference on System Sciences (HICSS), Wailea, Hawai, pp. 1367-1375.

[Quinn 1980]
Quinn, J.B. (1980): Strategies for change: logical incrementalism. Homewood, IL: Irwin.

[Ragoobar et al. 2011]
Ragoobar, T., Whalley, J., Harle, D. (2011): Public and private intervention for next generation access deployment: Possibilities for three European countries, Telecommunications Policy, 35(9-10), pp. 27-41.

[Rautenstrauch et al. 2003]
Rautenstrauch, T., Generotzky, L., Bigalke, T. (2003): Kooperationen und Netzwerke: Grundlagen und empirische Ergebnisse, Josef Eul Verlag GmbH, Köln, 1. Auflage.

[Rayburn 2011a]
Rayburn, D. (2011): Updated List of Vendors in the Content Delivery Ecosystem, http://www.cdnlist.com, retrieved 2011-11-22.

[Rayburn 2011b]
Rayburn, D. (2011): Telcos and Carriers forming new federated CDN Group called OCX (Operator Carrier Exchange),

http://blog.streamingmedia.com/the_business_of_online_vi/2011/06/telco-and-carriers-forming-new-federated-cdn-group-called-ocx-operator-carrier-exchange.html, retrieved 2011-11-22.

[Reed/DeFillippi 1990]
Reed, R., DeFillippi, R.J. (1990): Casual Ambiguity, Barriers to Imitation, and Sustainable Competitive Advantage, The Academy of Management Review, 15(1), pp. 88-103.

[Regionaldatenbank 2013]
Regionaldatenbank (2013): Regionaldatenbank, https://www.regionalstatistik.de/genesis/online/logon, retrieved 2013-04-11.

[Repschläger et al. 2013]
Repschläger, J., Erek, K., Zarnekow, R. (2013): Cloud Computing Adoption: An Empirical Study of Customer Preferences among Start-up Companies, Electronic Markets, 23(2), pp. 115-148.

[Repschläger 2013]
Repschläger, J. (2013): Entscheidungsfindung im Cloud Computing : Konzeption und Analyse eines Modells zur Anbieterauswahl, Universitätsverlag TU Berlin, Berlin, Germany.

[Rivard et al. 2006]
Rivard, S., Raymond, L., Verreault, D. (2006): Resource-based view and competitive strategy: An integrated model of the contribution of information technology to firm performance, The Journal of Strategic Information Systems, 15(1), pp. 29-50.

[Rochet/Tirole 2003]
Rochet, J.C., & Tirole, J. (2003): Platform competition in two-sided markets, Journal of the European Economic Association, 1(4), pp. 990-1029.

[Rohrbeck et al. 2013]
Rohrbeck, R., Konnertz, L., Knab, S. (2013): Collaborative Business Modelling for Systemic and Sustainability Innovations, International Journal of Technology Management, 63(1-2), pp. 4-23.

[Rokkas et al. 2010]
Rokkas, T., Katsianis, D., Varoutas, D. (2010): Techno-economic evaluation of FTTC/VDSL and FTTH roll-out scenarios: Discounted cash flows and real option valuation, Journal of Optical Communications and Networking, 2(9), pp. 760-772.

[Ruhle et al. 2011]
Ruhle, E.O., Brusic, I., Kittl, J., Ehrler M. (2011): Next Generation Access (NGA) supply side interventions – An international comparison, Telecommunications Policy, 35(9-10), pp. 794-803.

[Sabat 2005]
Sabat, K.H. (2005): The network investment economics of the mobile wireless industry, Information Systems Frontiers, 7(2), pp. 187-206.

[Sambamurthy et al. 1999]
Sambamurthy, V., Zmud, R.W. (1999): Arrangements for Information Technology Governance, A Theory of Multiple Contingencies, MIS Quarterly, 23(2), pp. 261-290.

[Saraf et al. 2007]
Saraf, N., Langdon, C.S., Gosain, S. (2007): IS Application Capabilities and Relational Value in Interfirm Partnerships, Information Systems Research, 18(3), pp. 320-339.

[Sawhney 1992]
Sawhney, H. (1992): Demand aggregation strategies for rural telephony, Telecommunications Policy, 16(2), pp. 167-178.

[Schäfer/Schöbel 2005]
Schäfer R.G., Schöbel A. (2005): Stand der Backbone-Infrastruktur in Deutschland – Eine Markt- und Wettbewerbsanalyse, WIK Diskussionsbeiträge, Nr. 265.

[Schnabel 2011]
Schnabel, P. (2011): Kommunikationstechnik-Fibel: Grundlagen der Kommunikationstechnik, 3. Auflage, Schnabel, Ludwigsburg, Germany.

[Schneir et al. 2013]
Schneir, J.R., Xiong, Y. (2013): Economic implications of a co-investment scheme for FTTH/PON architectures, Telecommunications Policy, 37(10), pp. 849-860.

[Shakkottai/ Srikant 2006]
Shakkottai, S., Srikant, R. (2006): Economics of Network Pricing With Multiple ISPs, IEEE/ACM Transactions on Networking, 14(6), pp. 1233–1245.

[Sheppard 1995]
Sheppard, J. (1995): A Resource Dependence Approach To Organizational Failure, Social Science Research, 24(1), pp. 28–62.

[Shin 2009]
Shin, S., Tucci, J.E. (2009): Lesson from WiFi Municipal Wireless Network, In Proceedings of the 15th Americas Conference on Information Systems (AMCIS), San Francisco, USA, Paper 145.

[Shrimali/Kumar 2006]
Shrimali, G., Kumar, S. (2006): Paid peering among internet service providers, In Proceedings of the Game theory for communications and networks (GameNets), Article No. 11.

[Skype 2011]
Skype. (2011): Skype Announces Mobile Partner Program for Operators, http://about.skype.com/press/2011/02/mobile_partner_program.html, retrieved 2014-02-19.

[Sridhar 2010]
Sridhar, V. (2010): An econometric analysis of mobile services growth across regions of India, Netnomics Journal, 11(3), pp. 205-220.

[Stacy 2011]
Stacy, O. (2011): Network sharing business models and the structuring issues and choices facing operators, Journal of Telecommunications Management, 3(4), pp. 306-312.

[Strauss 1987]

Strauss, A. (1987): Qualitative Analysis for social scientists, Cambridge University Press, Cambridge, UK.

[Strauss/Corbin 1990]

Strauss, A., Corbin, J. (1990): Basics of Qualitative Research: Grounded Theory Procedures and Techniques, Sage Publication, London, UK.

[Swisscom 2014]

Swisscom (2014): Fixed-Line Number Goes Mobile with Swisscom's Io App, http://www.swisscom.ch/en/about/medien/press-releases/2014/05/20140519-MM-Swisscom-iO-Festnetz.html, retrieved 2014-05-21.

[Sydow 1992]

Sydow, J. (1992): Strategische Netzwerke: Evolution und Organisation, Gabler, Wiesbaden.

[Tahon et al. 2014]

Tahon, M., van Ooteghem, J., Casier, K., Verbrugge, S., Colle, D., Pickavet, M., Demeester, P. (2014): Improving the FTTH business case – A joint telco-utility network rollout model. Telecommunications Policy, 38(5-6), pp. 426–437.

[Tanenbaum 2003]

Tanenbaum, A.S. (2003): Computer Networks, 4. Auflage, Prentice Hall, Upper Saddle River, NJ, USA.

[Telco 2.0 2008]

Telco 2.0. (2008): Use Case: Telco Customer Data for Advertising in Ott Video, http://www.telco2.net/blog/2008/11/move_networks_winning_with_cus.html, retrieved 2014-02-26.

[Telefonica 2014]

Telefonica (2014): Music-Flat, http://www.o2online.de/more/mobile-services/apps-entertainment/music-flat/, retrieved 2014-01-30.

[TeleGeography 2013]

TeleGeography (2013): Transit Database, http://www.telegeography.com, retrieved 2013-01-30.

[Telekom 2014a]

Telekom (2014): Music Streaming Mit Telekom Music-Flat Und Spotify, http://www.t-mobile.de/apps-und-musik/spotify/, retrieved 2014-03-19.

[Telekom. 2014b]

Telekom (2014): Find Software - Business Marketplace, https://portal.telekomcloud.com/en/#!category/36, retrieved 2014-02-27.

[Thurstone 1967]

Thurstone, L.L. (1967): The Measurement of Values, 4 ed., University Press, Chicago, USA.

[Tier1Research 2011]

Tier1Research (2011): Tier1Research, http://www.t1r.com/, retrieved 2011-11-23.

[Tilson et al. 2010]

Tilson, D., Lyytinen, K., Sørensen, C.(2010): Research commentary - Digital Infrastructures: the missing IS research agenda, Information Systems Research, 21(4), pp. 748-759.

[Timmers 1998]

Timmers, P. (1998): Business Models for Electronic Markets, Electronic markets 8(2), pp. 3-8.

[Troulos et al. 2010]

Troulos, C., Merekoulias, V., Maglaris, V. (2010): A business model for municipal FTTH/B networks: the case of rural Greece, Emerald Article 12(3), pp. 73-89.

[TÜV Rheinland/BMVI 2014]

TÜV Rheinland, Bundesministeriums für Verkehr und digitale Infrastruktur (2014): Bericht zum Breitbandatlas – Mitte 2014, http://www.zukunft-breitband.de/SharedDocs/DE/Anlage/Digitales/bericht-zum-breitbandatlas-mitte-2014-ergebnisse.pdf?__blob=publicationFile, retrieved 2014-10-22.

[Troulos/Maglaris 2011]

Troulos, C., Maglaris, V. (2011): Factors determining municipal broadband strategies across Europe, Telecommunications Policy 35(9), pp. 842-856.

[Ulset 2007]

Ulset, S. (2007): Restructuring Diversified Telecom Operators, Telecommunications Policy 31(3), pp. 209-229.

[Shapiro/ Varian 1999]

Shapiro, C., Varian, H. (1999): Information rules - A Strategic Guide to the Network Economy, Harvard Business School Press, Boston, USA.

[VATM 2013]

VATM (2013): Stellungnahme des VATM zum Antrag der Telekom Deutschland GmbH auf Teilwiderruf der Regulierungsverfügung über den Zugang zur TAL, BK3g-09-085 vom 21.03.2011, http://www.vatm.de/uploads/media/2013-01-21_VATM-Stellungnahme_Vectoring_Antrag_DTAG_BK3-12-131.pdf, retrieved 2013-01-08.

[Venkatesh/Mahajan 2009]

Venkatesh, R., Mahajan, V. (2009): The Design and Pricing of Bundles: A Review of Normative Guidelines and Practical Approaches, In: Handbook of Pricing Research in Marketing, Rao, V.R., (Ed.), Edward Elgar Publishing Company, Northampton, USA, pp. 232 – 257.

[Venkatraman/Henderson 1998]

Venkatraman, N., Henderson, J. (1998): Real Strategies for Virtual Organizing, Sloan Management Review 40(1), pp. 33-48.

[VHB 2011]

Verband der Hochschullehrer für Betriebswirtschaft e.V. (2011): Gesamtübersicht JQ 2.1., http://vhbonline.org/uploads/media/Ranking_Gesamt_2.1.pdf, retrieved 2014-01-30.

[Vidmar et al. 2010]

Vidmar, L., Peternel, B., Štular, M., Kos, A. (2010): Broadband access network investment optimization in rural areas, Proceedings of the 15th IEEE Mediterranean Electrotechnical Conference, Valletta, Malta, pp. 482 – 486.

[Vodafone 2009]
Vodafone (2009): Vodafone Casa TV Now Available On Xbox 360, http://press.vodafone.pt/en/2009/12/16/vodafone-casa-tv-now-available-on-xbox-360/, retrieved 2014-03-14.

[Vodafone 2013]
Vodafone (2013): Microsoft Office 365 from Vodafone, https://www.business.vodafone.com/site/bus/public/enuk/support/50_business_solutions/60_hosted_solutions/office_365/05_summary/p_summary.jsp, retrieved 2014-02-10.

[Vodafone NZ 2014]
Vodafone NZ (2014): Redeem Your Xbox Voucher Code - Vodafone Nz, http://www.vodafone.co.nz/pages/1375766137302/, retrieved 2014-02-05.

[Vom Brocke 2003]
Vom Brocke, J. (2003): Referenzmodellierung: Gestaltung und Verteilung von Konstruktionsprozessen, Logos Verlag, Berlin, Germany.

[Wade/Hulland 2004]
Wade, M., Hulland, J. (2004): The resource-based view and information systems research: review extension, and suggestions for future research, MIS Quarterly 28(1), pp. 107-142.

[Wallin 2005]
Wallin, J. (2005): Operationalizing Competences, in Competence Perspective on Managing Internal Process (Advances in Applied Business Strategy, Volume 7), In: Sanchez, R., and Heene, A. (Eds.), Emerald Group Publishing Limited, Bradford, UK, pp.151-179.

[Waterman et al. 2013]
Waterman, D., Sherman, R., Ji, S.W. (2013): The Economics Of Online Television: Industry Development, Aggregation, And “TV Everywhere”, Telecommunications Policy 37(9), pp. 725-736.

[Weiber 1995]
Weiber, R. (1995): Systemgüter und klassische Diffusionstheorie – Elemente einer Diffusionstheorie für kritische Masse-Systeme, In: Stoetzer, M.W., Mahler, A. (Eds.), Die Diffusion von Innovationen in der Telekommunikation, Springer, Berlin, Germany, pp. 39-70.

[Werner 2005]
Werner, M. (2005): Netze, Protokolle, Schnittstellen und Nachrichtenverkehr - Grundlagen und Anwendungen, Vieweg, Wiesbaden, Germany.

[Wernerfelt 1984]
Wernerfelt, B. (1984): A resource based view of the firm, Strategic Management Journal 5(2), pp. 171-180.

[Whitaker et al. 2005]
Whitaker, R.M., Raisanen, L. Hurley, S. (2005): The infrastructure efficiency of cellular wireless networks, Computer Networks 48(6), pp. 941-959.

[Wilde/Hess 2007]
Wilde, T., Hess, T. (2007): Forschungsmethoden der Wirtschaftsinformatik - Eine empirische Untersuchung, Wirtschaftsinformatik, 49(4), pp. 280 - 287.

[Williamson 1975]
Williamson, O.E. (1975): Markets and Hierarchies: Analysis and Antitrust Implications, The Free Press, New York.

[Williamson 1985]
Williamson, O.E. (1985): The Economic Institutions of Capitalism, Free Press, New York, USA.

[Williamson 1991]
Williamson, O.E. (1991): Strategizing, economizing, and economic organization, Strategic Management Journal 12(2), pp. 75-94.

[Winkler et al. 2011]
Winkler, T., Göbel, C., Benlian, A., Bidault, F. Günther, O. (2011): The Impact of Software as a Service on IS Authority – A Contingency Perspective, In Proceedings of the International Conference on Information Systems (ICIS), Paper 22.

[Wirtz 2001]
Wirtz, B.W. (2001): Electronic Business, 2. Auflage, Gabler, Wiesbaden, Germany.

[WKWI 2008]
WI-Orientierungslisten (2008): Wirtschaftsinformatik, 50(2), pp. 155-163, http://link.springer.com/article/10.1365%2Fs11576-008-0040-2, retrieved 2014-08-11.

[World Economic Forum 2012]
World Economic Forum (2012): Rethinking Personal Data: Strengthening Trust, http://www3.weforum.org/docs/WEF_IT_RethinkingPersonalData_Report_2012.pdf, retrieved 2014-02-03.

[World Economic Forum 2013]
World Economic Forum (2013): Unlocking the Value of Personal Data: From Collection to Usage, http://www3.weforum.org/docs/WEF_IT_UnlockingValuePersonalData_CollectionUsage_Report_2013.pdf, retrieved 2014-02-03.

[Wrona/Schell 2005]
Wrona, T.; Schell, H. (2005): Grundlagen und Merkmale von Kooperationen, In: Zentes, J.; Swoboda, B.; Morschett, D. (Eds.), Kooperationen, Allianzen und Netzwerke – Grundlagen-Ansätze- Perspektiven, 2. Auflage, Wiesbaden, Germany, pp. 330-343.

[Wulf 2012]
Wulf, J. (2012): Analysis and design of value production strategies and business models in the telecommunications industry, Universitätsverlag TU Berlin, Berlin, Germany.

[Wulf/Zarnekow 2011]

Wulf, J., Zarnekow, R. (2011): How do ICT firms react to convergence? An analysis of diversification strategies, In Proceedings of the 19th European Conference on Information Systems (ECIS), Paper 97.

[Wulf et al. 2010a]

Wulf, J., Zarnekow, R., Hau, T., Brenner, W. (2010): Carrier activities in the CDN market: An exploratory analysis and strategic implications. In Proceedings of the 14th International Conference on Intelligence in Next Generation Networks (ICIN), 1–6. Berlin, Germany.

[Wulf et al. 2010b]

Wulf, J., Zarnekow, R., Düser, M. (2010): Analysis of Future Telecommunication Business Models Using a Business Model Ontology, 9th Conference on Telecommunications Internet and Media Techno Economics (CTTE), pp. 1-7.

[Wulf et al. 2010c]

Wulf, J., Limbach, F., Zarnekow, R. (2010): Analysis of QoS platform cooperation strategies. 21th European Regional Conference of the International Telecommunications Society, Paper 39.

[Wulf et al. 2011]

Wulf, J., Limbach, F., Zarnekow, R., Düser, M. (2011): Economics of a Quality-of-Service interconnection market - A simulation-based analysis of a market scenario. In Proceedings of the International Conference on Information Systems (ICIS 2011), Paper 5.

[Xu et al. 2006]

Xu, D., Kulkarni, S. S., Rosenberg, C., Chai, H. K. (2006): Analysis of a CDN–P2P hybrid architecture for cost-effective streaming media distribution. Multimedia Systems, 11(4), pp. 383-399.

[Yates et al. 2011]

Yates, D.J., Gulati, G.J. Weiss, J.W. (2011): Different Paths to Broadband Access: The Impact of Governance and Policy on Broadband Diffusion in the Developed and Developing Worlds, in Proc. HICSS'11, 2011.

[Yin 1994]

Yin, R.K. (1994): Case Study Research: Design and Methods, 2nd ed., Sage Publications, Thousand Oaks, USA.

[Yin 2003]

Yin, R. K. (2003): Case Study Research: Design and Methods, 3rd ed., Sage Publications, Thousand Oaks, USA.

[Yin 2007]

Yin, R. K. (2007): Case Study Research: Design and Methods, 4th ed., Sage Publications, Thousand Oaks, USA.

[Yin et al. 2009]

Yin, H., Liu, X., Zhan, T., Sekar, V., Qiu, F., Lin, C., Zhang, H., Li, B. (2009): Design and deployment of a hybrid CDN-P2P system for live video streaming: experiences with LiveSky, Proceedings of the 17th ACM international conference on Multimedia, pp. 25-34.

[Yourfone 2014]

Yourfone (2014): Musik Flat Für Dein Handy, http://www.yourfone.de/tarife/musik-flat.html, retrieved 2014-03-10.

[Zajac/Olsen 1993]

Zajac, E.J., Olsen, C.P. (1993): From transaction cost to transactional value analysis: Implications for the study of interorganizational strategies, Journal of Management Studies, vol. 30, pp. 131–45, Jan. 1993.

[Zarnekow et al. 2013]

Zarnekow, R., Wulf, J., Bornstaedt, v. F. (2013): Internetwirtschaft, Springer, Berlin Heidelberg, Germany.

[Zattoo 2014]

Zattoo (2014): Referenzen (Auswahl), http://corporate.zattoo.com/de/zattoo-solutions/reference-choice, retrieved 2014-02-06.

[Zerdick et al. 2000]

Zerdick, A., Picot, A., Schrape, K., Artope, A., Goldhammer, K., Heger, D.K., Lange, U.T., Vierkan, E., Lopez-Escobar, E., Silverstone R. (2000): E-conomics: Strategies for the Digital Marketplace. Springer-Verlag, Berlin.

[Zielstra/Zipf 2010]

Zielstra, D., Zipf, A. (2010): Quantitative studies on the data quality of OpenStreetMap in Germany, In Proceedings of the 6th International Conference on Geographic Information Science. Zurich, Switzerland.